Thomas E. Bigford

ESTUARINE AND COASTAL MANAGEMENT

TOOLS OF THE TRADE

VOLUME 2

PROCEEDINGS OF
TENTH NATIONAL CONFERENCE

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J. Kevin Sullivan, Chair

Estuarine and Coastal Management - Tools of the Trade. Proceedings of the Tenth National Conference of The Coastal Society. October 12-15, 1986. New Orleans, LA.

Abstract only

MARYLAND CRITICAL AREA PROGRAM

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The Chesapeake Bay Critical Area Protection Law (Natural Resources Article 8-1801 - 8-1816) was passed by the General Assembly in 1984 because of concern about the decline of certain natural resources of the Chesapeake Bay. Recent studies by the U.S. Environmental Protection Agency and others have shown that this decline is related to the intensity of human activities within the watershed of the Bay.

In order to begin to address these sources of impact, the General Assembly designated a geographical area around the tidal waters of the Chesapeake Bay and its tributaries as the "Critical Area." It directed that new development in this area be such as to minimize impacts on the Bay's water quality and plant, fish, and wildlife habitat. Pursuant to the requirements of the Law, the Chesapeake Bay Critical Area Commission was established to develop criteria for guiding local jurisdictions in developing programs for Critical Area.

The process of approval for these criteria as can be imagined, was frought with political pitfalls and enhancements - all of which resulted in a set of landmark land-use guidelines for development around the Bay which passed General Assembly scrutiny in April of 1986. At this time, the Commission will seek to work with 60 jurisdictions in helping them use the criteria in the development of their local Critical Area Protection Programs.

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WATERFRONT DEVELOPMENT AND ENVIRONMENTAL COMPLIANCE

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The Port of New York and New Jersey, traditionally considered the nation's premier harbor, encompasses more than seven hundred miles of waterfront property. The port complex, located seventeen miles from the open sea, is well protected from storms and not subject to extreme weather conditions. Over several decades, activity along the shoreline has adapted to the technological changes in the maritime industry, as well as the population dynamics of the metropolitan area.

The advent of containerization rendered a number of finger piers, structures erected on piles and perpendicular to shoreline, on both sides of the Hudson River, obsolete. Consolidation and reorganization of rail service in the region has resulted in the abandonment of major portions of the New York and New Jersey waterfront south of the George Washington Bridge. As facilities were consolidated and waterfront areas abandoned many shoreside structures fell into a state of disrepair which would only worsen with the impact of tide and time. For at least a decade, much of this impacted shoreline remained dormant. The waterfront areas are now enjoying renewed interest on the part of both public and private development sponsors. The unobstructured view from the water's edge has, once again, proved to be a lure for city and suburban dwellers.

The Port of New York and New Jersey faces a most interesting challenge with respect to development along the water's edge. In 1972, the United States Congress enacted the Coastal Zone Management Act with the intent of generating "a national interest in the effective management, beneficial use, protection and development of the coastal zone."

As an incentive to coastal states, Congress provided funds for the development of coastal zone management programs designed to reflect the particular interests, environment and geographic location of the state. New York and New Jersey have since developed programs which seek to improve water quality and aquatic resources, rehabilitate unused or underutilized waterfront structures and provide public access to the shoreline. Both States implement the coastal zone management program through a series of permit proceedings, inter-agency reviews and consistency certifications.

In 1984, the States of New York and New Jersey passed legislation that enabled the Port Authority to acquire and develop two mixed-use sites on the waterfront. The New Jersey site is located in Hoboken, Hudson County and the New York site is located in the Hunters Point section of Queens. The waterfront development projects were designed to increase the local government's tax base and employment opportunities; provide public access and open space; stem erosion and physical deterioration of the shoreline; and provide additional commercial space and housing stock.

In metropolitan New York and New Jersey, proximity to the waterfront translates into proximity to a transportation network as well as one's place of employment. It is not surprising that given these advantages, in addition to unparalleled views of the harbor and skyline, mixed-use development is the most appealing prospect for sites along the shoreline. The Hoboken and Hunters Point projects are only two of at least twenty large scale waterfront development projects proposed for the Port Region. Given this accelerated interest in waterfront development on the part of public and private entities, one might question why proposals, which appear to incorporate the goals of coastal zone management legislation, take an inordinate amount of time to implement.

One difficulty in implementing waterfront development projects appears to stem from a lack of scientific agreement on the anticipated impacts to the aquatic environment. The scientific data base on coastal environments is in an evolutionary stage. The impact of pilings, fill and bulkheads on the aquatic environment is only now being examined in depth. Prior to the enactment of environmental legislation in the 1970's, waterfront structures were built, channels dredged and marshland filled with little regard to potential environmental impacts. Over the course of two centuries construction activities in the Port of New York and New Jersey focused on pile supported piers, bulkheading of shoreline areas and dredging forty five (45) federally authorized navigation channels. The development of the port complex did not necessarily result in an adverse effect on the environment: dredging may have had only a short-term impact on turbidity; and pile supported structures may have fostered an environment conducive to the proliferation of particular aquatic species. In addition, the development of the Port enriched the local and regional economy.

Today the pendulum seems to have shifted such that, no waterfront construction, or even alteration is permitted until every last potential impact has been identified, addressed and mitigated. Although this may appear to be a prudent and conservative approach to waterfront development and rehabilitation, the questions are endless and oftimes unanswerable. For example, the New York Harbor Collection and Removal of Drift Program envisions removing the deteriorated piers and thereby eliminating sources of drift. Objections have recently been registered that the program to clean-up waterfront areas and remove hazards to navigation may be disrupted to the inter-pier ecosystem as such may constitute an aquatic habitat. Nonetheless, new pier constuction also raises objections from environmentalists and regulators. The inertia with respect to project implementation results in frustrated efforts on the part of regulators and developers alike. How many seasons of fish sampling data is enough to determine the "resident and migratory species" of a particular cove? Will driving piles to support a public esplanade disturb the aquatic environment, increase siltation or create an improved climate for species who seek the shelter of pier and inter-pier waters? Does decking interfere with light penetration and thereby negatively impact the aquatic biota?

Some of the questions posited can be addressed on a qualitative level. However, when regulators seek to have developers define both qualitative and quantitative cummulative impacts of waterfront development along a particular stretch of shoreline; they may be asking questions which cannot be answered. In short, how much decking should be permitted; when does pile density resemble a fill activity; what number of fish constitute a resident species; and finally, are certain species favored over others? The cummulative impact analysis embodies a preference for projects that are "first time" as all development proposals which follow must take existing and proposed projects into consideration when evaluating environmental impacts.

The scope of cummulative impact analysis has recently become a bone of contention. At what point is a project far enough along in the planning stage to be included as part of the environmental analysis compiled by another developer. If a developer must include all project proposals, he/she faces a herculean task, particularly in view of the sheer number of proposals for the New York and New Jersey metropolitan area. If the proposed projects to be included in the environmental analysis are specific to a stretch of shoreline; the question becomes which projects, of what scale and in what proximity to the developer's proposal. In addition, reality dictates that many projects are proposed but few implemented. Consequently, developers may be charged with expending time and money on cummulative environmental analysis which bears no relation to the particular projects that are actually implemented over the course of many years.

Controversial waterfront development projects face an even greater obstacle when it comes to implementation. Regulatory agencies may be reluctant to authorize projects which are viewed as a potential target of litigation. Requests for additional information and expanded analysis translates into the best defense for an agency which may later have to justify the issuance of a permit or consistency certificate.

The problems associated with regulatory compliance are not rooted in any inconsistency in the regulations nor inconsistency between the proposed project and the coastal zone management policies. Rather, the latitude with which the regulations and policies are interpreted leads to the delay and sometimes the demise of a development project. For example, oftimes the regulatory review process does not begin until the regulating agency deems an application complete. Hence, the review timeframe is unpredictable. A developer may conduct several seasons of sampling only to discover later on that such sampling should have been more extensive or in a different location. Upon submitting sampling data, a developer may discover that the lack of staff has inhibited review and thereby additional delays ensue. A developer may also discover that data compiled for one agency does not satisfy the review requirements of another agency. All too often the discretion embodied in regulatory interpretation reflects the whim, fiat and bent of a particular agency or individual.

Complicating the situation faced by developers is the lack of a cohesive approach to evaluating the merits of a proposed project. The regulatory agencies typically represent federal, state and local governments each with their own area of interest, concern and information level. The specific interests may relate to marine life and fisheries, water quality, navigation, public access or infrastructure improvements. Although these concerns are not mutually exclusive, reaching a consensus with regulatory agencies on the scope of the environmental analysis and the design of the project can be a frustrating, if not an unattainable goal.

The question remains as to whether the multi-tiered review of a waterfront development proposal actually results in a project which satisfies the environmental, economic and aesthetic concerns. Inordinate delays in scoping the outline for an environmental impact statement, negotiations among and between federal, state and local agencies and months of research to compile the appropriate data can have a chilling effect on a developer's interest and economic commitment to a project. In this situation, neither the public nor the developer benefit as the unused waterfront area remains underutilized and unavailable to the population of an urban area. If the goal of coastal zone management is exclusively to preserve the status quo, then the regulatory review procedures, as they are currently administered, will do just that.

The coastal zone legislation recognizes that coastal areas are unique with respect to natural, ecological, recreational, industrial, cultural and aesthetic resources. The competing demands on these resources can be evaluated such that the social, economic and environmental interests are addressed and accommodated. The need to insure a proper balance between natural resources and economic development is the responsibility of the regulators as well as the proponents of projects.

The evaluation of the merits of a proposal must include an analysis of the costs and benefits to both the human and aquatic environment. Regulators must be sensitive to the fact that trade-offs are part of any development. Hence, the project must be viewed in terms of risks and benefits and repercussions of the "no-action" or "in-action" alternative. Developers must be sensitive, in design and implementation, to the fact that waterfront development will impact the waterway but can do so in a beneficial fashion. The developer must also evaluate the economics of a project from the perspective of providing the appropriate environmental analysis and identify the point at which the regulatory process is more costly than the project.

The thin strip of land along the water's edge is a precious resource, both fragile and dynamic. Deteriorated shorelines are neither aesthetically pleasing nor environmentally stable. The social and economic well being of the people of coastal areas are critically linked to the preservation and development of both the natural and man-made resources in the state's coastal zone.

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LAND USE PLANNING UNDER THE GUISE OF CAMA IN NORTH CAROLINA

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The Coastal Area Management Act (CAMA) was ratified in the State of North Carolina in 1974. This was a last minute effort by the legislature to interface with the federal legislation passed in 1971. Many planners felt that the difficulties in ratifying the legislation revealed a low level of support by the people. While CAMA is now accepted by many citizens, there are still some that have a problem with it. This is not uncommon with respect to land use controls, and CAMA is legislation for guiding land and water use. As the bill states, "In the implementation of the coastal area management plan, the public's opportunity to enjoy the physical, esthetic, cultural, and recreational qualities of the natural shorelines of the State shall be preserved to the greatest extent feasible; water resources shall be managed in order to preserve and enhance water quality and to provide optimum utilization of water resources; land resources shall be managed in order to guide growth and development and to minimize damage to the natural environment; and private property rights shall be preserved in accord with the Constitution of this State and of the United States" (NCAC, 1974).

In the early 1970's only a few states had adopted applicable statewide land use regulatory systems (Guernsey, 1972). Hawaii was the first state to adopt a comprehensive land use law in 1961. Wisconsin followed with legislation in 1966 to protect all shorelines. In 1970 Florida passed legislation for the purpose of developing a comprehensive plan for the protection, development and zoning of the coastal zone. California began with some piecemeal efforts related to the coastal zone in 1968, but did not achieve a comprehensive land use planning effort until 1972. In 1969 the Texas legislation began to study coastal related problems, but the study was not completed until 1972. Generally, none of the coastal zone management and planning programs at the state level moved as fast nor as far as they needed to in order to resolve land use issues and problems. Even the legislation passed by the 92nd Congress tends to fall short of the mark as we all can see as the coastal zone becomes more impacted with each passing day.

The intentions of the existing federal and state legislation are admirable. It seems that much of the problem is in the application of the legislation at the local level. We seem to know what to do, but not how to do it. This happens a lot. But it doesn't need to be that way. One of the major problems we are confronted with in the local application of land use legislation in North Carolina is the wide variation of planning and management sophistication. For example, large communities with full time planning staffs are very successful with a continuing planning effort, while in small towns and rural areas the planning effort is virtually inactive from update to update of the land use plans required by CAMA. The contrast between places having a large urbanizing population located on the ocean and rural towns located on the inner coastal plain shows the differences that CAMA attempts to handle. It should not be too hard to imagine how difficulties occur in the application of the Coastal area Management Act.

Planning vs. Management

In order to describe the problems related to the application of state legislation at the local level we must philosophize a little bit. What is meant by planning? What is meant by management? For all practical purposes land use planning is the conceptualizing, coordination and encouragement of private and public use of land to satisfy long term public interests. Even more fundamentally, planning is the process of bringing the future into the present so we can do something about it now! How many of us use this thinking in setting goals and policies at the local level? My limited observations tell me very few. The consequences without a continuous local planning effort are ecological disruptions or impacts when we use our spatially oriented resources such as land to satisfy our economic, social, recreational or political needs. In the past few decades, planning, management and land use controls have been increasingly used to protect our valuable resources. Unfortunately, local attitudes have not changed sufficiently to allow this process to occur with uniformity or regularity. Perhaps the problem is at the management end. Management is much different than planning. Many theorists say that managment deals with methods and means of effectively using the resources of an organization to achieve its established objectives (Carlisle, 1976). We have heard it said that you can manage programs, but you can't manage people. Is this the problem? Is it that we can manage our environmental resources, but when it comes to applying the same method to people our problems occur. Think about it! There is definitely a difference between the planning process and the management process. In the planning process, it is people oriented. In the management process, it is objective oriented. It is necessary in the local application of the Coastal Area Management Act to allow the planning process to work. And the planning process is complicated, perplexing and time consuming at the very least. Not that management isn't, but resources don't tend to answer back like people do.

Some Local Scenarios

During the past several years I have had the opportunity and good fortune to work with several coastal communities in North Carolina. This experience has allowed me to observe first hand the concerns of these communities and how they function. I have classified these concerns into several categories: 1) outside environmental influences, 2) outside socioeconomic influence, 3) administrative expertice, and 4) local leadership. With respect to outside environmental influences, problems abound. It is very difficult to sell the protection of environmental resources, particularly water, when coastal communities are being impacted by communites outside the coastal zone. For example, in Bertie County located where the Roanoke River and Chowan River have their confluence, the water quality entering the estuarine environment is already impacted from upstream sources. Further, because the Roanoke River is heavily dammed it has virtually ruined the striped bass population and the spring herring run. It is very difficult to formulate policies related to the best management practices under these circumstances. In this case, the planner must espouse drainage basin planning and management eventhough the likelihood of a comprehensive planning effort in a river basin as large as the Roanoke seems remote. And because it is remote, the local policies are generally vague with respect to land and water management. Another example of outside environmental influences being imposed on the coastal area is acid deposition. In most coastal areas the soils are already acidic. Acid rain impacts the soils even further affecting the more sensitive terrestrial biota as well as aquatic biota. How can a local land use plan address this very important issue? The citizens are stymied, so is the planner, and the problem continues. Planners realize that the planning process at the local level is the key to environmental integrity. But not all environmental problems can be solved at the local level in a coastal situation. The local policy makers, the citizens of the coastal communities, need to see some progress at the national or regional scale before they will be willing to articulate environmental policies more specifically.

Planning at the local level works best without outside pressures. Managers or planners from state and federal agencies must be extremely careful not to create what we can call the 'big brother syndrome'. Many people resent being told what they can and cannot do. How 'visitors' approach local coastal issues must be done with care. It takes a continuous planning process to educate the people regarding the purpose of land use and other environmental controls. This process does not begin with state or federal agencies nor should it, but it should be allowed to happen using the local planner. The planning effort must be allowed to develop by the state and federal agencies. Patience would certainly be a virtue in such cases. In Bertie County, the land use planning update took two years to complete. The Office of Coastal Management was very patient. And while there are some environmental issues unresolved such as the poor water quality coming from Virginia and piedmont North Carolina, the local land use plan and its contribution toward maintaining the integrity of the coastal area is unmistakable in its intent. The people of Bertie County have addressed the land use issues and have a document that will help them for the next five years and beyond. The situation in this rural county presented this planner with an unusual and beneficial planning experience. And because the planning board ceased to exist after the last land use plan update, it allowed the newly appointed citizen planners to have a fresh start in the planning process. It has given them valuable time to explore the meaning and the necessity of coastal planning.

There is a wide variation in the administration of local governments. Small towns, in particular, can be operating with a town manager who may have a degree in public administration with years of experience or a part time town clerk with a high school diploma and very little experience. Some towns are functioning without the benefit of a planning board or technical planning assistance, while other towns may have a planning department with several professional planners to assist the planning board and the town council. In a number of instances towns will seek additional assistance for land use planning if local planning tasks consume too much of the local planner's time. In the case of Kill Devil Hills the town planner opted for some outside assistance. The planner and the planning board desired a public opinion survey and analysis to be conducted as part of the land use planning effort which would allow town officials guidance in their decision making process and assist in formulating policies on the local land use issues. The survey served them well, for they not only obtained slightly over a fifty percent response, they garnered some valuable insight related to the local coastal issues. The importance of public participation cannot be overstressed. But time to conduct the survey and analysis could not be afforded at the local level. Unfortunately not all towns have the financing to seek the assistance they so badly need to carry out a continuous effort of town planning. In any case it is not easy to plan in a community, nor is it easy to manage a program such as CAMA in an area where just 'making ends meet' is the primary concern of the people.

Finally, there is the concern of local leadership. It is difficult to get people excited about CAMA. Generally there are two factions in the community: 1) prodevelopment, and 2) proenvironment. The scenario varies dependent upon how strong the leaders of these factions are. And it it is not unusual for town boards to vary in their thinking from one election to another. That is, during one term the board may be for development, and in the next the board will be against development. In some places the land use plan is constantly amended, in others the land use plan is used as a firm guiding hand, and in others it isn't used at all. By having a land use plan in place and setting policies for the coastal environment does not necessarily mean that the coastal area will be adequately or uniformly dealt with. There are no assurances that in the application of CAMA the environment will be under less stress. If the local leadership takes a lax attitude concerning the local environment, the likelihood that the plan will be utilized in its entirety is small. Consequently, some communities have a successful continuous planning process which tends to improve the coastal environment, while other communities have a somewhat loose interpretation of the planning process which allows our coasts to be impacted.

Some Final Thoughts

Many parts of the coastal area will continue to have growth. The land use plan helps in the effort to lessen the impact of this growth, but it is no panecea for holding or reducing environmental impact. This is particularly the case when some of my planning colleagues are suggesting that the carrying capacity of the barrier islands or the coastal plain be based on maximum levels of groundwater withdrawal, maximum wastewater treatment capacities, and how fast the area can be evacuated with more traffic lanes in the event of a storm. Consideration of land availability, stormwater runoff impact on water quality, alternatives to growth economics, local feelings about land use densities and mixes, and many other factors must be used in order to improve the coastal environment. We have a beginning in North Carolina. We have had some problems, but we have had many successes with CAMA. Hopefully, CAMA will be improved. Perhaps it might even be expanded to include whole drainage basins or the entire state. We certainly need it for our coasts are finite and fragile.

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STATUS OF THE COASTAL BARRIER RESOURCES ACT STUDY

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Section 10 of the Coastal Barrier Resources Act (CBRA) required the Department of the Interior to conduct a three year study and report to Congress. This report is to include recommendations;

1. For the conservation of the fish, wildlife, and other natural resources of the Coastal Barrier Resources System (CBRS) based on an evaluation and comparison of all management alternatives, and

2. For additions to/or deletions from the Coastal Barrier Resources System and for modifications to the boundaries of System Units.

This paper is a progress report on that study.

CBRA resulted from the realization that development of coastal barriers is frequently hazardous to life and property, and often results in the loss of unique and valuable natural resources. Much of this development would not have been possible without Federal subsidies.

CBRA is a statement by Congress that the Federal Government will no longer assist in financing new development on the 186 undeveloped, unprotected coastal barriers within 15 states on the Atlantic and Gulf Coasts comprising the CBRS.

To implement the Study, the Secretary of the Interior established a study group comprized of representatives from the National Park Service, Fish and Wildlife Service, U.S. Geological Survey and other appropriate entities.

The first phase of the study was a compilation of all feasible management alternatives and an inventory of all undeveloped coastal barriers on all coast-lines of the United States.

Significant issues reviewed included;

1. State, local and private conservation and protection initiatives

2. Federal tax policy - incentives and disincentives

3. Federal regulatory programs, Section 9, 10 and 404 permits

4. Acquisition

5. Federal Revenue Sharing

6. Evaluation of the impacts of exceptions allowed under CBRA

7. Redevelopment of developed areas destroyed by disasters

The inventory of undeveloped coastal barriers included a substantial expansion of the criteria used to establish the Coastal Barrier Resources System. A comparison of the original with the new criteria included;

1. CBRS confined to the Atlantic and Gulf Coasts.

The inventory included all coast lines of the United States including the Great Lakes, Caribbean, West Coast, Alaska and Hawaii.

2. CBRS included only unprotected, undeveloped barriers.

The inventory attempted to include all undeveloped barriers, regardless of ownership.

3. CBRS included primary barriers of unconsolidated, sedimentary material only.

The inventory included other land forms functioning as barriers, including carbonate-cemented deposits, vegetationally stabilized sediments (mangrove islands and cheniers), and bedrock/glacial deposits. Secondary barriers within large embayments were also included.

4. A very limited amount of associated aquatic habitat was included in the CBRS.

All associated aquatic habitat up to 1 mile of open water and 5 miles of marsh behind the barrier was included in the inventory.

5. The minimum shoreline length in the CBRS was 1/4 miles.

This was maintained in the inventory except for states specifically requesting addition of smaller areas that were otherwise qualified, and Alaska, where the minimum was one mile.

Results of the inventory included expansion from 15 States in the CBRS to 32 States and territories in the inventory, 186 vs 1335 units, 670 miles vs 1335 miles of shoreline and 450,000 vs 7 3/4 million acres.

I want to emphasize that this phase included no recommendations. It was intended only to explore all the possibilities and stimulate discussion.

The inventory maps were developed by the study group using U.S. Geological Survey topographic maps, aerial photography and any pertinent information available within the allowable timeframe. Governors of the affected states were notified of the study and requested to designate a contact. State representatives were sent a draft set of maps and asked to review them for accuracy based on the study criteria. Members of the study group met with representatives of 17 States to review the maps and make technical adjustments.

A March 1985 Federal Register Notice announced the availability of maps and management alternatives for public review and comment. Affected Congressional Committees and members were provided with briefings. Governors of affected states and territories were requested to comment. Study members participated in 25 state- sponsored public meetings and meetings with state agencies. The public comment period closed on September 30, 1985.

Official responses were received from all but 4 states and territories. Over 2500 comments from the public were received in response to the Federal Register Notice.

Generally those states already in the System with the most stringent state laws favor the expansion and strengthening of the CBRA. Of the 15 states now in the CBRS, ten favor expansion of the System, with some caveats. The greatest concerns were, the impact on Federal assistance for management and development of otherwise protected areas, and the possible impacts on port development. Of the other 5 states, one did not respond and four, including three not in the Coastal Zone Management Program, favored the status quo or substantial deletions in the present System. Of the three Atlantic coast states not presently in the System, two favor accession. In the Great Lakes, four states oppose inclusion, two are favorable and one did not respond. All the West Coast states are opposed to inclusion.

Many local communities perceive the CBRS as a threat to their development and concomitant expansion of jobs and the tax base. It is interesting that a number of communities on heavily developed barriers recognize the downside of development and favor strengthening the Act. One gets the feeling that many relatively undeveloped communities will favor the law as soon as they are developed. Apparently everyone has to learn from their own mistakes.

Reaction of special interest groups was as expected. Conservation groups and the League of Women Voters support expansion; development organizations are opposed. Individual responses were heavily in favor of expansion.

Secretary Hodel is reviewing the comments, the requirements of the law, and options presented by the Study Group. He will then develop proposed recommendations which will be announced in the Federal Register for 90 days of public comment. Governors, local authorities, and Federal agencies will be asked to comment. There will be a number of Congressional briefings. Members of the study group will be available for state briefings and public meetings. Following the close of the comment period, final recommendations will be prepared and the report submitted to the Congress.

These will be recommendations only. The Department of the Interior has no authority to implement any of the recommendations. Action by the Congress through amendment of the CBRA is required to expand or contract the Coastal Barrier Resources System or to modify any other provisions of the law.

In closing, one final comment. There still seems to be considerable confusion about this law. CBRA does one thing, and one thing only. It withdraws Federal assistance for new development within those areas designated by Congress. It is not a vast new Federal regulatory program. I am the only person in the entire Federal government committed to this law full time.

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Abstract only

MANAGING COASTAL DUNES

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Dune Management is often recognized as a component of shoreline management. There is a concept (albeit mistaken) that dune stability produces shoreline stability. Sediment budget studies in conjunction with shoreline process-response models lead to the conclusion that coastal dunes are the product of a retreating erosional shoreline and that imposed stability is antagonistic to the development and functioning of the dune system.

A sediment budget/morphological process-response model is proposed that covers the balances that must be achieved for coastal dune development, equilibrium, and attenuation. A second version of the model incorporates management strategies that can be effectively applied in the several stages of the coastal dune model. The conclusion that coastal dunes are the products of a slowly retreating shoreline imposes severe constraints on the temporal applications of active or passive protection strageies.

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BARRIER ISLAND SETTLEMENT AND LANDUSE EVOLUTION: A GULF COAST MODEL

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Introduction

For coastal planners to make effective zoning decisions in their respective seaside communities, it is important not only to understand the physical processes at play but also the cultural-historical antecedents of the present landuse patterns. Often the various components of an established American beach resort's urban morphology originated spontaneously (i.e. unguided by zoning), and distinctive patterns of landuse evolved. At present, many coastal resort communities are approaching their areal limits to growth, and pressures to intensify landuse (i.e. "redevelop") may threaten the "vernacular" seaside urban morphology.

The aim of this paper is to present a background of the geography of coastal resorts and to offer a schematic explanatory model of resort evolution based on research conducted along the Gulf of Mexico littoral. Three seaside resorts--Fort Myers Beach and Pensacola Beach in Florida, and Grand Isle, Louisiana--are briefly described in terms of resort evolution, settlement morphology, and conformity to the proposed model.

Previous Research

Much of the research in coastal urbanization has been conducted in England, site of Scarborough, the world's oldest seaside resort (where sea water began to replace mineral water as a health cure in the early 1700s). The geographer E.W. Gilbert's pioneering research in coastal resort genesis, evolution, and morphology during the 1930s (Gilbert, 1939) paved the way for extensive future recreation research in the United Kingdom. His tome in Brighton (Gilbert, 1954) still stands among the most thorough studies of resort evolution.

Barrett (1958), in his study of 80+ seaside resorts in Great Britain, developed a model of "theoretical accommodation zones", in which a zone of hotels and other "frontal amenities" faced the beach directly seaward of a downtown core. Farther away from the beach, the type of lodging facilities became simpler (boarding houses and bed-and-breakfast places), and with distance from the core area, the intensity of tourism-related activities decreased.

Stansfield (1971), in a comparison of British and Northeast U.S. resorts, found a similar pattern of "frontal amenities" which he labelled the recreational business district (RBD) to distinguish from the central business district (CBD). The RBD, a highly-specialized business district composed of hotels, tourist-oriented shops, and amusement facilities, catered especially to short-term vacationers. This concept was readily adopted by many tourism and recreation researchers (e.g. Lavery, 1971).

Although resort evolution is a popular theme in the literature of tourism, the research focus has been primarily sociological or economic, and often theoretical in nature. Resort growth is generally described in terms of an S-curve or bell-curve, analagous to the 'product life cycle' concept used in marketing. One of the better theoretical descriptions of resort growth is provided by Butler (1980), who identifies several discrete stages of development. The upper limits of growth are determined by market saturation and decay in resort infrastructure, which send tourists and recreationists off to less-spoiled beaches.

Corollary morphologic aspects of resort evolution have not been well documented. Generalized models of coastal landscape change have been developed (e.g. Miossec, 1976; Preobrazhensky & Krivosheyev, 1982), but systematic correlation of development stage with landscape expression is a new and usually site-specific research focus. Variations of the Butler (1980) model have been applied to examinations of coastal landscape change at Malta (Young, 1983), Grand Isle (Meyer-Arendt, 1985), and Antigua (Weaver, 1986).

A Resort Morphology Model

On the basis of the development patterns noted at older Gulf Coast resorts, a schematic model of resort evolution is offered (Figure 1). Initial touristic occupance (Stage A) is facilitated by, but not necessarily dependent on, the provision of access. Access, however, leads to increased day use, and the point of closest beach access evolves into the recreational business district. Limited summer home construction occurs, though lack of services restricts the level of residential development.

With the "take-off" of development in Stage B, the RBD expands along the beach and along the access highway. Residential expansion also takes place along the beachfront and in the vicinity of the business district. The original RBD core is still the prime focus of tourists and recreationists, and often a fishing pier is added. An incipient community has formed by this time.

Stage C entails an expansion of the development patterns already established. Residential expansion continues along the beachfront, and the bayshore becomes a secondary locus for development. If extensive wetlands occupy the backbarrier zone, rampant conversion (by means of dredging) to residential canal subdivisions takes place. If the number of permanent

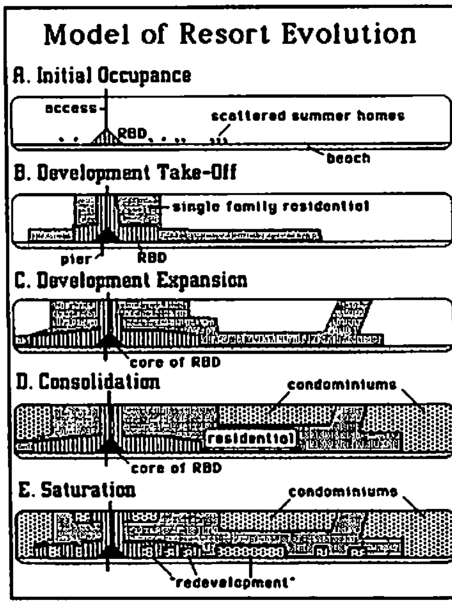

Figure 1. Proposed Model of Gulf Coast Resort Evolution

residents is fairly high (perhaps 500 or so), a CBD may form adjacent to, and inland of, the RBD.

In Stage D, landuse becomes consolidated as the remaining vacant land fills in. Land values have by now effectively precluded all but the wealthy from building single-family second homes, and multi-unit dwellings (particularly condominiums) are constructed. The landuse zonation is quite distinguishable at this stage of development. Intense recreational activity is concentrated along the access corridor and beachfront flanking the RBD core, where most of the hubbub takes place. A broad residential area (mainly single-family) flanks the commercial zone, and the condominium zone occupies the extremes and formerly less desirable lands. This pattern of complete development may be interspersed with vacant lands, reflecting the establishment of parks or preserves--or the denial of wetlands permits.

By Stage E, if market demand for beach recreation at this crowded resort remains strong, pressures for redevelopment lead to increasing encroachment of condominiums into both the RBD and residential zones, particularly along the beachfront. This trend is encouraged by deterioration of older facilities and escalation of real estate values and property taxes, which often force sellouts by fixed-income property owners. This process of landuse intensification can be greatly accelerated as a consequence of hurricane onslaught, which can literally "wipe the slate clean" and--in the absence of landuse zoning--pave the way for dense highrise construction along the beachfront. (Gulf Shores, Alabama after Hurricane Frederic [1979] is perhaps the best example of this.)

Fort Myers Beach

Estero Island, essentially uninhabited until homesteaders arrived in the late 19th century, has witnessed tremendous recreational development since then, in large part due to its tropical south Florida setting. All five stages of development are evident at this island.

The island initially developed as a summer resort for residents of nearby Fort Myers. Prior to beach access provision in 1921 (in the form of a short wooden bridge to the mainland), several of the homestead properties had been subdivided, and a Beach Hotel was built in 1912 (Schell, 1980). By the time of the Florida Boom in the 1920s, the point of closest beach access had developed into a "honky-tonk" (or RBD), complete with gambling casino, beach pavilion, & bathhouse. A recreational settlement core, consisting largely of private beach homes extending linearly along the shorefront to past the Beach Hotel, had developed. Owners of low bayside property dredged canals to boost real estate values, but demand for mosquito-ridden lots remained low. In spite of two devastating hurricanes during the 1920s, Fort Myers Beach rebounded, and the pattern of beachfront expansion continued, albeit slowly, until after World War II (Meyer-Arendt, 1986).

The postwar boom, characterized by greater affluence and mobility, was felt intensively throughout south Florida. The status of Fort Myers Beach soon changed from a local summer resort to a national winter resort as the Midwestern and Northeastern snowbirds began their annual seasonal migrations. As beachfront properties became developed, the mangroves began to be converted to residential canal subdivisions. Development was most intense nearest the point of mainland access, and a CBD developed adjacent to the RBD, still the focal point of recreational activity. Motels and cottage resorts were also primarily concentrated in this area. By 1970, only the unstable southern beach spit and several tracts of backbarrier mangroves remained undeveloped.

The year 1970 approximately marks the onset of the condominium era among most Gulf Coast seaside resorts. This form of intense landuse began to modify the pre-existing resort morphology. At Fort Myers Beach, the remaining parcels of vacant land, primarily at the south end, filled in, first along the beachfront, secondly along the bayshore, and thirdly on canal properties dredged out of the mangroves.

Increasing environmental legislation led to a total ban on mangrove conversion by 1980. Continued market demand for resort property, coupled with lack of land for areal expansion, prompted developers to acquire blocks of older residential beachfront properties for conversion into condominium apartments. No zoning restrictions prevented this trend, but Lee County imposed lowered density standards in 1980 (from 35 to 14 units/acre). County planners feel that the carrying capacity of the island has been reached (Ahlert et al., 1982), and condominium construction has significantly fallen off in recent years . Fort Myers Beach can presently be described as a saturated seaside resort. The population swells from 6000 to 25,000 or 30,000 during the winter season, and the 7-mile drive along the length of the island can take over one hour. In spite of greater zoning restrictions, the mechanism of landuse intensification through acquisition and redevelopment of older properties remains.

Pensacola Beach

Like Fort Myers Beach, Pensacola Beach developed as a summer playground for residents of nearby Pensacola. As early as the 1880s, boats carried recreationists to the beaches of Santa Rosa Island for the day, and a U.S. Coast Guard life-saving station became the focal point for recreational activities. Following a 1906 hurricane which destroyed the Coast Guard station, a hotel was built on the beach, but this lasted only until the next hurricane, in 1916. Highway access was provided in 1931, but Escambia County, which had bought Santa Rosa Island from the U.S. Government, leased only a small portion of beachfront land for construction of a casino/amusement center--in essence an RBD without a surrounding settlement. The county soon gave up its claim to the island, and for 20 years, the landuse on the Beach consisted only of the Casino.

Pensacola Beach also felt a postwar boom. The U.S. Government again returned Santa Rosa Island to Escambia County with the stipulation that lands not be sold--but only leased--and that all development be in the "public interest" (Lenox, 1973) In 1947, the Santa Rosa Island Authority was created to oversee to leasing of lands for commercial and residential development. Initially, a commercial district was zoned for the area closest to the Casino, and residential subdivisions were to be created to the east. A community began to take shape in 1951, and by 1957 the commercial area was totally leased, mainly to motels, rental beach cottages, and other recreation-oriented businesses. Much of the remaining land was leased by speculators (in large blocks) in anticipation of future development. The year 1960 witnessed the beginnings of a westward expansion to balance the landuse zonation east of the RBD. By the late 1960s, a popular RBD--centered on the Casino and fishing pier, the family-oriented Quietwater Beach, and the adjacent commercial district, was flanked by residential subdivisions, and land for further development was still available at both ends of the community.

Pensacola Beach also witnessed a condominium boom beginning about 1970 (SRIA Annual Reports, var. years). As at Fort Myers Beach, the last remaining parcels of empty land became the loci of this increasingly highrise construction. The zone between the RBD and the entrance to the Gulf Islands National Seashore (formerly Ft. Pickens State Park) was especially favorable to developers. Public recreational facilities and dune preserves were quickly established to prevent total encroachment. Today, the few remaining parcels at the west end are already slated for development. The east end also saw condominium and residential growth during the 1970s, but in the last few years, efforts by residents and environmentalists succeeded in limiting further development to 61 acres. Construction on the first 10 acres has recently begun.

As Pensacola Beach is nearing its areal limits to growth, pressures for "redevelopment" are intensifying. Several older motels have been converted to condominiums, and in the last few years, several others have been razed for highrise construction. Although continued highrise development is of financial benefit due to lease revenues, the present trend--plus a proposal to expand the official "core area" (or RBD) into the older residential sectors--has stimulated a public outcry. Wallace, Roberts, & Todd, a Miami-based environmental planning firm (whose credentials include the landmark **Sanibel Report**), has been commissioned to give proper direction to development, and until the plan is presented and approved (in Fall 1986), a moratorium on RBD redevelopment is in effect. Pensacola Beach is now in the consolidation stage of development, at the point of transition to the saturation stage. It is anticipated that the comprehensive landuse plan will confine further development to the respective discrete landuse zones that have already evolved.

Grand Isle

Grand Isle, although settled for over two centuries, has not been subjected to the recreational development pressures as have the other two sites, in part due to its remote location, but also because of its low-quality beach and periodic destructive hurricane onslaughts. Being a resort attractive to fishermen, and less so to beach recreationists, lack of strong market demand has kept the island in Stage C of the model.

Grand Isle was the first of the 3 sites to undergo recreational transformations, in large part due to its initial relative proximity to New Orleans. The first tourism boom began after the Civil War with the conversion of a defunct sugar plantation to a resort hotel (Stielow, 1982). The fad of sea-bathing enticed New Orleanians to endure 8-hour boat rides to get to the island, and by the early 1890s, 3 major hotels and several boarding houses catered to the tourists. In terms of resort morphology, this recreational development represented the first major settlement expansion away from the village proper, which was nestled among the higher central beach ridges, which were extensively covered with live oaks (*Quercus virginiana*). This initial flirtation with exposed beach settlement ended with the infamous Cheniere Caminada Hurricane of 1893 which destroyed most tourist facilities but left the village intact.

The memory of the storm prevented new recreational development for decades, and not until the1920s did Grand Isle again enter Stage A of the resort model. Highway access in 1932 laid the foundations for the modern settlement morphology. The central village was still the focus of commercial activity, but a pattern of spotty beachfront development evolved, concentrated between the west end (the point of access) and the village. Land developers bought up large parcels of land for subdivision in anticipation of a boom that was delayed until after World War II.

Half of the prewar subdivided lots were sold by 1950, and the beachfront was the locus of greatest construction. The beach highway evolved into a strip RBD consisting of motels, rental cottages, and tourist businesses, and near the center of the island the RBD blended with the village CBD. The less desirable backbarrier marshes were developed least, although several oil and sulfur companies made the east end the base for their offshore operations. The physical environment was less hospitable than at the Florida resorts, and by the mid-1950s, erosion was undermining many beachfront homes and detracting from the attractiveness of the beach. Spotty bulkhead and groin construction only accelerated the erosion, and by the early 1960s, the postwar boom was waning. Beach recreationists turned their attentions to the increasingly accessible beaches of Mississippi, Alabama, and Florida (Hubbert, 1983).

In 1965, Hurricane Betsy made landfall on Grand Isle, and 85% of all structures were damaged. The storm provided a facelift, however, and the resort morphology was re-established intact--the RDB strip became lined with more modern motels and businesses. Beach nourishment restored the shorefront, and summer homes reoccupied this zone. The post-storm mini-boom was shortlived, however, and by the early 1970s beach erosion had again contributed to serious environmental degradation, keeping all but diehard fishermen and weekenders from the island (Meyer-Arendt, 1985).

The condominium boom has largely bypassed Grand Isle. In 1980, a condominium/marina complex started construction near the east end, and in 1985 a west end marina hotel converted to condos. The post-Betsy commercial strip of motels and souvenir shops still comprises the RBD and little pressure for redevelopment exists. In 1985, a turnaround for tourism was foreseen when a $15 million U.S. Corps of Engineers dune-and-beach-restoration project was completed (USACE, 1978), but 3 major hurricanes later that same year dampened that enthusiasm. (Although damage to island structures was negligible, the new beach was severely eroded and 2 miles of the 7-mile sand levee were removed.) Nonetheless, a 150 acre resort complex--complete with a major hotel, numerous condominiums and townhouses, and 600 single-family lots--is slated for construction, if the necessary wetlands permits can be obtained. Grand Isle is best described as being in Stage C of the model, perhaps on the verge of entering Stage D. Whether the consolidation stage will be reached anytime soon is dependent upon the perceived recreational resources of the island and associated market demand.

Summary

Although Fort Myers Beach, Pensacola Beach, and Grand Isle can all be understood in terms of the resort model, the individual settlement histories do not necessarily have to progress through all of the stages. As a requisite to reaching the saturation stage, continued high market demand must exist. Deterioration of either natural or cultural amenities may cause a decline in a resort's popularity, and consequently the settlement morphology may be "frozen" at its most recent stage of development. Landuse controls, such as wetlands legislation, post-storm reconstruction restrictions (as enacted by Florida last year), density restrictions, and zoning can all modify the patterns of "spontaneous development" outlined in the model. A determination of what is optimal for a particular resort can only be made by examining a host of variables (e.g. traffic flows, parking, carrying capacity of beaches, etc.). In terms of resort morphology, some variant of the consolidation stage (Stage D), in which landuse categories are allocated specific zones, may be the ideal toward which planners should direct development...provided this stage has not yet been surpassed.

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Abstract only

THE RELATIONSHIP BETWEEN COASTAL PROCESSES AND LOCAL VARIATIONS IN THE SEDIMENT BUDGET AT FIRE ISLAND, NEW YORK

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Previous research has concentrated upon the regional aspects of coastal processes as related to generalized barrier island sediment budgets without regard to variations in local coastal processes and the resulting barrier island morphology.

Three distinct morphological regions can be identified at Fire Island. First, the older and highly dynamic eastern segment of the island which is dominated by inlet, overwash, and marsh deposits. The primary mechanisms for the landward transport of sediments are inlet and overwash processes. Second, the more recent and highly stable central section of the island, in the vicinity of the relict offshore Huntington River Delta, is marked by eolian processes and extensive unbreached dunes. The delta acts as a baffle to the effects of major storm waves. Finally, the juvenile western section of the island is dominated by lateral spit platform accretion in the vicinity of Fire Island Inlet, recurved dune deposits associated with inlet migration, and beach ridge development. Sediments for the accreting spit platform are derived from the updraft Huntington River Delta and the dominant mechanism for the inland transport of sediments is by overwash processes.

In order to calculate the local sediment budget, fifty equally spaced cross-island transects were employed as representative samples. The profiles were taken from topographic/vegetative maps based on infrared photography having a scale of 1:2400 and a two foot contour interval. Additional profiles were taken offshore to a depth of 30 feet in order to establish a nearshore sediment budget. The individual cells were subdivided to correspond with the appropriate morphological units. The relative depth of each depositional lense was determined from fifteen cross-island transects where selective cores were taken. The volume for each lense was determined by trapezoidal integration of the profile data and expanded spatially to conform with areal components for each cell. The volume for the barrier above mean-sea-level was found to be sixty million cubic yards. Inlet deposits accounted for 44% of overall barrier island volume, while 30% are associated with overwash deposits, 14% with eolian, 10% with beach and 2% with marsh deposits. These amounts vary locally as previously described. The net nearshore sediment budget for the island was found to be positive, despite a net landward migration of the island.

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Abstract only

GEOMORPHOLOGY AND SEDIMENTARY FACIES OF AN EPHEMERAL WASHOVER BREACH/TIDAL INLET, CAMINADA-MOREAU HEADLAND, SOUTHEAST LOUISIANA

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This study examines the origin, development, geomorphic history and stratigraphy of and ephemeral washover breach/tidal inlet located 0.381 km east of Bay Champagne on the Caminada-Moreau headland of Lafourche Parish, southeastern Louisiana. Strike and dip oriented stratigraphic cross-sections were constructed from eight (8) vibracores averaging 3.5 m in depth. High altitude aerial photographs of the study area, taking in 1960, 1965, 1973, and 1985, as well as oblique aerial photographs taken prior to and just after Hurricane Juan in 1985 were utilized to determine the relative rates of beach erosion and vertical accretion of sand by washover processes in the inlet.

Through macroscopic core analysis, three (3) distinct sedimentary facies were recognized. From bottom to top, these facies are: (1) Bay Fill; (2) Marsh; and (3) Washover.

1. The Bay Fill facies is characterized by alternating layers of thin sands and silty sands with silty clays and clays. An increase in sand content and bed thickness is noticeable towards the top of the sequence, representing a gradual increase in energy and proximity to a source of sediment supply. These sediments appear to have been deposited as crevasse splays from the Bayou Lafourche distributary. Sedimentary structures associated with this facies include parallel laminations and cross-stratified sands and silts with a variety of climbing ripples and trough cross-bedding. Mica and thin layers of organic debris are common along bedding plane surfaces in this facies.

2. The Marsh facies is characterized by clays with extensive plant (root) and animal burrow traces which increase towards the top. Organic particles are also incorporated into the clays, and occur as both thin layers and discrete particles within the clays. Some sand-filled root burrows are also seen, as well as some siderite bands and nodules. This facies also contains some oyster shells at the top of individual units.

3. The Washover facies is characterized by thin fine-grained sand blankets of several superimposed washover deposits. Each washover deposit can be ascribed to severe storm or hurricane events, and contains a shell-rich layer with an erosive contact overlain by horizontally-laminated sands.

High altitude and oblique aerial photographs of the study area indicate that the inlet is active only during storms, winter cold fronts, and hurricanes when the beach is breached by waves. The photographs also confirm that the inlet has not migrated laterally (at least since 1960). This may in part be due to the transgressive (retrogradational) nature of the headland in response to erosion because of a lack of longshore sediment transport. This theory is also supported by the beach profile data which indicates vertical accretion of sand in the inlet due to washover deposition.

The inlet represents a topographic low (less than 1 m above msl) compared to the surrounding barrier shoreline; it is easily recognized as a "gap" in the barrier, extending from the ocean to lagoon without interruption as a sandy, vegetationless low plain. The inlet thalwag or channel is slightly sinuous in nature, and as stated above, is only active during shore periods of time in response to storms. This inlet is therefore classified as ephemeral due to its limited role as an active inlet and its non-migratory nature. Additionally, its preservation potential is considered minimal due to rapid shoreline retreat, erosion, and reworking of the shoreface.

ORGANIZING INFORMATION

James Berger and Jerry Oglesby, Chairs

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A DATA MANAGEMENT SYSTEM FOR VISUALLY COLLECTED ENVIRONMENTAL DATA

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Introduction

The Corps of Engineers has as part of its mission the responsibility for the design and construction of shore protection works. In carrying out this mission coastal project planners and designers require information on meteorologic and oceanographic forces which effect the coast. The objective of the LEO program is to provide this information by establishing an economical and easily retrievable reservoir of repetitive and systematic observations of both the forces and response elements in the coastal zone.

Data Collection

LEO observations include surf conditions, local winds, littoral currents, and foreshore slope. Surf conditions include estimates of breaker height, period, direction, and type of breaking waves. Wind observations include speed, measured using a wind meter, and direction. Longshore currents are measured using small packets of dye which disperse upon immersion. The current speed is estimated from the movement of the dye patch centroid for a one-minute period. Current direction is also noted. A measurement of foreshore slope (using a topographic hand level) is made at the upper limit of that part of the beach which is being wetted by swash runup.

All this data is recorded by the observer on the form shown in Figure 1 from which the data can be readily transcribed to computer disk or magnetic tape for further processing.

The applications expected of the LEO data and the willingness of the volunteer observers determine the collection period and frequency of observations. As a minimum, observations should be made four times a week over a period of a year to generate a useable data set.

Data Processing and Storage

Before being converted to a standard computer-readable format, the LEO data sheets, as they come in from the field, are visually checked for proper coding of date and location and for obvious errors. The forms are then sent for keypunching. During computer processing LEO data are passed through an edit routine that checks for unreasonable values and flags those particular values. The observer is then contacted and requested to verify or correct questionable data. After these corrections are made, the LEO data are archived in a data base that is presently stored on magnetic tapes.

Data Retrieval

The LEO retrieval system is a computer-based system that performs three functions; data retrieval, data analysis, and report generating. The system is designed to be interactive and self-tutorial. It guides the user through various steps of retrieving a data set for a particular location and time period from the data base and then uses this data set to produce available statistical reports. The reports may be displayed at the user's terminal or directed to a high-speed printer.

LITTORAL ENVIRONMENT OBSERVATIONS

RECORD ALL DATA CAREFULLY AND LEGIBLY

SITE NUMBERS 1 2 3 4 5 | YEAR 6 7 | MONTH 8 9 | DAY 10 11 | TIME 12 13 14 15 — Record time using the 24 hour system

WAVE PERIOD (16 17 18)
Record the time in seconds for eleven (11) wave crests to pass a stationary point. If calm record 0.

BREAKER HEIGHT (19 20 . 21)
Record the best estimate of the average wave height to the nearest tenth of a foot

WAVE ANGLE AT BREAKER (22 23 24)
Record to the nearest degree the direction the waves are coming from using the protractor on the reverse side. 0 if calm

WAVE TYPE (25)
0 – Calm
1 – Spilling
2 – Plunging
3 – Surging
4 – Spill / Plunge

WIND SPEED (26 27)
Record wind speed to the nearest mph. If calm record 0.

WIND DIRECTION – Direction the wind is coming from (28)
1 – N 3 – E 5 – S 7 – W 0 – Calm
2 – NE 4 – SE 6 – SW 8 – NW

FORESHORE SLOPE (29 30)
Record foreshore slope to the nearest degree

WIDTH OF SURF ZONE (31 32–33 34)
Estimate in feet the distance from shore to breakers, if calm record 0.

LONGSHORE CURRENT

DYE (36 37 38)
Estimate distance in feet from shoreline to point of dye injection

CURRENT SPEED (43 44 45)
Measure in feet the distance the dye patch is observed to move during a one (1) minute period; if no longshore movement record 0.

CURRENT DIRECTION (46 47)
0 No longshore movement
+1 Dye moves toward right
−1 Dye moves toward left

RIP CURRENTS (49 50 51 52)
If rip currents are present, indicate spacing (feet). If spacing is irregular estimate average spacing. If no rips record 0.

BEACH CUSPS (54 55 56)
If cusps are present, indicate spacing (feet). If spacing is irregular estimate average spacing. If no cusps record 0.

PLEASE PRINT:

SITE NAME ____________ OBSERVER ____________

Please Check The Form For Completeness

REMARKS: ____________

CERC 113-72
8 Mar 72

Make any additional remarks, computations or sketches on the reverse side of this form.

Figure 1 - LEO data collection form

The LEO retrieval system is operational on Control Data's Cyber 170 Corps of Engineers dedicated computer in Rockville, Maryland. Communication is established by means of a terminal dial-up capability. Once the user has gained access to Control Data's system, the LEO system is started and functions are selected and processed. This interactive procedure is initiated from a terminal with either printer or screen display.

Data retrieval function

This function is initiated interactively and then completed in batch mode. An interactive conversational procedure prompts the user for information identifying a specific subset of the data base. In batch mode, data are retrieved from tape and copied to an exclusively named user disk file to be used for further processing in the Data Reporting Function.

Data reporting function

This function prepares and displays statistical reports. It may be run in either interactive or batch mode. If run interactively, the user may view the reports at his terminal. If run in batch mode, the reports are processed independently of the user's session and printed at a high-speed printer.

The Data Reporting Function offers a library of statistical programs to produce various reports. Each report is headed by the report title, site name and number, and latitude/longitude. All reports may be displayed on the terminal's screen or printer or printed at a remote high-speed printer. The retrieval system restricts terminal report output to 22 lines. This program-controlled interrupt offers time to view the report and an opportunity to continue or stop the report display. The following are the reports available to users of LEO data.

1. Daily LEO observatons (Figure 2) - a formatted listing of the LEO data set. Data parameters provided in the report are surf conditions, local winds, littoral currents, and foreshore slope. These parameters are displayed by date and time of observation.

LITTORAL ENVIRONMENT OBSERVATIONS (LEO)
(12897) PANAMA CITY, FLORIDA LAT 30 12.78 - LONG 85 52.54

DATE	TIME	WAVE PERIOD SEC	WAVE HEIGHT FEET	WAVE DIR	WIND SPEED MPH	WIND DIR	SHORE SLOPE DEG	SURF WIDTH FEET	DYE DIST FEET	LONGSHORE CURRENT FT/SEC	LONGSHORE CURRENT DIR
1 JAN 84	0700	11.9	3.0	080	10	NE	10	190	40	.67	1
1 JAN 84	2000	11.7	3.0	080	11	NE	10	230	40	.58	1
2 JAN 84	0700	11.0	2.0	080	10	NE	10	140	40	.50	1
2 JAN 84	1900	10.7	2.0	080	9	NE	10	210	40	.50	1
3 JAN 84	0700	10.1	2.0	080	11	NE	10	180	40	.42	1
3 JAN 84	1900	10.7	2.0	080	11	NE	10	150	40	.42	1
4 JAN 84	0700	10.4	1.5	085	10	N	10	130	40	.25	1
4 JAN 84	1900	9.7	1.0	085	9	SE	10	90	40	.50	1
5 JAN 84	0700	11.1	2.0	100	13	SW	10	160	40	.42	1
5 JAN 84	1800	10.0	2.5	100	12	SW	10	210	40	.50	1
6 JAN 84	0700	10.0	2.0	080	18	NE	10	190	40	.00	0
6 JAN 84	1800	10.7	2.0	080	18	NE	10	230	40	.33	1

*** MEANS ITEM WAS LEFT BLANK
LONGSHORE CURRENT DIRECTION: -1 = FLOW TO RIGHT, 1 = FLOW TO LEFT, 0 = NO FLOW

Figure 2 - Daily LEO observations

2. <u>Table showing days when LEO observations were made (Figure 3)</u> - a graphic representation of days when observations were made during the month for a particular year. Included also are the number of observations made for the month and for the entire time period.

```
DAYS WHEN LEO OBSERVATIONS WERE TAKEN
(12897)PANAMA CITY              ,FLORIDA
LATITUDE 30 12.78 - LONGITUDE  85 52.54

                   1984
             1111111111222222222233
    1234567890123456789012345678901
JAN >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>   64
FEB >>>>>>>>>>>>>>>>*>>>>>>>>>>>>     60
MAR >>>>>>>>>>>>>**>>>>>>>>>>>*>>>>   60
APR >>>>>>>>>>>>*>>*>>>>>>>>>>>>>>    64
MAY >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>   62
JUN >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>    60
JUL >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>   63
AUG >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>   62
SEP >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>    62
OCT >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>   65
NOV >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>    61
DEC >>>>>>>>>>>>>>>>>>>>>>>>>    >>   58
* ONE OBSERVATION,    > TWO OBSERVATIONS

741 OBSERVATIONS DURING THE PERIOD 01-01-84 TO 12-31-84
```

Figure 3 - Days when observations were taken

3. <u>A summary table of surf, wind, sediment transport, & beach statistics</u> - a collection of four separate categories of data. The four categories of data are:

a. <u>Surf observations (Figure 4)</u> - monthly averages of wave height, period, width of surf zone, angle of wave approach to the shoreline, the number of observations made, and the number of observations of calm conditions. The report also gives averages for all the surf data acquired during the year.

SURF OBSERVATIONS SUMMARY — DATA COLLECTED FROM 01 JAN 84 TO 31 DEC 84
(12897) PANAMA CITY, FLORIDA — LAT 30 12.78 - LONG 85 52.54

MON	NUMBER OBS.	CALM OBS.	AVERAGE HEIGHT (FT)(1)	AVERAGE PERIOD (SEC)(1)	---PERCENT OCCURRENCE--- NUM	>90	=90	<90	AVG. ZONE (FT)	NUM OBS
JAN	64	1	3.17	11.42	63	12.7	9.5	77.8	348	62
FEB	60	1	3.34	11.15	59	33.9	13.6	52.5	397	59
MAR	60	7	2.83	9.93	53	22.6	20.8	56.6	361	51
APR	64	4	3.73	11.08	60	35.0	16.7	48.3	527	60
MAY	62	4	2.90	10.55	58	8.6	25.9	65.5	397	58
JUN	60	15	1.23	7.39	45	22.2	20.0	57.8	120	45
JUL	63	11	1.46	8.30	52	11.5	36.5	51.9	146	52
AUG	62	6	1.85	9.18	56	30.4	19.6	50.0	164	55
SEP	62	4	3.74	11.05	58	.0	5.2	94.8	504	50
OCT	65	0	2.93	11.43	65	.0	12.3	87.7	381	65
NOV	61	0	3.71	11.62	61	1.6	14.8	83.6	504	52
DEC	58	6	3.18	10.36	52	17.3	3.8	78.8	453	51
YR	741	59	2.84	10.30	682	16.0	16.3	67.7	363	661

(1) CALMS NOT INCLUDED IN AVERAGE CALCULATION.

Figure 4 - Surf observations

b. Wind observations (Figure 5) - monthly averages of wind speed and percent occurence of wind coming from a specific direction (i.e. north, northeast, south, etc.). An average for all wind data acquired during the year is also printed.

WIND OBSERVATIONS SUMMARY DATA COLLECTED FROM 01 JAN 84 TO 31 DEC 84
(12897) PANAMA CITY, FLORIDA LAT 30 12.78 - LONG 85 52.54

MON	NUM OBS	AVG SPEED (MPH)(1)	PERCENT OCCURRENCE FROM NORTH	N. EAST	EAST	S. EAST	SOUTH	S. WEST	WEST	N. WEST	CALM
JAN	64	13.9	14.1	40.6	14.1	15.6	3.1	3.1	.0	9.4	.0
FEB	60	15.7	5.0	18.3	10.0	21.7	13.3	3.3	3.3	25.0	.0
MAR	59	13.0	10.2	11.9	18.6	25.4	13.6	5.1	.0	13.6	1.7
APR	64	15.4	7.8	3.1	10.9	25.0	20.3	6.3	4.7	21.9	.0
MAY	62	12.3	8.1	4.8	14.5	38.7	24.2	.0	1.6	6.5	1.6
JUN	60	8.1	.0	3.3	18.3	43.3	8.3	11.7	11.7	3.3	.0
JUL	62	8.1	.0	1.6	30.6	12.9	45.2	9.7	.0	.0	.0
AUG	61	8.4	1.6	8.2	11.5	32.8	16.4	4.9	4.9	18.0	1.6
SEP	62	12.2	3.2	45.2	27.4	17.7	6.5	.0	.0	.0	.0
OCT	64	12.3	3.1	4.7	35.9	35.9	20.3	.0	.0	.0	.0
NOV	61	13.5	24.6	24.6	19.7	26.2	3.3	.0	.0	1.6	.0
DEC	57	14.1	12.3	7.0	29.8	28.1	5.3	3.5	8.8	5.3	.0
YR	736	12.3	7.5	14.5	20.1	26.9	15.1	3.9	2.9	8.7	.4

(1) CALMS, IF ANY INCLUDED IN AVERAGE CALCULATION.

Figure 5 - Wind Observations

c. Current observations (Figure 6) - monthly averages, standard deviation, and number of observations made for current movement to the left and current movement to the right. Also given is the monthly net current averages and number of observations made.

CURRENT OBSERVATIONS SUMMARY DATA COLLECTED FROM 01 JAN 84 TO 31 DEC 84
(12897) PANAMA CITY, FLORIDA LAT 30 12.78 - LONG 85 52.54

MON	NUMBER CALM OBS.	CURRENT TO LEFT AVERAGE (1)	STANDARD DEV.	NUM OBS	CURRENT TO RIGHT AVERAGE (1)	STANDARD DEV.	NUM OBS	NET CURRENT AVERAGE (1,2)	NUM OBS
JAN	4	-1.21	.48	6	.81	.41	54	.61	60
FEB	1	-.93	.37	19	.59	.26	36	.07	55
MAR	2	-.94	.26	13	.51	.25	45	.18	58
APR	3	-.89	.44	24	.80	.37	37	.13	61
MAY	2	-1.03	.25	5	.70	.31	55	.56	60
JUN	12	-.27	.14	13	.27	.14	35	.12	48
JUL	11	-.23	.20	7	.26	.13	45	.19	52
AUG	3	-.41	.14	19	.44	.21	40	.17	59
SEP	0	.00	.00	0	.93	.54	62	.93	62
OCT	2	.00	.00	0	.58	.28	63	.58	63
NOV	1	-.33	.00	1	.70	.40	59	.68	60
DEC	3	-.40	.23	10	.60	.31	44	.42	54
YR	44	-.69	.44	117	.62	.39	575	.40	692

(1) CALMS NOT INCLUDED IN AVERAGE CALCULATION.
(2) CURRENT MOVEMENT INDICATORS: MINUS SIGN (-) = LEFT; NO SIGN = RIGHT.

Figure 6 - Current observations

d. <u>Sedimemt transport volume (Figure 7)</u> - monthly net, gross left, and gross right transport volumes. Two methods described in section four (Shore Protection Manual (SPM) 1984) are used to calculate the transport volume. The yearly volume is calculated by summing the monthly values.

SEDIMENT TRANSPORT VOLUME SUMMARY — DATA COLLECTED FROM 01 JAN 84 TO 31 DEC 84
(12897) PANAMA CITY, FLORIDA — LAT 30 12.78 - LONG 85 52.54

MON	METHOD1 CU YD OBS	GROSS LEFT CU YD OBS	GROSS RIGHT CU YD OBS	METHOD2 CU YD OBS	GROSS LEFT CU YD OBS	GROSS RIGHT CU YD OBS
JAN	41985(63)	-49404(8)	91389(49)	98316(59)	-146073(6)	244390(53)
FEB	-29792(59)	-62273(20)	32481(31)	-165163(54)	-265935(19)	100771(35)
MAR	-14388(53)	-61885(12)	47497(30)	-50303(49)	-153994(11)	103690(38)
APR	-8198(60)	-75871(21)	67672(29)	-34469(59)	-278183(23)	243713(36)
MAY	38600(58)	-21092(5)	59692(38)	180194(57)	-66524(5)	246719(52)
JUN	9146(45)	-2965(10)	12112(26)	5180(41)	-1447(12)	6628(29)
JUL	12151(52)	-1431(8)	13582(27)	12294(45)	-662(3)	12957(42)
AUG	9568(56)	-8544(17)	18113(28)	27109(52)	-4736(17)	31846(35)
SEP	241463(58)	0(0)	241463(65)	756533(50)	0(0)	756533(50)
OCT	81643(65)	0(0)	81643(57)	217356(63)	0(0)	217356(63)
NOV	171332(61)	-1477(1)	172810(51)	381253(52)	-4491(1)	385744(51)
DEC	130886(52)	-19795(9)	150681(41)	334053(48)	-20778(7)	354831(41)
YR	684398(682)	-304737(100)	989135(462)	1742353(629)	-942823(104)	2685178(525)

NUMBERS IN PARENTHESIS REPRESENT NUMBER OF OBSERVATIONS PER CATEGORY

EXPLANATION OF THE SEDIMENT TRANSPORT VOLUME METHODS USED IN THE NEXT REPORT

ESTIMATED SEDIMENT TRANSPORT VOLUMES ARE GIVEN IN CUBIC YARDS. TWO METHODS DESCRIBED IN SECTION 4 OF THE "SHORE PROTECTION MANUAL" (SPM) ARE USED TO CALCULATE THE TRANSPORT VOLUME. NEGATIVE VALUES INDICATE TRANSPORT TO THE LEFT.

METHOD 1. THIS METHOD IS BASED ON EQUATIONS 4-38 AND 4-50B FROM THE SPM. A LONGSHORE ENERGY FLUX (EQUATION 4-38) IS FIRST CALCULATED FOR ONLY THE DAYS OF THE MONTH WHERE WAVE HEIGHT AND ANGLE OF APPROACH HAVE BEEN RECORDED, THEN AN AVERAGE FLUX FOR EACH MONTH IS CALCULATED, AND FINALLY THESE MONTHLY VALUES OF FLUX ARE SUBSTITUTED INTO EQUATION 4-50B AND DIVIDED BY 12 TO GET THE NET MONTHLY SEDIMENT TRANSPORT VOLUMES. THE YEARLY SEDIMENT TRANSPORT VOLUME IS CALCULATED BY SUMMING THE MONTHLY VALUES.

METHOD 2. THIS METHOD IS BASED ON EQUATIONS 4-51, 4-52, AND 4-50B FROM THE SPM, USING RECORDED OBSERVATIONS OF WAVE HEIGHT, WIDTH OF SURF ZONE, LONGSHORE CURRENT, AND DISTANCE TO DYE PATCH FROMSHORELINE AND FOLLOWING THE SAME PROCEDURE AS METHOD 1. NOTE: RECENT FINDINGS INDICATE A FRICTION FACTOR OF .006 SHOULD BE USED IN EQUATION 4-52.

Figure 7 - Sediment transport volume

4. <u>Percent occurrence of wave period vs wave height (Figure 8)</u> - a tabular grid of percent occurrence of waves by height and period for all possible wave directions. Period is presented in row order at two second intervals. Height is displayed in columnar format at one foot increments.

LEO PERCENT OCCURRENCE OF WAVE PERIOD VS WAVE HEIGHT

12897-PANAMA CITY, FLORIDA DATA COLLECTED 01JAN84 TO 31DEC84

HGT (FT) ----------	0 0.9	1 1.9	2 2.9	3 3.9	4 4.9	5 5.9	6 6.9	7 7.9	8 8.9	9 9.9	10 10.9	11 11.9	12 12.9	13 +	PERCENT
PER (SEC)															
0-> 1.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2-> 3.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4-> 5.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6-> 7.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8-> 9.9	0.	11.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	18.
10->11.9	0.	4.	28.	19.	2.	1.	0.	0.	0.	0.	0.	0.	0.	0.	53.
12->13.9	0.	0.	0.	3.	8.	9.	4.	1.	0.	0.	0.	0.	0.	0.	26.
14->15.9	0.	0.	0.	0.	0.	1.	2.	0.	0.	0.	0.	0.	0.	0.	3.
16->17.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18->19.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20->21.9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22 +	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PERCENT	0.	15.	34.	22.	11.	11.	7.	1.	0.	0.	0.	0.	0.	0.	

CALM = 8. PERCENT (59 OBSERVATIONS) TOTAL OBSERVATIONS = 741

ONLY REPORT IN THIS CATEGORY ---- WHEN READY TO PROCEED: TYPE SPACE & CR

Figure 8 - Wave period vs wave height

5. Percent occurrence of wind speed vs wind direction (Figure 9) - a tabular grid reports percent occurrence of winds by speed and direction. Speed is presented in row order at two mile per hour increments. Direction is presented in columnar format by direction from which the wind is coming.

LEO PERCENT OCCURRENCE OF WIND SPEED VS WIND DIRECTION

12897-PANAMA CITY, FLORIDA DATA COLLECTED 01JAN84 TO 31DEC84

DIRECTION -----------	N	NE	E	SE	S	SW	W	NW	PERCENT
SPEED (MPH)									
0-> 1.9	.0	.0	.0	.0	.0	.0	.0	.0	.0
2-> 3.9	.0	.4	.1	.7	.1	.1	.0	.0	1.5
4-> 5.9	.0	.3	1.4	1.2	.5	.7	.5	.1	4.8
6-> 7.9	.4	.5	2.4	2.8	2.4	.7	.7	.7	10.5
8-> 9.9	.5	2.4	3.0	4.4	3.5	.8	.3	.8	15.8
10-> 11.9	1.1	3.1	5.8	5.4	2.0	.4	.7	.8	19.2
12-> 13.9	.3	1.5	3.4	4.4	1.1	.4	.1	.4	11.6
14-> 15.9	.5	.8	1.4	3.3	1.4	.3	.1	.8	8.8
16-> 17.9	1.4	2.3	1.1	2.9	.5	.1	.1	1.1	9.5
18-> 19.9	1.4	1.4	.8	1.0	1.4	.1	.1	1.5	7.6
20-> 21.9	1.4	1.0	.7	1.1	1.0	.1	.1	1.1	6.4
22-> 23.9	.3	.7	.3	.1	.5	.0	.0	.5	2.4
24+	.3	.1	.0	.0	.5	.1	.0	.8	1.9
PERCENT	7.5	14.6	20.1	28.9	15.1	3.9	2.9	8.7	

CALM = .3 PERCENT (2 OBSERVATIONS) TOTAL OBSERVATIONS = 737

Figure 9 - Wind speed vs wind direction

Summary

The LEO program can provide an economic data base of coastal information for areas where no other data exist or where funds are not available for sophisticated instrumentation. The program provides data of sufficient accurracy to determine seasonal and geographic trends and to describe some key aspects of the nearshore environment. However, LEO data must be used carefully with recognition of its limitations.

Acknowledgements

The success of the LEO program is the result of the efforts of individuals who have shown an unbounded interest in observing coastal phenomena and recording their observations for use by scientists and engineers. Without these individuals, a program of this scope could not exist. Use of trade names or manufacturers in this report does not constitute an official endorsement of the use of such hardware or software. Funds for the LEO program are provided by the Corps of Engineers District Offices as requirements arise. Partial funding was provided under the Coastal Field Data Collection program of the Corps of Engineers Civil Works budget, Mr. John H. Lockhart, Jr., technical monitor. The Chief of Engineers is gratefully acknowledged for granting permission to publish this paper.

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Abstract only

A SOURCE OF TOXICS AND POLLUTANTS DATA FOR COASTAL AREAS

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As a result of monitoring and other studies, concentrations of metals, hydrocarbons, pesticides, and other compounds have been measured in U.S. coastal areas. Some of these data have been incorporated in a data file of toxics and pollutants at the National Oceanographic Data Center. A summary of the levels of nearly 60 compounds from this file has been done recently. The number of samples and the maximum and minimum levels found in water, sediment, and organisms are summarized for all coastal areas. These data are an available resource for all investigators.

Estuarine and Coastal Management - Tools of the Trade. Proceedings of the Tenth National Conference of The Coastal Society. October 12-15, 1986. New Orleans, LA.

MANAGEMENT AND ANALYSIS OF ESTUARINE DATA USING SAS

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Introduction

The Statistical Analysis System (SAS) is a computer program for managing and statistically analyzing data. SAS was develped in the early 1970's in response to the growing need for an integrated computer package that could carry out statistical computations as well as manipulate large or complicated data sets. In the SAS package, these two capabilities are combined with an easy-to-use command language processor. Using SAS, it is possible to write complicated computer procedures for managing or analyzing estuarine data using a few straightforward SAS commands. Today, the SAS package is very popular with estuarine researchers and managers in government, research institutions, and private industry. This paper discusses many of the SAS tools currently being used for managing and analyzing the estuarine data base now under development by the U.S. Environmental Protection Agency's National Estuary Program.

The National Estuary Program provides for the characterization of water and sediment quality, living resources, and the effects of pollution on the nation's estuaries. The purpose of this characterization is to document the changes that have occurred as well as the present health of estuaries and to support the development of new pollution abatement strategies. These tasks require a large, quality assured data base.

The first step in the estuarine characterization process is to identify and prioritize problems of widespread concern (e.g., depletion of fish stocks, eutrophication, etc.). Once these problem areas are identified, associated research hypotheses are developed. Next, the appropriate variables and parameters for each hypothesis/problem area are defined. At the same time, scientifically acceptable parameter limits, measurement units, and common definitions for each variable must be developed so that diverse data sets may be quality assured and integrated into a single computer data base.

The National Estuary Program is using SAS for tracking data sets, for data management, for analyzing estuarine data, and for quality assurance. Each of these topics will be briefly discussed in the following sections.

SAS Estuarine Data Set Tracking

The National Estuary Program is using SAS to track the process of identifying and acquiring historical data sets for inclusion in the National Estuary Data Base. A SAS data set structure is used to record information generated from interviews with researchers and environmental managers. This information includes the spatial and temporal coverage and types of data included in each historical data set. The information is updated as necessary using basic SAS DATA step procedures. SAS report writing and graphical procedures are used to prepare summaries of the data base. This helps to focus the search for data sets and to identify data gaps.

Estuarine Data Management Using SAS

The data structure used for the National Estuary Data Base is a simple rectangular data matrix. The columns of the matrix represent variables, and the rows represent observations. All measured parameter values are stored in double (64 bit) precision. Sampling design parameters such as station name are stored using SAS character variables. Character variables in SAS can store up to 200 byte character strings. The data dictionary for selected variables in the data base is shown in Table 1. SAS variable names can be any combination of letters, numbers, and most special characters, up to a maximum length of eight characters. A 40 byte label is associated with each variable in the data base. This provides additional information on the precise nature of each parameter, measurement units, sampling or analytical procedures, etc. Variable labels in SAS appear on the print-out from most statistical procedures.

Most data manipulation in SAS is accomplished in the DATA step. Estuary staff use the DATA step to select observations and variables for analysis, to transform variable values, to create new variables from combinations of existing variables, and to perform additional quality control checks on the data base. The SAS DATA step includes many more data management capabilities than can be described in this paper. A list of some common data management tools available in SAS is given in Table 2.

Table 1.--Data Dictionary for Selected Variables in the National Estuaries Program Data Base.

SAS Variable Name	Type	Length (Bytes)	SAS Label
DO	Numeric	8	Dissolved Oxygen (mg/l)
BOD5	Numeric	8	5 Day Biological Oxygen Demand (mg/l)
CHLORAC	Numeric	8	Chlorophyll A Corrected (ug/l)
CHLORAU	Numeric	8	Chlorophyll A Uncorrected (ug/l)
NH3	Numeric	8	Ammonia as N (mg/l)
SALIN	Numeric	8	Salinity (ppt)
SECCHI	Numeric	8	Secchi Depth (m)
DEPTH	Numeric	8	Station Depth (m)
STATION	Character	15	Sampling Station
SEGMENT	Character	5	Bay Segment

SAS Estuarine Data Analysis

Many statistical procedures for summarizing and analyzing estuarine data are available in SAS (Figure 1). These can be divided into three major groups - descriptive, model building, and inferential. Several of the descriptive procedures are discussed below. The model building procedures include PROC REG (for regression analysis), PROC CORR (for correlation analysis), and PROC DISCRIM (for discriminant analysis). Inferential procedures are used to statistically test hypotheses about some estuarine process. An example is PROC GLM, which is used for linear model analyses. These procedures typically require one or more assumptions about the distribution of the data, and sometimes about the sampling/experimental design. They are not always appropriate for the analysis of historical data, but are very powerful for analyzing data from a designed experiment or sampling program.

Examples of SAS Descriptive Statistical Procedures

PROC FREQ is used to describe both character and numeric data. Its primary purpose is to calculate observed frequency counts for one or more variables. The frequency counts are presented in a frequency table, which can be one-way or multi-way (for crosstabulations of two or more variables). This procedure can also compute various statistical tests of association or independence, such as the usual Chi-Square Test.

PROC UNIVARIATE computes various statistics describing the distribution of one or more numeric variables. Included are measures of central tendency such as the mean and median, and estimates of variability such as the standared deviation and range. The procedure also computes a number of useful quantiles, including the sample quartiles and various percentiles. These and other statistics are presented in a concise table.

Figure 1.-- Selected SAS Statistical Procedures.

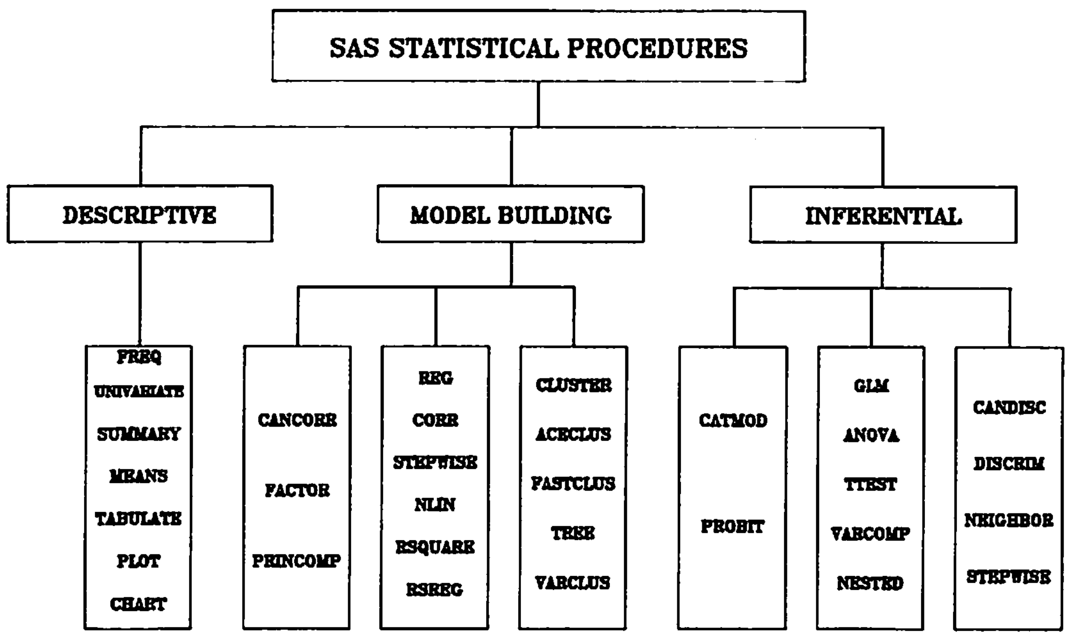

Table 2.--Selected SAS Data Management Tools.

Data Input
Data Set Transfer - Among Different Machines
Sorting - Multiple Sort Fields
Character String Manipulation
Appending of Two or More Data Sets
Merging of Two or More Data Sets
Interleaving of Two or More Data Sets
Data Set Subsetting Based on Logical Testing
Deletion of Variables or Observations
Variable Renaming
General Data Transformations
Macros - For Storing Frequently Used Sections of Code
Matrix Processing
Multiple Simultaneous File Processing - Input and Output

PROC TABULATE calculates descriptive statistics and displays them in tables. The tables are suitable for most reports. This procedure can also calculate frequency counts and percentages. PROC TABULATE allows users a great deal of flexibility in the format of their tables. The physical layout of the tables and the arrangement of variables and values in the table are controlled by the user.

Estuarine Data Quality Assurance Using SAS

Many analyses supporting quality assurance activities can be carried out using SAS graphical procedures. For example, PROC GPLOT and PROC GCHART produce scatter plots (with overlaid means and standard deviations, if desired), bar charts, line graphs, and other types of graphical displays. These help the estuarine researcher to identify, e.g., keypunch and other data processing errors, and discrepencies in measurement units. In the National Estuaries Program, data checking is an interactive process. SAS print-outs are returned to the data submitter or researcher for verification. After correction, the data are displayed a second time using SAS graphical procedures to double check the correction process.

Another important aspect of estuarine data quality assurance is documentation. The National Estuaries Program Data Base includes many different types of data collected under a variety of sampling programs. Field and analytical procedures must be accurately and concisely communicated to future Data Base users. Data associated with unusual circumstances must be noted. Such procedures and notes are stored in the Data Base through the use of SAS variable labels plus supplemental, accompanying variables. For example, each physical and chemical variable can be associated with a two byte character variable in which remark codes are stored such as "less than detection limit." Another variable is used to store numeric codes representing various analytical procedures. Examples of SAS variable labels are shown in Table 1.

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INTEGRATING EPA'S ESTUARINE AND COASTAL ZONE INFORMATION WITH USER FRIENDLY DATA BASE MANAGEMENT TOOLS

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Introduction

Numerous Federal, state, and local governments as well as scientific and environmental organizations are concerned with estuarine and coastal zone environmental management. This concern includes both the short and long term pollution effects on the associated living resources. Effective evaluation of point and non-point pollution impacts on these ecosystems requires accessing, integrating, and analyzing the extensive ecological and pollution information residing in numerous data bases. Unfortunately, integrating data from these sources is cumbersome and frustrating because of different access methods, languages, and data structures. In this paper our overall objective is to show how integrating these data can improve environmental decision-making for the concerned community identified above. We describe a user-friendly decision support tool, PIPQUIC, and a second methodology for accessing several EPA data bases that contain useful estuarine and coastal zone environmental and pollution data. We illustrate an analysis using examples for the Patapsco River and Narragansett Bay.

PIPQUIC: Multimedia Environmental Tools

PIPQUIC is an innovative, analytically-powerful environmental decision-support tool designed and implemented by American Management Systems, Inc., (AMS) for the Regulatory Integration Division (RID) of

EPA's Office of Policy, Planning and Evaluation. PIPQUIC is a fully-integrated data base combining air, water, hazardous waste, and health risk data. It contains pollutant source data for the specific geographic areas of Philadelphia, Baltimore, Santa Clara, Rhode Island, and Kanawha Valley, West Virginia. In addition, PIPQUIC provides user-friendly interactive gateways to several EPA data bases (CDS, NEDS, PCS, STORET, HWDMS and FINDS).

PIPQUIC is designed for users with no previous computer experience and allows them to systematically analyze extensive data traditionally stored in the separate, media-specific data bases. PIPQUIC supports all phases of environmental management: problem identification, planning, regulatory development, program implementation and results evaluation. PIPQUIC tools include environmental profiles (e.g., rank sources of air or water pollution); exposure and risk analyses (e.g., pinpoint culpability for modeled pollutant concentrations and risk); and "what-if" analyses (e.g., evaluate alternative pollution control strategies).

PIPQUIC: Baltimore study area

For major industrial surface-water dischargers into the Patapsco River and Baltimore Harbor, PIPQUIC retrieved data from EPA's PCS to profile flow, total suspended solids, and 100 toxic compounds. Loadings were computed by multiplying flow times concentration where loading data were not available. PIPQUIC also integrated extensive Discharge Monitoring Report (DMR) data collected from industry files, that had not been previously incorporated into any automated system. Finally, a model based on the National Urban Runoff Program (NURP) was used with PIPQUIC to estimate seasonally-adjusted non-point toxic discharges. Indirect discharge (pretreatment) data from the Baltimore Water Department was also acquired and and added to the data base. Hazardous waste data from Maryland's Hazardous Waste Manifest System as well as EPA's Hazardous Waste Data Management System were also made available through PIPQUIC.

The integrated air emissions data include Maryland's toxics inventory for major point sources and estimated toxic organic emissions for minor point sources. These data were accessed from Maryland's Air Registry System and incorporated a set of emission factors developed by EPA's Office of Air Quality Planning and Standards. For boilers and sewage treatment plants, AMS added detailed emissions estimates provided by another contractor. The Hazardous Emissions Model and Integrated System (HEMIS), a state-of-the-art national data base of county-level emissions estimates was used to provide data on impacts such as gas marketing; road vechiles; waste oil burning; residential, industrial, commercial heating; cooling towers; and agricultural burning.

A profile of the point sources of pollution in the Patapsco River

In the Patapsco River Basin there are 28 NPDES municipal dischargers with only four of those being majors (discharging more than 1 MGD). Of the 186 NPDES industrial dischargers, 31 discharge more than 1 MGD (figures 1 and 2). On a first order analysis, it is possible to determine what the rank order of pollutant discharges are based on parameter type (figure 3). To illustrate how an interactive decision support system can be used to answer the what if scenarios, we examine which industry types (based on SIC codes) are responsible for discharging the pollutant lead, and then identify which particular facility is the significant discharger (figures 4 and 5). It is possible to develop any number of scenarios and examine any combination of pollutant types or facilities to gather a profile of pollutant impact on a particular waterbody. We then used PIPQUIC to access and retrieve STORET ambient water quality data for several lead paramters. The results of these retrievals provided a detailed listing of stations, and identified the dates of sampling, responsible agency, and parameter levels. We were also able to map these stations and see their locations on the river in relation to the major municipal and industrial discharger.

Using PCS to Profile Point Sources of Pollution in Narragansett Bay

The Technical Support Division of EPA's Office of Marine and Estuarine Protection (OMEP) asked AMS to support their point-source discharge characterization studies for selected U.S. estuaries by showing how data from EPA's Permit Compliance System (PCS) could be used in estuarine characterization studies. In addition to having AMS evaluate the data quality of PCS, OMEP asked AMS to develop a methodology to download PCS data for limited geographical areas into an easy-to-use, quality-controlled data base.

OMEP and AMS agreed that, due to resource constraints, the most effective approach would be to establish a limited data base containing data extracted from PCS for two selected estuaries. The estuaries selected were Narragansett Bay and Puget Sound. This section describes the methodology developed to create estuary-categorization data bases using PCS data and the types of analysis provided.

Analysis of PCS structure and data quality

The PCS data was acquired on magnetic tapes and reviewed. A set of criteria for extracting data for use in later phases of this work assignment was developed and computer programs were written to read and summarize the tapes' contents. The four record types used are described below:

- Facility Data: Facility data records are keyed to a NPDES permit number and contain information about each facility. 113,844 facilities are listed in PCS nation-wide. PCS User Support staff report that Basin Codes, present in about 90% of the Facility Records, are of good quality.

- Pipe Data: Pipe data are keyed to a NPDES permit number and an outfall identifier. The outfall IDs are usually equivalent to pipe numbers.

- Permit Limitation Data: Permit limitation data are keyed to a

NPDES permit number, an outfall ID, and a five-digit parameter code similar but not identical to codes used in STORET, and special fields for monitoring type and location. For individual parameters, permit limitations may be stored in terms of maximum, minimum or average amounts or concentrations.

- **Measurement Data:** Measurement data are keyed to NPDES permit number, an outfall ID, parameter code, etc., and a reporting date, usually year and month. Measurement records contain maximum, average or minimum amounts or concentrations reported on monthly Discharge Monitoring Reports (DMRs) by permitted facilities.

Creation of the selected estuary data base

The PCS data of interest was extracted and loaded into a direct-access data base using SAS software on the NCC IBM. PCS data were loaded for Facility data, Outfall data, Permit Limitation data, and Measurement/Violation data for the two selected estuaries -- Narragansett Bay and Puget Sound.

Since latitude and longitude data are not part of the PCS record file, we merged facility coordinates from another EPA system, FINDS. FINDS contains latitude/longitude data for the ZIP code centroids of approximately 40 percent of PCS facilities.

The following general conclusions apply to these procedures:

- For most dischargers in PCS, only data at the Facility record level is available. PCS does not contain Measurement record data for most dischargers found at the Facility record level.
- In both estuaries, a few facilities, largely the major dischargers, account for virtually all measurements.
- Virtually all lower level records are tied to "parent" records, indicating good quality control.
- Many important dischargers lacked latitude/longitude coordinates in FINDS, and some facility coordinates in FINDS were inaccurate.

Data manipulation, and loading estimates

Because PCS Measurement records contain no field for unit of measure, the first step necessary in estimating pollutant loadings from PCS data is to link the Measurement records to their corresponding Limit Records to obtain the standard units of measure. Moreover, to complicate the problem of estimating pollutant loadings, some measurements are reported in terms of concentration, e.g., milligrams per liter, and some are reported in terms of quantities.

To estimate pollutant loadings using the PCS data, an algorithm consisting of several steps was developed to standardize these variables. This resulted in a set of month-by-month records for the selected pollutants. We chose KGD as the standard unit for loadings and merged monthly pollutant records with monthly Flow records.

A profile of point source pollution in Narragansett Bay

For Narragansett Bay, AMS extracted data for 613 facilities in EPA Region I with PCS basin codes "0611." About 200 facilities in Massachusetts and Rhode Island had missing basin code values and these facilities were consequently not included in the working data subsets.

Of the 613 facilities listed in PCS as discharging into Narragansett Bay, 123 have at least one corresponding Outfall record, 121 have at least one corresponding Limit record, and 103 have at least one corresponding Measurement record. Of the 354 total Outfall records, 340 have a corresponding Limit record and 263 have a corresponding Measurement record. Of the 3,129 total Limit records, 1,926 have a corresponding Measurement record. In total, there were 51,515 measurement records that satisfied the criteria established for inclusion into the working data set.

The analyses performed on these data fall into the following catagories:

- o Time series, based on monthly data from 1985 to present, help spot trends
- o Bar charts based on 1985 averages, rank sources and profile point sources of pollution in terms of pollutant type and facility
- o Bay Maps, based on 1985 averages, pinpoint facility locations and illustrate discharge levels in terms of circles related in size to KGD.

Examples of these analyses are provided in figures 6, 7, and 8.

Conclusion

The above examples show how integrating estuarine and coastal zone information can improve environmental decion-making by providing pollutant profile results in an interactive framework that enables what-if and sensitivity analyses. These results can be used to determine emission and risk implications of alternative control options when comparing various pollutants and facilities. Similarily, these analyses can assist in targeting the highest payoff control opportunities within a regulatory or standard setting context. One obvious application, for example, would be establishing an ambient monitoring station near the Bethlehem Steel Plant to determine whether the high discharge levels of lead are detected in the water column of the Patapsco River. With this type of information, the State of Maryland permit writers could better set parameter limits based on "real" impact data. In the case of Narragansett Bay, the data base tools could be used to assist in targeting specific point sources of discharge to try and limit specific pollutant types (e.g. cadmium) or specific loading sources. These types of multi-media and integrated environmental decision-making should become more commonplace in the EPA arena. The tools to accomplish this enlightened approach are available with today's technology. The goal is now to sensitize and enlist the support of the appropriate administrators and managers to use these decision support tools.

Figure 1

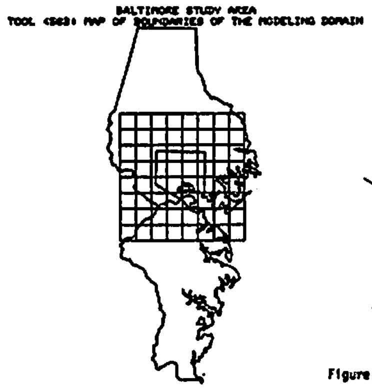


Figure 2

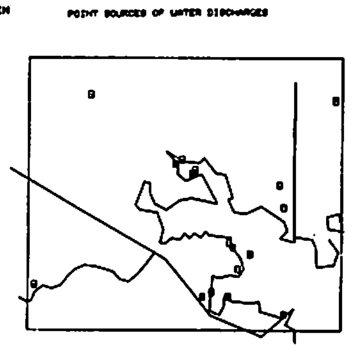


Figure 3

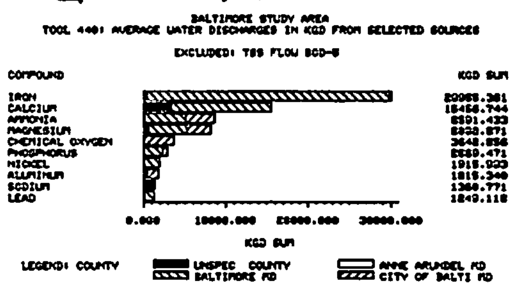


Figure 4

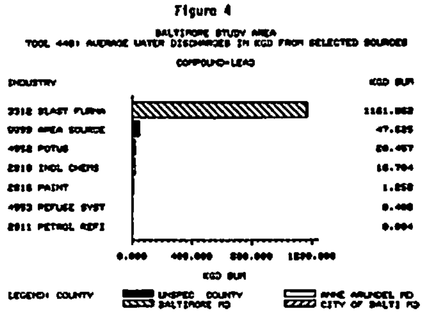


Figure 5

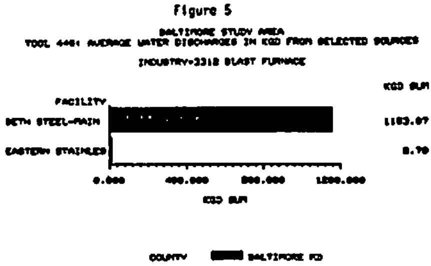


Figure 6

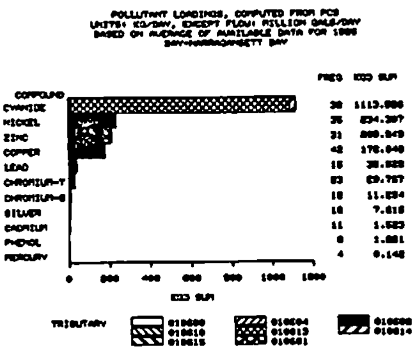


Figure 8

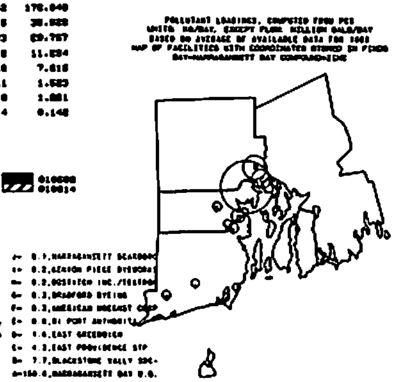
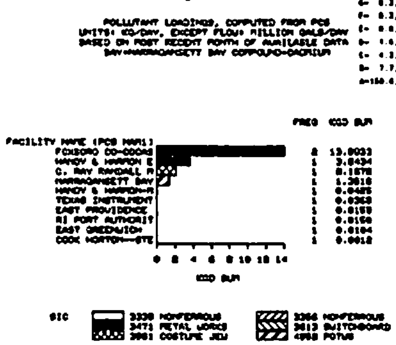


Figure 7



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THE OCEAN DATA EVALUATION SYSTEM (ODES): A DECISION SUPPORT TOOL FOR ANALYSIS OF MARINE AND ESTUARINE ENVIRONMENTAL DATA

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Overview of System Goals and Capabilities

The Ocean Data Evaluation System (ODES) is a U.S. EPA computer-based decision support system located on the U.S. EPA National Computer Center IBM mainframe in Research Triangle Park, NC. The system was developed to help technical staff and resource managers make informed decisions regarding such activities as the issuance of discharge permits, designation of discharge sites, approval of monitoring plans, and assessment of discharge permit compliance. ODES was developed with two basic components: 1) a database containing physical, chemical, and 2) a biological environmental data and a series of analytical tools for data analysis. By integrating these components into a single system, ODES provides users with the ability to answer a variety of environmental questions quickly and efficiently.

The ODES system currently can store a wide variety of environmental data from marine monitoring programs. User can access this information and produce tabular reports (e.g., actual data or data summaries), graphics (e.g., bar charts, plots of data over time, scatterplots, and coastal maps), and statistical analyses (e.g., analysis of variance, correlation, regression, and power analysis). Users can log onto ODES and perform these analyses from any location in the U.S. using a microcomputer equipped with a modem.

History

CDES was originally developed by the Marine Operations Division of the U.S. EPA Office of Marine and Estuárine Protection to support the 301(h) sewage discharge program of the Clean Water Act. Under this program, publicly owned sewage treatment plants may apply for waivers from the requirements for secondary treatment of sewage effluent. If a waiver is granted, dischargers are required to collect and submit environmental monitoring data to the U.S. EPA. CDES was designed to provide both dischargers and the U.S. EPA with the ability to use this environmental data in assessing the impacts of the sewage discharges on the marine environment.

The CDES system has recently expanded to include data from the U.S. EPA ocean dumping and estuarine programs. Data from Puget Sound, several northeastern estuaries, and baseline surveys at the 106-mile deep-water dump site off the New Jersey coast are being added to CDES.

System Design

Specific objectives that guided develop of CDES included:

- Rapid, multiuser access to quality assured environmental data
- Menu-driven operation with no requirements for knowledge of computer programming
- Access to powerful statistical and analytical procedures
- Graphical display of data, including data overlays on maps
- Retrieval of information in a variety of formats
- Downloading information to microcomputers.

The software that was selected to meet these objectives reside on the U.S. EPA IBM 3090 mainframe. The data within the system are stored in SAS files. These files are integrated, allowing simultaneous access to a variety of data (e.g., sediment chemistry and benthos).

CDES information may be accessed for the purpose of data retrievals and analysis. Users, however, do not interact directly with the system at this applications program level. Instead, individuals logged onto CDES view menus and respond to prompts produced by a command processor and editor. Users respond to the system prompts generated by this editor by entering simple English commands. The command processor takes these responses and, using the appropriate applications programs, performs the requested analysis. Numerous help commands and dictionaries are available to assist users with their responses.

The only equipment needed to log onto CDES is a microcomputer, a modem, and telecommunications software. This equipment, coupled with a valid user account, will allow individuals to dial the CDES computer using toll-free TYMNET phone lines. Instructions for obtaining an CDES account and using CDES are contained in the "CDES Users Guide" ("User Support," below). All costs for accessing and using CDES are currently paid by the U.S. EPA.

Data Entry to CDES

Data are stored in SAS files using National Oceanographic Data Center (NODC) variable codes. Data files are available for all types of information commonly collected in conjunction with marine and estuarine monitoring programs:

- Sediment Chemistry
- Water Quality
- Bioaccumulation
- Benthos
- Trawl/-Seine
- Bioassay
- Point Source Effluent
- Fish Pathology

A description of these CDES data files and the appropriate data submissions formats can be found in the <u>CDES Data Submissions Manual</u> (see "User Support," below).

All data submitted to the system are subjected to a quality assurance review prior to entry into CDES. The purpose of this review is to ensure that data are entered correctly and to document the field and laboratory techniques used to generate the data. When the review is completed, a quality assurance report is produced discussing any issues that might affect the use and interpretation of the data. A copy of this report can be obtained from the CDES support staff for any data file in CDES. Abstracts of each quality assurance report are also directly available to CDES users while logged onto the system.

Analytical and Reporting Features

CDES features the following tools for the retrieval, display, and analysis of data:

Tool No.	Description
1 =	PLOT OF ONE OR TWO VARIABLES OVER TIME
2 =	PLOT OF SEVERAL VARIABLES OVER TIME (OVERLAY)
3 =	PLOT OF MEANS OVER TIME (WITH STANDARD ERROR BARS)
10 =	T TEST FOR REPLICATED DATA
11 =	WILCOXON/MANN-WHITNEY U TEST FOR REPLICATED DATA
12 =	ONE-WAY ANALYSIS OF VARIANCE FOR REPLICATED DATA
13 =	KRUSKAL-WALLIS K-SAMPLE LOCATION TEST FOR REPLICATED DATA
14 =	STATISTICAL POWER ANALYSIS (currently being developed)
20 =	X-Y SCATTERPLOT WITH CORRELATION STATISTICS
30 =	CLUSTER ANALYSIS
60 =	PLUME MODELS
70 =	MAPS OF SHORELINES AND SAMPLING STATIONS
71 =	3-D CONTOUR OF A VARIABLE FOR A SELECTED GEOGRAPHIC AREA
110 =	RETRIEVAL OF BENTHIC SURVEY DATA
140 =	RETRIEVAL OF EFFLUENT DATA
150 =	RETRIEVAL OF RECEIVING WATER QUALITY DATA
170 =	RETRIEVAL OF SEDIMENT POLLUTANT DATA
190 =	RETRIEVAL OF BIOASSAY DATA
300 =	301(H) FACILITIES SUMMARY
302 =	301(H) BENTHIC SURVEY DATA SUMMARY

New tools are continually being added to the system. For example, several enhancements to the graphics capabilities of ODES have recently been completed. These include tools for producing bar charts and maps of coastal regions. The mapping tools permit users to plot sampling station locations and to overlay data stored within ODES onto maps of study areas. The release of all new tools is announced in the ODES Bulletin ("User Support," below).

User Support

The ODES staff supports users through a number of activities. Individuals with questions or comments regarding the ODES system are encouraged to call the user support staff at either of the following two telephone hotline numbers:

- (703) 841-6109 (9 AM - 6 PM Eastern Time)
- (703) 822-9596 (1 PM - 5 PM Pacific Time)

The support staff periodically distributes an information bulletin to all ODES users. The bulletin includes lists of recent data sets added to ODES, information on new ODES tools, and answers to frequently asked questions. The ODES staff also produces three manuals to assist ODES users: ODES Users Guide, ODES Data Submissions Manual, and ODES Tool Description Manual. These manuals can be obtained by calling the ODES user support phone numbers listed above.

Access to System

All requests for access to ODES should be directed to the U.S. EPA ODES coordinator at the following address:

Allison J. Duryee
ODES Manager
Marine Operations Division
Office of Marine and Estuarine Protection (WH-556M)
U.S. Environmental Protection Agency
401 M Street SW
Washington, DC 20460

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COASTAL WETLANDS: ESTABLISHING A NATIONAL DATA BASE

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Introduction

Coastal wetlands are an important and irreplaceable national resource. From Maine to Florida, across the Gulf of Mexico to Texas, and intermittently along the West Coast, a thin belt of wetlands provide critical habitat to fish, shellfish, and wildlife; filter and process agricultural wastes, and buffer coastal areas against storm and wave damage. They also generate large revenues from a wide variety of recreational activities such as fishing and hunting.

However, coastal wetlands have been disappearing at an average rate of 20,000 acres (31 square miles) per year over the past 25 years (Frayer et al., 1983). Urbanization, agriculture, hydrocarbon exploration, and other human activities have contributed to this loss. Furthermore, the U.S. Census Bureau predicts that by 1990, 75 percent of the U.S. population will live within 50 miles of the coastline (including the Great Lakes), indicating even greater competition in coastal areas for limited space and resources (President's Council on Environmental Quality, 1984). In spite of these facts, no comprehensive information base on the Nation's coastal wetlands is presently available.

This paper briefly describes a project to develop a comprehensive and consistently derived coastal wetland data base for the coterminous USA. The inventory is part of a series of activities now underway at NOAA to develop a national estuarine assessment capability. This includes compilation of the best available information at the national level needed to characterize the physical, hydrologic, biological, and economic dimensions of the Nation's estuaries.

The wetland inventory project is being conducted jointly by the Strategic Assessment Branch (SAB) of the Ocean Assessments Division of the Office of Oceanography and Marine Assessment, National Ocean Service (NOS), and the Beaufort Laboratory of the Southeast Fisheries Center, National Marine Fisheries Service (NMFS), both components of the National Oceanic and Atmospheric Administration (NOAA). Development of this information is an integral part of NOS's program of strategic assessments of the Nation's coastal and oceanic region (Ehler and Basta, 1984) and NMFS' national program to determine the status and trends of coastal fisheries habitat (Lindall and Thayer, 1982).

Why is NOAA Interested in Coastal Wetlands?

Both NMFS and NOS have traditional roles in the management and protection of the Nation's coastal and oceanic resources. Because coastal wetlands provide an important habitat and food resource for coastal fisheries, their distribution and abundance are of interest to NMFS. Coastal wetlands are also an important ecological component of the health of estuaries and are therefore of interest to SAB which is currently conducting a comprehensive National Estuarine Inventory (NEI).

Development of the NEI began in 1983. Volume I was completed in November of 1985 and contains physical and hydrologic data as well as maps for 92 estuarine systems representing approximately 90 percent of the estuarine surface area and freshwater inflow to the East Coast, Gulf of Mexico, and West Coast of the coterminous USA (Strategic Assessment Branch, 1985). Volume II of the NEI will be published in January of 1987 and will include detailed land use and population data for each of the 92 estuaries.

Each estuary is designated by a common spatial unit, the estuarine drainage area (EDA), that comprises the land and water component of an entire watershed that most directly affects an estuary. EDAs are identified to establish the spatial unit for compiling land use, physical, biological, and other data to characterize the estuary. The goal is to build a comprehensive framework for evaluating the health and status of the Nation's estuaries and to bring estuaries into focus as a national resource base. When completed, the NEI will be used to make comparisons, rankings, statistical correlations and other analyses related to resource use, environmental quality, and economic values among estuaries. Wetlands data will be incorporated into this framework.

Existing Wetlands Data

Existing data on the areal extent and distribution of coastal wetlands of the USA have been compiled by SAB and NMFS in: An Inventory of the Coastal Wetlands of the USA (Inventory) (Alexander et al., 1986). Twenty-three sources were consulted to compile acreage figures for 242 counties in 22 coastal states. These data indicate the presence of over 11 million acres of wetlands along the coastlines of the coterminous USA. Approximately 4.4 million acres were identified as salt marsh, 1.5 million acres as fresh marsh, 0.2 million acres as tidal flats, and 5 million acres as swamp. The Gulf of Mexico had the most wetlands (5.2 million acres) followed by the Southeast (4.2 million acres), the Northeast (1.7 million acres), and the West Coast (0.2 million acres). Detailed information on data sources and a complete table of wetland types and acreages by coastal county are presented in two appendices to the Inventory.

The fundamental obstacle to consolidating existing data into a national data base however, is a lack of consistency between the 23 data sources consulted. Variability in data quality and consistency, and lack of a unifying theme or purpose makes it difficult to produce an accurate national picture of coastal wetlands. In addition, much of the existing information is incomplete and/or outdated. However, the Inventory represents the first attempt to compile a comprehensive data base for coastal wetlands.

The U.S. Fish and Wildlife Service (FWS) estimated the extent of coastal and non-coastal wetlands in 1983 (Frayer et al., 1983). However, the data for this report were compiled by random sampling rather than a comprehensive inventory and were intended to highlight overall national and regional trends. Frayer et al. (1983) suggest therefore, that the data are meaningful only at the national or regional level and are generally unreliable for smaller areas such as states, counties, or estuaries. Another Federal program, the land use/land cover program (LU/LC) of the U.S. Geological Survey (USGS), compiles land use data, including wetlands, based on aerial photography. Although the LU/LC data represents a complete National data base, the wetlands component is differentiated into only two categories, forested and non-forested, compared to the much more detailed Cowardin et al. (1979) classification system used by the FWS and many state wetland inventories. There is also some question about the ability of the LU/LC data to distinguish accurately between forested uplands and forested wetlands.

While the compilation and evaluation of existing data was a necessary first step, they are not suitable for the development of a comprehensive national data base. Therefore, the next step was to evaluate alternative methods for achieving this objective.

Alternatives

The most important consideration when reviewing alternatives was the objective to develop current, consistently derived, and comprehensive baseline information on the distribution and areal extent of wetlands in the coterminous USA in a timely and cost-effective manner. Several alternatives were investigated.
Landsat imagery, both multispectral scanner (MSS) and thematic mapper (TM) have been used in identifying and quantifying wetland areas (May, 1986 ; Haddad and Harris, 1985). TM appears to be the most promising and is being used with local success in several areas. However, it has yet to be proven over large coastal areas with variable geography and wetland types, and also requires trained personnel and expensive equipment for image processing.

The NWI program was established by the FWS in 1974 to generate scientific information on the characteristics and extent of the Nation's wetlands (Tiner, 1984). This information was to be developed in two stages: 1) the creation of detailed wetland maps; and 2) research on historical status and trends. The maps, developed using aerial photography, are generally based on 1:24,000 scale USGS quadrangles and illustrate wetland habitats classified using the Cowardin et al. (1979) system. Although NWI wetland maps represent the most reliable source of consistently derived coastal wetland information available, only approximately 1,000 of the over 5,000 maps required for complete coverage of the Nation's estuaries and other coastal areas have been digitized. Therefore, only a fraction of the wetlands data needed for this project are available. Since the current FWS technique for digitizing these maps is expensive and time consuming, a complete data base of NWI coastal maps is not anticipated or planned for by the FWS in the near future. Furthermore, manipulation of existing and/or future FWS digital data into spatial units such as coastal counties or EDAs adds additional time and expense to the analysis. Finally, it was not clear whether the detailed FWS digitizing procedure would be cost-effective for the level of data resolution required by NOAA.

Systematic grid sampling of these same NWI maps appeared to be the most reasonable alternative given that these maps: 1) represent the best source of consistently derived coastal wetlands data available; 2) are generally available for the entire coastal region of the coterminus USA (of approximately 5,000 1:24,000 scale maps required, approximately 3,300 are currently available); and 3) lend themselves well to a simple quantification technique such as grid sampling.

Systematic grid sampling consists of counting dots printed in a square, pattern on a transparent overlay. The spacing of dots, in combination with the scale of the map, will determine the resolution of the grid (Bonner, 1975). For example, dots 0.7 inches apart on a 1:24,000 scale map will produce a grid resolution of 45 acres. The relative amounts of various land use or habitat types present on a particular map are estimated by placing the grid over the map and counting the number of dots that fall on each category represented. Depending on the interval between dots and the distribution of land use or habitat types, this can be a highly accurate method for making area estimates.

To test this procedure, a simple grid sampling technique was used to quantify habitat types for 16 previously digitized 1:24,000 scale NWI maps. For the purposes of these preliminary tests, the numerous habitat types designated on the NWI maps were aggregated into six general categories: 1) salt marsh; 2) fresh marsh; 3) tidal flats; 4) swamp; 5) open water; and 6) uplands. After some testing, a 45 acre grid cell size with approximately 900 sampling points per map was determined to be both efficient and accurate for estimating these six habitat types at this scale. Each map was sampled separately by mounting the grid over the map and systematically recording the habitat type at each sampling point. This information was recorded on data sheets and entered into a computer mapping and statistics program. Based on the results (Table 1), it appeared that grid sampling could provide a time and cost-effective technique for compiling a reasonably accurate coastal wetlands data base.

Table 1. Grid sampling results for two test areas in coastal Louisiana and Texas.

TOTAL ACREAGE FOR TWO TEST AREAS
(Coastal Louisiana and Texas)

Habitat	Digital	Grid	% Difference
1. Upland	109,227	108,443	-0.72
2. Open Water	434,896	431,959	-0.68
3. Salt Marsh	97,642	97,217	-0.44
4. Fresh Marsh	17,584	17,885	+1.71
5. Tidal Flat	8,013	7,885	-1.97
6. Swamp	1,225	1,061	-13.39
TOTAL	668,587	664,420	-0.62

Coastal Wetlands Workshop

On April 29, 1986, SAB and NMFS held a workshop bringing together individuals with experience in wetlands mapping and management to discuss NOAA's efforts to compile a national coastal wetlands data base. Sixteen professionals from six Federal organizations participated: U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (COE), USGS, FWS, NMFS, and NOS. Specific objectives were to: 1) review current information on the distribution and extent of coastal wetlands; 2) outline the requirements for improving this data base; and 3) develop recommendations for NOAA to proceed further with this work.

In general, workshop participants endorsed NOAA's proposal to grid sample NWI maps (Strategic Assessment Branch, 1986). It was suggested however, that the technique be modified to improve the quality and usefulness of the data being developed. Two key recommendations were proposed:

1) Expand the habitat categories sampled from six to the fifteen listed below:

a. high salt marsh
b. low salt marsh
c. brackish marsh
d. unclassified non-fresh marsh
e. tidal fresh marsh
f. non-tidal fresh marsh
g. unclassified fresh marsh
h. tidal flats
j. estuarine forested-scrub/shrub
k. tidal fresh forested-scrub/shrub
l. non-tidal fresh forested-scrub/shrub
m. unclassified fresh forested-scrub/shrub
n. upland
o. open water-fresh
p. open water-non-fresh

2) Conduct a more complete statistical evaluation of the grid sampling procedure.

These recommendations were examined by NOAA and incorporated into the operational phase of the project.

Grid Sampling: The Operational Phase

Grid sampling of available NWI maps began on June 17, 1986. Fifteen habitat types are now sampled from each map when they are present. The wetlands team also met with representatives from USGS and NMFS and determined that the sampling design is adequate for the number of wetland categories sampled. A data base management system has been developed to record map information such as name, location, scale, and availability in order to efficiently monitor and document the progress. Software has also been developed to reproduce grid sampled data in map form on a color monitor and color printer. Up to six different 1:24,000 scale maps of grid sampled wetland data can be simultaneously displayed illustrating the general distribution of habitat types. Hard copies can be obtained using a color ink-jet printer. Additional software has been developed to aggregate grid sampled data by state, county, and hydrologic unit as well as by EDA . A quality control procedure has been implemented to minimize the types of errors inherent in this technique.

The first product from this work will describe the general distribution and areal extent of coastal wetlands in the Northeast (ME-CT) and should be available by the spring of 1987. Reports to follow will include the Mid-Atlantic (NY- VA), Southeast (NC-FL), Gulf of Mexico (FL-TX), and the West Coast (CA-WA). NOAA expects to complete this work by the end of 1988.

Conclusion

Recognizing that coastal wetlands are an important national resource, NOAA has endeavored to develop the first comprehensive national coastal wetlands data base. Grid sampling offers an inexpensive and relatively simple method for estimating the areal extent of wetlands from NWI maps at a level of aggregation suitable for national assessement. Development of these data would not be possible without the significant contribution made by the FWS in mapping coastal wetlands. Products from this project will complement the FWS work and provide a useful management tool for coastal resource managers at all levels of government, particularly those Federal agencies with responsibilities for wetlands management and conservation (e.g. FWS, EPA, and COE). Baseline data for the Nation's coastal wetlands will be a significant addition to our understanding of these systems and should improve our ability to manage them effectively. These data will eventually be integrated into NOAA's NEI framework to establish a national estaurine assessment capability.

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THE USE OF THE NATIONAL WATER DATA EXCHANGE IN SUPPORT OF ESTUARINE AND COASTAL PROGRAMS

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Introduction

The National Water Data Exchange (NAWDEX) was established by the U.S. Geological Survey in 1976. Its program is directed toward improving the exchange of water and water-related data collected and made available by hundreds of Federal and non-Federal agencies throughout the United States.

The use of NAWDEX can provide valuable support to coastal and estuarine programs by providing information on the availability of quantity and quality data for surface-water and ground-water in coastal and estuarine areas. The NAWDEX program maintains direct access to the computerized water-data systems of the U.S. Geological Survey and the U.S. Environmental Protection Agency and can provide data from these systems either in response to data requests or by direct access by the user organization. The program also maintains close working relationships with many other Federal and non-Federal organizations that serve as sources for water or water-related data, thereby, facilitating user access to data stored by these organizations. This paper describes the NAWDEX program and the services which can be provided to assist coastal and estuarine programs.

The Nawdex Program Structure

NAWDEX is comprised of a membership of Federal and non-Federal organizations who work together to improve access to available water data and to improve the data-exchange process. Membership in the NAWDEX program is accomplished through a Memorandum of Understanding signed between the participating individual or organization and NAWDEX Program Office. In the Memorandum, members pledge their support to the program by taking an active role in its activities, by providing for indexing of their data acquisitions and by agreement to respond to public requests for their data. Currently (1986), over 290 Federal, State and local governmental, academic, and private organizations participate as members. Affiliations have also been established with water-data organizations in Canada, Mexico, Brazil, South Africa, Nigeria, Taiwan, and India.

The program is managed by a central program office located in the U.S. Geological Survey's Water Resources Division in Reston, Virginia. This office coordinates the program membership and user-service activities, and develops and maintains the software systems and data bases necessary for the program's operations.

Indexing Services

NAWDEX operates a nationwide program for the indexing of water and water-related data available from its members and other organizations. This program is operated in close cooperation with the U.S. Geological Survey's Office of Water Data Coordination (OWDC) which has national responsibility for the coordination of water-data acquisition activities by all Federal agencies. The information gathered by the NAWDEX program is stored in three major data bases: (1) a Master Water Data Index, (2) a Water Data Sources Directory, and (3) a Water Supply Computerized Information Directory.

Master Water Data Index

The Master Water Data Index is a central index that provides information about sites at which water data are collected nationwide. For each site, information is provided about surface-water quantity, ground-water quantity, water quality and meteorological data that have been collected. This information includes the geographic location of the site, the type of site (stream, estuary, well, and so forth), the identification of the source organization, the periods of records for which each type of data are available, the major water-data parameters measured for each data type and their frequency of measurement, and the media in which the data are available. Currently, over 440,000 sites operated by over 430 organizations have been indexed. Of these sites over 13,000 are identified as being estuary or ocean sites. An additional large number of sites are identified as streams or wells that either contribute to or are located within estuarine and coastal areas.

Water Data Sources Directory

The Water Data Sources Directory serves as a central world-wide index of organizations that are sources of water or water-related data, provide services related to the dissemination of these data, or are, otherwise, involved in water-related activities. For each organization, information is provided about the major orientation of its activities, offices from which data or services may be obtained; the number, type and geographical area of location of water data sites for which data are available or being collected; other organizations that may serve as a source of data; and water-related data collected by the organization. Currently, over 800 organizations with water-related sources of data have been registered in the Directory. An additional 2,200 have been identified for potential inclusion.

Water Supply Computerized Information Directory

The Water Supply Computerized Information Directory was developed by the Electric Power Research Institute and contributed by them, under a Memorandum of Agreement, to NAWDEX for operation conjunctively with the Water Data Sources Directory. The Directory contains information about organizations that are sources of data about water supply. For each organization, information is contained about the structure of the organization, offices from which data may be obtained, descriptions of automated data bases maintained by the organization, descriptions of water laws that have relevance to water supply, the geographic areas in which the organization collects data and relevant publications of the organization pertaining to water supply. Currently, over 200 organizations having various data related to water supply are registered in the Directory.

Bibliographic Citations and Abstracts

The Water Resources Scientific Information Center (WRSIC) was transferred to the U.S. Geological Survey's Water Resources Division from the U.S. Department of Interior's Office of Water Research and Technology in August 1982. The WRSIC program is closely coordinated with that of NAWDEX and its information services are being provided conjunctively with those of NAWDEX. WRSIC maintains the Selected Water Resources Abstracts data base. It contains bibliographic citations and abstracts of water-resources literature published worldwide. Currently (1986), the data base contains over 181,000 abstracts.

User Services

NAWDEX coordinates an extensive user-service program through a national network of 76 Assistance Centers located in 45 States, the District of Columbia, and Puerto Rico. These centers include the NAWDEX Program Office, selected District, State, and Subdistrict offices of the U.S. Geological Survey's Water Resources Division, 9 offices of the Geological Survey Public Inquiries Offices and offices of 14 NAWDEX member organizations. Most of these centers have direct access to the data bases of NAWDEX and the U.S. Geological Survey's National Water Data Storage and Retrieval Systems (WATSTORE), thereby, providing convenient and rapid dissemination of information and water data stored in these systems. Several centers also have access, for dissemination purposes, to the WRSIC bibliographic data base and the Storage and Retrieval (STORET) system of the U.S. Environmental Protection Agency. Access to a variety of other data systems are available through the Assistance Centers operated by NAWDEX members. Services provided by NAWDEX include data-search assistance, data dissemination, data referrals, and direct, computerized access to Federal data systems. It also provides a variety of information products including catalogs of available data, directories of data sources, and summaries of available data.

Data Search Assistance

Through its central indexes and directories, NAWDEX can assist users in quickly identifying types of data that may be available in specific geographic areas of interest. The central index of data sites can be searched geographically by State, county, polygons of latitude and longitude, and river basins. These search criteria are significant to estuarine and coastal programs in that they can be coastal counties, a polygon of latitude and longitude that describe the extents of coastal areas, coastal river basin, or any combination of these criteria. In addition, the type of site can also be specified, i.e., stream, estuary, ocean, lake, etc. The central directories may be further used to identify source organizations and to identify water-related data such as oceanographic, meteorological, climatic, soils, water-use and other types that may be available from registered organizations. The program, thus, serves as a central source of information about a wide variety of data available from a large number of organizations.

Data Dissemination

The NAWDEX program is authorized to access and disseminate water data stored in the U.S. Geological Survey's WATSTORE system and the U.S. Environmental Protection Agency's STORET system. This includes large volumes of streamflow, peak flow, sediment, ground-water levels, surface and ground-water quality, and a variety of other types of water data.

Also, NAWDEX Assistance Centers provide dissemination services from several State-level data systems including the Texas Natural Resources Information System (TNRIS), the Nebraska Natural Resources Information System (NNRIS), the Hydrologic Information Storage and Retrieval System (HISARS) for the States of Virginia, Utah, and several others. Information stored in the Selected Water Resources Abstracts data base of WRSIC is also disseminated by NAWDEX through several of its Assistance Centers. In addition, this data base may be searched by using Dialog Information Services, Inc. (a commercial on-line utility).

Data Referrals

If specific data cannot be retrieved and disseminated by a NAWDEX Assistance Center, the central directories assist the centers in referring the request to the proper data source for response.

Direct Data Access

The NAWDEX Program Office is authorized to provide its members direct access via computer terminals to its index data base and directories and to the WATSTORE data system of the U.S. Geological Survey and the STORET data system of the U.S. Environmental Protection Agency.

Information Products

The NAWDEX program provides a variety of information products from its computerized data bases. These include the following:

> Ad hoc reports in informal formats in response to individual requests for information about water-data types, site locations, or organizations.

- Printed catalogs of water data sites for specific geographic areas which are produced on demand.

- Printed directories of data source organizations, including:

  - a Water Data Sources Directory
  - a Directory of Water-Related Data Sources
  - a Directory of Water and Water-Related Data Sources
  - a Directory of Water Resources Organizations

- Numerical summaries of indexed water-data sites collecting sites collecting specific data types in defined geographic areas.

- Site-location maps of specific data types by State, county, or hydrologic basin produced in relative scales or specified scales and projections as overlays to base maps.

For example, the Office of Water Data Coordination published a report in 1977 entitled, "Index to Stations in Coastal Areas," which contained information on the availability of quantity and quality data collected in streams, lakes, reservoirs, estuaries, springs, and wells located in coastal ecosystems, including wetlands, estuaries, and beaches. The information in this report is indexed in the Master Water Data Index of NAWDEX and can be retrieved in response to an ad hoc request or produced in catalogues of specific coastal areas upon demand.

Summary

NAWDEX has an active participation of over 290 member organizations that are working together to improve access to available water data. It has indexed data for over 440,000 water-data sites operated by over 430 organizations nationwide. NAWDEX stores information on more than 800 organizations that are sources of data or active in water-resources activities and works closely with the Water Resources Scientific Information Center (WRSIC), which maintains over 181,000 abstracts of water-resources literature produced worldwide. NAWDEX coordinates an extensive user-service program through 76 Assistance Centers located in 45 States, the District of Columbia, and Puerto Rico. The Centers provide services in data-search assistance, data referrals, and dissemination of data from member data systems. The NAWDEX Program Office further provides direct-access to the water data systems of the U.S. Geological Survey (WATSTORE) and the U.S. Environmental Protection Agency (STORET). A variety of information products are provided by the program including ad hoc reports on available data, printed data catalogs and organizational directories, numerical summaries of index water-data sites, and site-location maps.

Through its information resources and services, NAWDEX can provide valuable support to a variety of estuarine and coastal programs. It can assist in identifying needed water data existing in specific study areas and either directly provide the data or assist in acquiring the data from the proper source. It can also assist in identifying the availability and sources of a wide variety of water-related data types that may have relevance to estuarine and coastal studies and investigations.

Additional Information

For additional information about NAWDEX and its service, contact:

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Reston, Virginia 22092

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Abstract only

THE DATA MANAGEMENT SYSTEM OF THE LOUISIANA NATURAL HERITAGE PROGRAM - A NATURAL AREAS INVENTORY OF THE STATE

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The Louisiana Natural Heritage Program (LNHP) is a natural areas inventory targeting endangered species habitat, outstanding examples of native ecosystems, environmentally critical areas, and sites for scientific research. The purpose of the program is 1) to gather information systematically and on a continuing basis on the occurrences of significant natural areas in Louisiana, 2) to assemble and store this information efficiently, 3) to make its retrieval simple and cost-effective so that impacts of various activities on these areas can be evaluated, and 4) to set preservation priorities so that areas/species in need of protection are addressed while others which are secure or less significant do not divert limited resource dollars.

A data management system for the LNHP has been developed by The Nature Conservancy over the last ten years. The data management system consists of a tightly structured manual, map, and computer (IBM-PC-AT) filing system that records information on the existence, characteristics, numbers, condition, status, location, and distribution of the occurrences of elements of the natural ecological diversity of the state. The classification systems, element descriptions and other information that describe the targets of the inventory process are maintained in the element files. Specific locational data of significant habitat are plotted on USGS 7.5 minute topographical maps (1:24,000) in the hanging map file and general map file along with supporting documentation for each occurrence. The managed area file organizes information on publicly and privately owned areas in Louisiana that offer some degree of protection to natural areas. A separate source file is maintained to cross reference all material associated with the data base including all supporting articles, journals, unpublished documents, books, organizations, individuals, etc. Abstracts of key information kept in the manual files are entered into the computer files to facilitate rapid/efficient storage and processing/retrieval of data. To date, 852 element occurrences of special plants (305), special animals (231), natural communities (131), other natural features such bird rookeries (185) have been documented and mapped for coastal Louisiana. The LNHP is one of 40 such programs in the United States. Unlike biological inventories of the past which operated in isolation these programs form a closely knit network. Ultimately the programs will produce regional and national classification systems, data synthesis, and perspectives on species endangerment and conservation needs. The Natural Heritage programs have developed an effective and efficient information system for biological conservation planning.

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DETERMINING AND SERVICING MARINE POLLUTION DATA AND INFORMATION NEEDS OF ESTUARINE AND COASTAL ZONE MANAGERS AND DECISION MAKERS

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OPDIN Structured to Serve

The Ocean Pollution Data and Information Network (OPDIN) includes a Central Coordination and Referral Office (CCRO) and Regional services through National Oceanographic Data Center Liaison Offices in Anchorage, Alaska; Seattle, Washington; La Jolla, California; Miami, Florida; and Woods Hole, Massachusetts. The CCRO primarily serves the Washington, D.C. metropolitan community of managers and decision makers, and provides national services to the Regional Offices. The Regional Offices deal with the communities in their respective regions on a day-to-day basis and have an intimate understanding of the current issues and resources in their regions.

The Typical Request

An Example of CCRO Request Response, Figure 1, illustrates some of the Network resources available to the decision maker. In this example, the customer is provided with a complete inventory of information, data and expertise relevant to his problem, including its source, availability, cost and access timeliness. As each customer describes his needs, the OPDIN staff member enumerates the features of potentially relevant Network resources (CCRO Response in Figure 1). Customer selections guide the staff through each resource to the products that satisfy the request (Products in Figure 1).

FIGURE 1.

EXAMPLE OF CCRO REQUEST RESPONSE

USER REQUEST ---- INFORMATION ON PCB STUDIES FOR WEST COAST ESTUARIES

CCRO RESPONSE	PRODUCTS
- NMPIS (PC)	*Descriptions of Federal PCB/Halogenated HC Projects in Estuaries in WA, OR & CA*
- NON-FED (M)	*Descriptions of Non-Federal Projects*
- HANDBOOK (PC)	*Identification of Federal Systems with PCB data*
- GREY LIT (PC)	*Grey Literature citations for PCB articals*
- C/RCRO RES. (M)	*Literature and data on PCB*
- REFERRALS	*Data, information, local contacts and investigators*

In this example, the customer wants informat on on PCBs in West Coast estuaries. The OPDIN staff member identifies each of the resource files that might provide such information, and explains what is available from each file. Some of the files are available on personal computer (PC) on the staff member's desk. A search of these files may be conducted while the customer is still on the phone or in the office. In addition, the staff member may be able to identify and discuss the relevance of hardcopy resources available in their office and other OPDIN offices (M). The referral to resources in other organizations is discussed. Those files can be accessed directly by the OPDIN staff member, or the customer may be referred to the appropriate expert in the respective organization for more complete information from the resource. The customer may take delivery of information from the diverse resources as they arrive or ask the OPDIN staff member to coordinate the responses into a single package.

OPDIN Resources

Over the years of customer servicing, the OPDIN offices have identified a wealth of resources that can be used by managers to make and substantiate decisions. OPDIN has a small staff, so much of its service concerns referrals. OPDIN also has developed directories, bibliographies, inventories and data bases of its own to service its customers. Figure 2 enumerates the major OPDIN resources.

FIGURE 2

OPDIN RESOURCES

NMPIS
National Marine Pollution Information System

N/FED
Inventory of Non-Federally Funded Activity

GREY LITERATURE
Automated Bibliography of Unpublished Literature

CCRO/RCRO
Central/Regional Coordination & Referral Office(s)

HANDBOOK
Handbook of Existing Data & Information Systems

CIS
Coastal Information System

REQUESTS
CCRO Customer Service Reporting System

Two directories are maintained by OPDIN. The National Marine Pollution Information System (NMPIS) is a data base used to generate the annual Catalog of Federally Funded Projects (NMPPO, 1985a) for the National Marine Pollution Program. It is a micro-computer data base containing the names, addresses, funding levels, and activity descriptions of personnel involved in federally-funded marine pollution related activities.

Similar information is available in a series of non-Federally funded (non-automated) project catalogs. Regional catalogs for the Great Lakes (NMPPO, 1985b), Northeast & Mid-Atlantic (NMPPO, 1985c), and South Atlantic & Gulf of Mexico (NMPPO, 1984) have been published. The West Coast and Alaska catalog will be available in the near future.

An essential ingredient of any research effort is the library search. OPDIN can supplement the results of a standard library search with searches of a marine pollution oriented 'grey literature' PC data base describing reports generated by or for the Federal agencies involved in marine pollution studies. Additionally, the CCRO and its Regional Offices have built libraries of local resources and contacts.

FIGURE 3

ACCESS TO DOC RESOURCES

NOAA

NESDIS - National Environmental Satellite, Data, & Information Service

NODC - National Oceanographic Data Center *(Pubs & DBs)*
National Climatic, Geophysical & Satellite Data Centers *(Pubs & DBs)*

AISC -Assessment and Information Services Center
Environmental Assessments of Estuaries (Pubs)
Lockheed, SDC & BIRS *(Commercial Bibliographic DBs)*
NEDRES - National Environmental Data REferral Service *(DB)*

NMPPO - National Marine Pollution Program Office
Annual Catalogs of Federally funded projects 1978-84 (Pubs & DB)
Federal Plan for Marine Res., Dev., & Monitoring, 1985-89 (Pubs)

NERRS - *National Estuarine Reserve Research System*
Estuarine Research Project Abstracts, PI & $ (Pub in press & DB)

NMFS - *National Marine Fisheries Service*
Headquarters & Regional Activities

EPO - Estuarine Programs Office
Coordination of NOAA roles/involvement in the national estuaries (Pubs)
NOAA FY1984 Estuarine Projects Catalog (Pub & DB)

Strategic Assessment
National Estuarine Inventory and Data Atlas (Pubs & DB)

Status and Trends
Estuarine and Marine Monitoring Programs (DB)

NTIS

National Technical Information Service *(DBs)*

OPDIN Access to System Resources

The Network initiates and maintains access and/or referral to over seventy federal systems actively involved with marine pollution data and information. A "Handbook of Federal Systems and Services for Marine Pollution Data and Information" (CCRO, 1985a) was first designed and completed in 1983, with subsequent updates occuring on an annual basis.

The Handbook briefly describes the characteristics of the above systems including: scope of service, role/purpose, types of data/information available, quantity of data/information, means of access, determination of relevant data, response time, approximate costs, hardware and software, storage media, related systems, and principal contact.

Most of the systems described in the Handbook are in some part repositories for coastal and estuarine data and/or information. These systems can be placed under two catagories; NOAA

FIGURE 4

ACCESS TO INTERAGENCY RESOURCES

USDA	*AGRICOLA - Agricultural Online Access* *CALS - Current Awareness Literature Service* *CRIS - Current Research Information System*
USCG	*CHRIS-HACS - Chemical Hazards Response Information System/ Hazard Assessment Computer System* *PIRS - Pollution Incident Reporting System*
EPA	*STORET - Water Data Storage and Retrieval System* *CBP - Chesapeake Bay Program Computer Center* *ODES - Ocean Data Evaluation System* *PCS - Permit Compliance System*
NIH	*MEDLARS - Medical Literature Analysis and Retrieval System* *MICRO-IS - Microbial Information System*
NAVY	*NEPSS - Naval Environmental Protection Support Service* *MESO - Naval Ocean Systems Center*
ARMY	*WES - Waterways Experiment Station*
USGS	*WATSTORE - National Water Data Storage and Retrieval System* *NAWDEX - National Water Data Exchange*
FWS	*National Coastal Ecosystem Team, Slidell, LA*
MMS	*Regional OCS Offices*
DOE	*OSTI - Technical Information System*

and other Department of Commerce (Figure 3), and other Federal system resources (Figure 4).

During FY87, the Handbook will be automated to facilitate more timely and efficient searches of its contents in response to user requests. An outreach effort is already underway to identify and describe those Federal systems for marine pollution data and information that have, to date, escaped the awareness of the Network.

OPDIN Evolves with its User Community

In 1982, the first year the Network was routinely responding to customer requests, less than one hundred requests were serviced. OPDIN requests have nearly doubled each year since 1982. In an effort to statistically characterize and evaluate the needs of this growing user community, an automated 'Customer Service Reporting System' was designed and implemented on a personal computer in 1985.

A customer service report form was designed that contains attribute fields useful for statistical evaluation of Network efficiency and the user community. These fields include:

* customer name
* address
* customer class
* contact type
* expected use
* type of products
* output media
* area of concern
* pollutants considered
* data/info files referenced
* response time
* cost information

These forms are completed at the time of request and entered into the data base on a monthly basis. Quarterly statistics characterizing the user community are compiled and interpretation of these results are reported annually (CCRO, 1985b). Network resources are enhanced to facilitate better response to priority subjects identified from the quarterly statistics. New initiatives are formulated to meet projected user community concerns.

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Abstract only

COASTAL WETLANDS - USES OF A GEOGRAPHIC INFORMATION SYSTEM

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Since 1980, the National Coastal Ecosystems Team (NCET) has implemented a Geographic Information System (GIS) in coastal resources planning and management projects. The GIS comprises three subsystems: the Analytical Mapping System (AMS) used for data entry, the Map Overlay and Statistical System (MOSS) used for data base management and analysis, and the Cartographic Output System (COS) used for creating high quality map products. Digital data bases at NCET generally are comprised of historical (1950's wetlands habitat maps), 1970's and 1980's wetland data bases, and special project data (bathymetry, bottom sediments, and land use). The GIS applications developed at NCET fall into three categories: 1) resource inventories, 2) wetland change analyses, and 3) cartographic modeling.

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Abstract only

INFORMATION SYSTEMS FOR ESTUARINE AND COASTAL DATA MANAGEMENT

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Several Information Management systems have been developed which integrate management, bibliographic and scientific data utilizing microcomputers. These systems are designed with readily available hardware and commercially available software so that they are relatively inexpensive to implement and operate. One such system was implemented on a microcomputer system with two distinct levels. The first level contains the data base programs, a general information file, a bibliographic file and a condensed data file with scientific and management information. The second level consists of a minicomputer or mainframe data base which is accessed through the microcomputer system. The distributive data base design makes available a large variety of data on a single system. Integration with other software such as geographic information systems (GIS) and statistical and modeling packages results in a powerful tool for coastal and estuarine information management.

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Abstract only

ENVIRONMENTAL INFORMATION MANAGEMENT ON A PERSONAL COMPUTER

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Information management is often considered in terms of large computer systems, such as mainframes or at least minicomputers. However, with the advances and sophistication available in personal computers, it is possible to have a complete system for environmental information for a coastal area contained within a desk-top computer. Two such systems have been developed, and a third is being planned. The systems are intended to provide a rapid screening capability for planners and decision-makers, but they are not intended to supplant data management systems, nor more elaborate geographical information systems.

Under a combination of federal or private foundation funding, the first prototype system was developed for information from the Port of New York and New Jersey, and the second system was developed for the Port of New Orleans. Space-specific and use-specific information on local ports, estuaries, facilities, etc. is available for both areas, as well as general information, references, and a glossary of terms. The systems were developed at the State University of New York at Stony Brook, using the capabilities of the commercial software Lotus 1-2-3. For both systems, specific regional information requirements were identified, as well as sources. The specific acquisition of the data and entrance into spreadsheets followed. Output programs and products were written next. In the final task, the system was documented.

Because of the current high level of interest by the public, and by state and federal governments, the third system being planned is one for the Chesapeake Bay. The system will attempt to incorporate information on many of the concerns identified in the Bay Restoration Plan, such as point and non-point nutrients, dissolved oxygen, toxic substances, living resources, fishing areas, etc. The system will enable the user to explore relationships between problems and possible causes.

EDUCATING DECISIONMAKERS

William Eichbaum, Chair

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HOW WELL DOES SCIENCE SERVE MANAGEMENT

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The Narragansett Bay Project (NBP) provides a rich opportunity to observe the tensions which develop when scientists are funded to provide the information base to support a management plan. The NBP is authorized by the Water Quality Renewal Act of 1984 to spend $1,500,000 each year for the four fiscal years beginning in fiscal 1985. The Water Quality Renewal Act is quite explicit in its statement (in Sec. 46b) of the purpose of grants from these funds:

> "The Administrator shall...make a grant for purposes of assessing the principal factors having an adverse effect on the environmental quality of the Narragansett Bay, as perceived by both scientists and users, **in conjunction with developing and implementing a management program** to improve the Bay's water quality....The applicant will...**not later than three years after enactment of this section, implement management practices**..." (emphasis supplied)

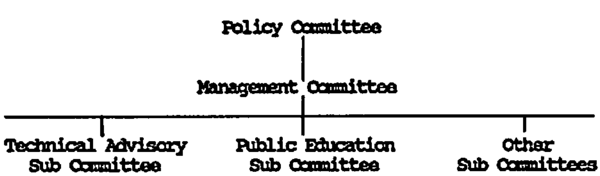
It is important to notice two points particularly in the legislation: that the word "research" nowhere appears in the authorizing legislation and that the results of the NBP are expected to be applied almost immediately, far faster than basic research typically can reach fruition. Congress was as clear as it could have been that these funds are to be used for applied work and not for basic research.

Public statements and interviews with several individuals concerned with the NBP reveal two very different views of the proper method of responding to the Congressional instruction. One, which we will call "Science First" holds that the preferred approach is to gain the best possible understanding of the physical and biological systems which operate in the Bay. This understanding provides the basis for prediction of the effects of changing any important parameter, such as the input of partially treated wastewater, which in turn allows the design of a mangement program. Such a comprehensive understanding, by comparing trends in measured parameters with baseline data, also could predict "lurking dangers" which, without attention, may develop into tomorrow's crises. With forewarning, mitigative or preventative action might replace the crisis management that preoccupies most environmental agencies today. From an agency perspective, this approach has the important advantage that it does not require overt political judgments. Management goals and the institutional structures to implement them can follow, and need not precede the scientific and technical work.

To hold the "Science First" perspective requires a sincere scientific optimism; a belief that a system as complex as a large estuary can be understood at the predictive level. Although our sample is small to generalize, we mention in passing that we observe that this hopeful view is held by administrators who have not been trained as basic scientists and by basic scientists themselves. They differ importantly, however, in the time scale of their optimism; with scientists expecting to reach a working model of an estuarine system only after many years of intensive research effort, while administrators expect predictive models much more quickly.

We call the opposing model "Policy First". Here management goals are defined first and then strategies to reach these goals are devised. Priorities for assembling exisiting information and generating new information are set by the need to select among and to refine these strategies. While "new knowledge" may be discovered in this process, it is an incidental bonus and not an intended outcome; no science is done for the sake of science alone. The focus is immediate and performance of contractors is judged by how directly and powerfully their results aid in reaching management goals. Individuals trained in the sciences who have significant management experience and students of policy science seem more likely to hold this view. These people are not hopeful that a predictive scientific model can be devised in the near-term (in the case of the NBP, within three years), and they do not believe that management can wait for the completion of the ultimate experiment.

To understand which model best describes the NBP, it is instructive to look first at the management structure, as set out in the first year's workplan:



The Policy Committee has two members, the Administrator of EPA, Region I, and the Director the the Rhode Island Department of Environmental Management. While this Committee retains final control, it is not intended to exert direct and sustained control of the NBP. This role is assigned to the Management Committee, a broadly based Committee, with representatives from user groups, environmental groups, municipal government, industry and federal and state management agencies. In the first fiscal year, and up to the time that the Management Committee was asked to approve the workplan for the second fiscal year, that Committee had not itself derived explicit management goals for the NBP. Instead, the Technical Advisory Committee (later called the Scientific and Technicial Advisory Committee), in close consultation with NBP staff, prepared a workplan and Requests for Proposals (RFP's) which were approved with only minor modification by the Management Committee. Initially, no funds were allocated for policy studies, but near the end of the funding decision process, proposals were solicited for first one and then two policy studies. Significantly, the Scientific/Technical Committee found itself unqualified to review policy proposals, and the Management Committee created an ad-hoc Policy Issues Committee from among its own members to review these proposals, none of whom are formally trained in policy formulation. By contrast, the members of the Scientific and Technical Committee were chosen carefully to represent the highest level of technical skills available to the Project. Not surprisingly, less than 5% of the program funds in the first fiscal year were devoted to policy studies.

Requests for Proposals for Fiscal Year 1986 were generated in a manner similar to the previous year. The Management Committee still had not adopted explicit management goals to guide its sub-committees. The Scientific and Technical Committee, working closely with the NBP staff, recommended technical RFP's and the ad-hoc Policy Issues Committee suggested areas for policy research. When these reached the Management Committee, the Committee recognized that there was virtually no connection between the recommendations of the two committees. This recognition provided the impetus for several lengthy meetings which resulted in identification of eight "Management Questions for Narragansett Bay" and the Management Committee agreed to use these Questions as guides for RFP review.

Two distinct approaches for the selection of projects to address these Management Questions are likely to follow depending on whether the initiative is taken by the Management Committee or by its subcommittees. If the Management Committee sets the agenda, it can, after considering the goals it has set, ask for the projects which promise to provide the most signficant progress toward answering the questions that have been posed. Because this approach tries to get the most information for the resources available; this might be called a "maximizing" approach. On the other hand, if a sub-committee takes the initiative by submitting RFP's and workplans for approval, then the test will be whether the proposed research is relevant to the question at hand. Given the breadth of most questions relating to the management of complex systems, relevance is not difficult to establish, and thus this test might be called a "satisficing" approach.

The NBP Management Committee, perhaps because it faced time constraints because it delayed so long in articulating its Management Questions, clearly following the "satisficing" path. The Scientific and Technical Committee did not modify its recommendations in any way to respond to the Management Questions, and discussion centered on degree of relevance, not on whether more productive projects could have been proposed. However, with the Management Questions before it, the

Management Committee did slightly reduce the funds allocated to science and for fiscal year 1986 approximately 10% are allocated to policy-related investigations.

Given the clarity of the Congressional instruction and the immediacy with which NBP results must be applied, we looked for the forces that took the NBP in the Science First direction. Comments by contractors for fiscal year 1985 and by NBP staff in public meetings and in interviews make clear that professional incentives are a major factor. We were told of the importance of publishability and of peer recognition and that both were more likely to follow from the discovery of new knowledge than from the shaping of existing information into a form needed for management use.

Another, more interesting factor which favors the Science First track is the self-perception of the contractors and of their conception of the appropriate use of their work. One contractor whose work was the updating of a biological model of the Bay held out little hope that it would ever serve as a predictive model, because it was not yet able even to describe the current state of the Bay. The most interesting use of the model, the researcher thought, was to uncover basic misunderstanding of ecological connections. In the discussion of first year results, other contractors were reluctant to speculate about possible use of their results for management purposes. Most contractors did not even attend a round-table discussion intended to share results and to explore applications. The Chair of the Scientific and Technical Committee, in addressing contractors, focussed squarely on this issue: "You will be asked blunt questions which are not exactly what we call research; if we can somehow link our research to these blunt questions, we will be successful."

It appears that the NBP Management Committee is beginning to move more toward the "maximizing" approach as it nears the time when it must consider the fiscal year 1987 program. Recognizing that it was not substantively prepared to take the initiative in setting the investigative agenda, the Committee has been educating itself at the last several monthly meetings by inviting speakers in areas related to Management Questions. The Committee also has agreed to participate in an extended mediation session to clarify management goals and strategies to reach them. There is reason to be hopeful that the NBP increasingly will encourage its contractors to structure their work to ease management implementation.

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TAKIN' IT TO THE STREAMS
A REVIEW OF EFFORTS TO PROTECT WATER QUALITY IN COASTAL NORTH CAROLINA

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The development of North Carolina's coastal area was as slow as the flow of the waters in the coastal streams until the 1970's. That decade brought a surge of growth that continues into the 80's. This growth is concentrated on the water's edge, for the beautiful character of these coastal waters draws vacationers and retirees alike.

In response to this growth, in 1974, the North Carolina General Assembly passed the Coastal Area Management Act (CAMA) to "provide a management system capable of preserving and managing the natural ecological conditions of the estuarine system, the barrier dune system, and the beaches, so as to safeguard and perpetuate their biological, economic and aesthetic values." In pursuit of this goal the Coastal Resources Commission (CRC) identified areas of environmental concern, established use standards for their protection, and established a permitting system. In order to preserve the estuaries, the state had previously adopted a dredge and fill act in 1969; these existing standards for protection of wetlands and the waters were incorporated into this new CAMA permitting program.

The Commission focused most of its initial efforts on the ocean hazard areas and developed one of the best "oceanfront" programs in the country. The process of developing ocean hazard area standards was time consuming, yet it followed a logical progression--existing oceanfront structures were being threatened and public beaches destroyed by erosion, therefore, indicators of the susceptibility of areas to erosion were studied. Setbacks and development standards were adopted to guard new development against these problems. As years of working with these rules went by, the Commission made modifications to address and correct any problems they experienced. The "soundside" of the program was aimed at development in the marshes and the waters, virtually ignoring the impacts of shoreline development.

The causes of the degradation of water quality were not as easily grasped <u>in toto</u> as were the oceanfront problems and thus were addressed in a less unified approach. Another reason for this approach was that the Dredge and Fill Act had been initially implemented by another commission, and the Coastal Resources Commission did not feel comfortable with these issues. During the period of 1978-1984, the Commission dealt individually with three major water quality issues, but with limited success: septic tanks, marinas and peat mining. Although the CRC was sincere in its efforts to address these issues, other authorities had historically primary jurisdiction over the activities.

The reluctance of the CRC to focus on the soundside continued even though the Coastal Area Management Act contained a charge to manage water resources "in order to preserve and enhance water quality and provide optimum use of water resources." In 1984 the CRC appointed a water quality task force to determine their scope of authority to deal with pollution issues. This group informed the Commission that they had broad powers to control development to achieve the water quality goals of CAMA.

The attempt to resolve these issues, then, pointed out a major institutional obstacle to dealing with water quality problems: various aspects of water quality were and continue to be regulated by three different agencies, with policies and regulations adopted by three different Commissions--the Environmental Management Commission develops numerical water quality standards and permits treatment plants and other discharges; the Commission of Health Services is responsible for sanitation, septic tanks and shellfish; and the Coastal Resources Commission is responsible for regulating development in and adjoining the coastal waters and guiding local land use planning. Another authority, the Marine Fisheries Commission, also has a major role in reviewing permit applications for their effect on living resources. Until recently, however, only the Coastal Resources Commission had focused on the peculiar nature of estuarine pollution. Because each commission's job was fairly rigidly defined, non-point source pollution of the estuaries, the largest problem now apparent in coastal water quality, was falling between the cracks.

<u>Problems with the Problem</u>

Addressing the problem of coastal water quality with the Coastal Resources Commission has been complicated, to say the least. First, estuarine ecology and hydrology are so complex that it takes a good deal of education to bring decisionmakers (in this case citizen commission members and appointed department heads) to a workable understanding of the issue. The backgrounds of the commission members and the lobbying efforts of special interest groups both cloud and complicate the issue.

Because coastal non-point sources range from urban runoff to agricultural runoff, a comprehensive effort which addresses the various sources is needed to solve the problem. The fact that a comprehensive effort is needed to deal with non-point source pollution is itself a problem in that decisionmakers are often more comfortable dealing only with strict numerical standards for discharges from pipes.

Because a comprehensive solution was needed, program administrators felt education efforts must be equally inclusive. The process began with a water quality task force which identified several areas of study, then, a series of roundtable discussions with participants from all walks of coastal life was held in three coastal locations. The participants identified eight issues for further work. The CRC endorsed the roundtable report and asked other commissions and agencies to help in addressing the issues. The first issues to be addressed were marinas (which the CRC could and did address alone) and stormwater management.

An intercommission task force was established to coordinate the stormwater efforts. An integrated approach involving all of the commissions was clearly necessary. Certain elements of the non-point source problem were well suited to being addressed through the land use controls of the CRC, yet a number of contributing sources were regulated by the other commissions. Unfortunately, the task force did not work effectively because all of the members of the various commissions did not immediately see the need for changes.

Not wanting to let the matter drop, the CRC started to address the issue unilaterally. General water quality policies were drafted and discussed. Since no one spoke in opposition to the policies at public hearings, they were quickly adopted.

Unlike the oceanfront erosion issue of previous years, however, the commission did not feel that they had a suitable understanding of the issues associated with stormwater runoff. The staff collected and analyzed all available research. They attempted to look at all of the problems, their causes, and the potential solutions in light of the complex coastal ecological system. They prepared extensive reports on the problem, as they did for the oceanfront, yet no easy, precise solution surfaced. Staff advised that all available research indicated that controlling the amount of impervious surface near coastal waters would be the most effective runoff management strategy. Impervious surface limits would also be similar in type to the other land use controls administered by the Coastal Resources Commission, would fit into their existing jurisdiction and would be easier to administer. Unfortunately, there was no single density standard or shoreline setback offered by researchers which would solve all problems. Developers demanded to know how much of the total water quality problem was due to development and wanted to be shown that any rules would actually protect water quality. The only argument that staff could offer was that density controls and setbacks would help the situation. There was in fact no proof that land use controls would work satisfactorily to prevent violations of ambient water quality standards. Voluntary best management practices combined with education might well be the best solution in the long run, yet some reasonable rules were needed immediately, as the problem would get progressively worse while regulators waited for the perfect standards. Applying non-point source controls to already developed lands would be extremely expensive if not impossible.

No one associated with these efforts expected the Commission to completely solve the stormwater runoff problem. Like the oceanfront standards, the goal was to keep the problem from getting worse--to help stop the decline of the estuarine resource and encourage other state and local decisionmakers to become involved in reversing the trends in water quality. For a commission to adopt restrictions on the use of private property, however, they must be convinced that the regulations are appropriate.

Subsequent to these CRC discussions the Environmental Management Commission decided to address the issue. Their approach was a combination of land use density controls (with which they had little experience) and engineering criteria which were similar to the approach used in their point source control programs. The draft rules of the Coastal Resources Commission had purposefully excluded engineering solutions because they would be extremely difficult to permit and monitor and would almost surely fail in the coastal area, which has either extremely porous soils or nonporous mucky soils, and very high water tables.

Once again, no perfect solution was found. The Environmental Management Commission eventually adopted rules for density and setbacks, as well as an option for holding or treating the runoff from a certain design storm. The jurisdictional area was set by political compromise rather than by scientific data. Fortunately, their action also called for more research on the subject so that the rules may be refined as more solid data becomes available. But the first step has now been taken. The CRC is now working to reinforce and support the action of their sister commission, but it may be years before any evidence of water quality improvement from these actions is apparent.

Attacking on All Fronts

Because of the comprehensive nature of the problem, the efforts to improve water quality in the estuarine system cannot focus entirely on state regulation of development runoff, especially in a state where only a small percentage of the shoreline is developed. To this end, the North Carolina General Assembly has set up a fund to share with farmers the costs associated with implementing best management practices. The various water quality agencies also have developed working agreements to implement the water quality policies.

The Coastal Resources Commission has also instituted a land use planning outreach effort. Plans for the 75 local governments in the coastal area already include analysis of present resource conditions, policies for resource protection, and policies identifying land uses ranging from conservation to urban development. Each local government is encouraged to address water quality concerns in their land use plans and coastal management staff attends local planning board meetings to advise them. Staff emphasizes how much each community depends on clean water--for tourism, fisheries, and other livelihoods--and that it is to their own advantage that they help clean up the water. A recognition by local leaders that there is a hard to define "way of life" that may be lost is an important ingredient. Staff also notes that it is each communities responsibility not to contribute to the problem and that when coastal communities "clean their own house" they can demand that upstream communities also clean theirs. The local board members are also reminded that shore lands, if planned and developed for water quality management, can also serve other purposes, such as minimizing flood hazards, preserving open space and wildlife habitat, and providing recreational areas. A handbook on water quality aimed at local government officials has also been widely distributed. This guide outlines the basics of estuarine ecology and water pollution, and tells what local planning and regulation can do to contribute to solving the non-point pollution problem.

Local governments have responded to the outreach effort by adopting policies which expand on state efforts. Several local governments have adopted waterside buffers to keep development away from the coastal waters. Others have adopted impervious surface limits for their entire jurisdictions in an effort to reduce runoff.

The CRC has also adopted resolutions asking the state's educational institutions, the Soil Conservation Service and other groups to participate in the water quality effort. The effort will continue indefinitely, as the other water quality issues are identified and addressed.

Lessons

All indications are that relying on the old methods of state agencies enforcing numerical effluent standards for point sources will not completely protect estuarine water quality. Non-point pollution will continue to cause water quality degradation.

All available information must be used to address the problem. Unfortunately, research will never be complete to everyone's satisfaction. Developers call for the exact information about their specific site and do not want to rely on generic research. A cry for more research also can be used to stall the adoption of regulations until the specific projects can be completed. Similarly, the efforts to show that some groups (e.g. agriculture and forestry) are not being adequately regulated can be used to show that no groups should be regulated until all can be regulated equally.

The best method of protecting water quality appears to be water management, which must also include comprehensive land management. Traditional state water quality agencies are not geared toward, and may not have legislative authority to deal with land management. Nevertheless, regulations by authorized agencies within each group's jurisdiction and authority will be necessary to manage development until voluntary measures are taken.

The best way to ensure land and water management in the long run is by focusing on the smallest unit possible, whether the local government or the local person. Unfortunately, because the gospel of land and water management must be spread to so many individuals, it will take a long time to accomplish. The best role of the state and federal governments is to regulate in the short term, continue studies, develop guidelines and, perhaps most importantly, fund educational programs.

In conclusion, it appears that precise standards on which to design comprehensive water quality programs are not forthcoming. The primary objective must be to educate the public at large that they can help to bring about improved water quality through improved land and water management. If decisionmakers can also learn this one small lesson, the attainment of the goal of protecting and improving coastal water quality will be made immeasurably easier.

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EDUCATING DECISION MAKERS: INTERGOVERNMENTAL RESOURCE MANAGEMENT PROBLEMS IN CHESAPEAKE BAY

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In dealing with any large, complex management problem, such as restoring the water quality and habitat value of the Chesapeake Bay, there will be a large number of jurisdictions involved. Inevitably, jurisdictions will differ in their approaches to solving specific management problems. In developing a coordinated, consistent approach to managing such a system, the supply of information about the status of the resource, and about the effectiveness of control strategies becomes vital. While a consistent information base is not sufficient to result in consistent management approaches among jurisdictions, it is a necessary element. Jurisdictions with more information about a particular resource problem are more likely to respond. Improving information availability can produce one of two results: action can be taken to reconcile management approaches to make them more equal, or the wisdom of divergent approaches can be explained by a better understanding of true differences in the status of the resource.

The estuarine portion of the Chesapeake Bay is divided almost equally between the two states of Maryland and Virginia. While the basin which it drains encompasses four other states and the District of Columbia, it is these two states which have the longest history of involvement with Chesapeake Bay management. The two states have often differed in their management programs. I hope to show that these differing approaches are based in part on on differences in the information available to the states and in part on true differences in the status of the resource.

The Chesapeake Bay Commission was formed in 1981 to coordinate legislation and policy decisions between the States of Maryland and Virginia as they relate to Chesapeake Bay.[1] In 1985 it was enlarged to include Pennsylvania.[2] The Commission is largely legislative in orientation; fifteen of twenty-one members are state senators or delegates. Because of its makeup, the Commission focuses primarily on those things which legislators either do - such as introduce legislation and approve budgets - or acquiesce in, such as adoption of controversial regulations.

When the Commission was first formed, there was a perception that one of its main functions would be to make the legislation in the two states - Maryland and Virginia - more uniform. The original focus was on fisheries management. As the Chesapeake Bay Program studies drew to a close in 1983, environmental quality became more of a focus. On both fronts, uniformity has proven to be an elusive, and, perhaps not worth while, goal. Today, the Commission is concerned that state responses to common problems are consistent and are of equivalent effectiveness. Other papers on Chesapeake Bay this volume have documented the tremendous amount that the Chesapeake Bay region's governments and citizens have been able to accomplish so far in terms of new legislation and budget initiatives, and innovative programs.

In many subject areas, Maryland and Virginia, and also Pennsylvania and the District of Columbia, have been able to agree on a common set of problems and solutions. This common set of problems and solutions is almost wholly based on information and recommendations emanating from the seven year $27 million EPA Chesapeake Bay Program,[3] and an excellent job of communicating the study's results. Improved sewage treatment, agricultural best management practices cost share programs, monitoring of living resources and water quality, chlorine removal and planting submerged grasses have all gotten substantial boosts.[4]

I will focus, however, on some areas of divergence, and the role scientific or management information - or the lack of it - has played in that divergence. I will use three examples: (1) sediment control, (2) coastal land use, and (3) striped bass management. In each of these three areas the availability and type of information accessible have played a role in the differing positions taken by the two states, and particularly by state legislators.

It is necessary to point out that there are other factors, which are of equal, and in many cases, much greater importance in influencing the shape of legislative action. Deep rooted philosophical differences in the role of government in problem solving, differences in the geographical distribution of legislative districts, and real physical differences in the nature of the environmental problems facing each jurisdiction do exist. Nonetheless, information availability has played a not insignificant role.

The first illustration I will use is sediment control. In the early 1970's, both Maryland and Virginia enacted laws which required a sediment control plan to be prepared and approved by local authorities prior to any land disturbance for development purposes.[4] Both were patterned closely after national model legislation and were very similar in intent, scope, and implementation mechanisms. There was one vital difference. The Maryland law required the state Department of Natural Resources to periodically review each local government's program, including an assessment of how well the law was being enforced. The Virginia law only required that the state Division of Soil and Water Conservation review each local government to ensure an adequate ordinance had been adopted. Neither state had the authority to enforce the law if it were not being adequately carried out.

In Maryland, the small state staff carried out their reviews diligently. Despite periodic improvements in the state Act, and despite years of technical assistance, and tactics such as threats and public ridicule toward those jurisdictions with poor records, the Sediment Control Law remained one of Maryland's most flagrantly ignored environmental laws. Over time a very damaging record of noncompliance with the Act and non-enforcement by local governments was established. Statewide a majority of sites were found to be out of compliance at any one time.[5] Results of the reviews were widely publicized. As a result, as part of the Maryland Bay "package" of initiatives, legislation transferring authority for enforcement of Sediment Control Law from local governments to the state was proposed in 1984. The legislation passed easily in both houses of the Maryland General Assembly.[6]

Chesapeake Bay Commission members suspect that sediment control is every bit as much an enforcement problem in Virginia as it was in Maryland prior to the 1984 law. But since no state agency has been charged with evaluating the quality of local government enforcement, the "proof" of such a problem is merely anecdotal. Surveys of local Erosion and Sediment control ordinance administrators and of Soil and Water Conservation Districts have revealed that most believe that enforcement is a problem.[7] No data exists, however, on how many violations are occurring statewide. As a consequence, the only action so far accomplished legislatively in Virginia has been the enactment of a law allowing local governments to issue stop work orders as an enforcement mechanism.[8] This is a provision which, of course, had strong local support, the only opposition coming from the building industry. Stronger state action would require a better documentation of the extent of the enforcement problem.

Land use legislation is another area in which the two states diverge. Coastal land use legislation protecting a 1000 foot strip next to the water's edge was introduced in Virginia in 1978.[9] After passing the Senate, much amended, it was defeated in the House Conservation and Natural Resources Committee by a vote of 9-11. As a result of this and other frustrations experienced in trying to develop a coastal management program to comply with the Federal Coastal Zone Management Act, Virginia temporarily curtailed efforts to develop a coastal management program (a program was submitted in 1985 and approved in 1986). The 1984 Virginia Chesapeake Bay Initiatives did not contain any land use control legislative proposals.

Legislation similar to the 1978 Virginia bill, but more restrictive - the Chesapeake Bay Critical Area Act - was enacted in Maryland in 1984.[10] While it was a highly controversial proposal the legislation passed with a significant majority in both houses. The protection of shoreline areas through this bill was successfully sold as a necessary element of the Bay Restoration effort. A vote against the bill was viewed as a vote against the Bay.

Timing, surely, had much to do with the failure of the Virginia bill in 1978 and the success of the Maryland bill in 1984. Information developed through the Chesapeake Bay Program in the interim more clearly established the relationships between land use and water quality, and 1984 was a time of enhanced public awareness of the need for action to restore the Bay's health. But beyond that, the actual documentation of development patterns and problems in Maryland was much more highly developed. Seven years of federal Coastal Zone Management funding to Maryland had also resulted in more complete inventories of shoreline land uses, assessment of local land use activities, and information on the impacts of individual development projects.

Resource managers in Maryland have a tendency to belittle the land use information base that is available through the Maryland Automated Geographic Information (MAGI) system, but in fact, that land use information base in much better than that of many other states in the Chesapeake Bay region. It was possible in Maryland to produce maps, which, at least on a gross scale, showed how coastal land was being devoured for residential and commercial use, and to equate areas of high growth to areas of reduced water quality. This was possible because of a geographic information system, the existence of state required county water and severage plans and numerous resource inventories conducted by the coastal zone management program.

It was also possible in Maryland to point to land use control activities which did <u>not</u> work to preserve the Bay: a series of "cooperative" programs such as the state land use plan, the authority of the Department of State Planning to intervene in, but not overrule local decisions, and the "network" approach to coastal zone management could all be demonstrated to have been ineffective at controlling the impacts of growth.[11]

Virginia does not have a department of state planning, or any other agency which is charged with keeping track of growth and development. It would be impossible, at this point, to map the tidal shoreline of Virginia, showing how much of that land had been converted from one use to another over the last ten years.[11] The impacts of growth, while obvious in Fairfax and Virginia Beach, cannot be documented on a statewide basis. Further, since many counties have only recently adopted zoning, and only recently has a "networked" Coastal Zone Management Program been established, there is no record of failure of these other approaches within the state.

A final example is in the realm not of environmental protection but fisheries management. Striped bass have declined drastically since the mid-1970's. An interstate plan[12] to restore the population has been based largely on one piece of information, the juvenile index. This index measures the number of young fish found in the prime spawning and nursery areas in Maryland each year, and has been shown to be a good predictor of commercial harvest three years later. It is, thus, considered and indicator of reproductive success.

This juvenile index fell from a high of 30 in 1970 to a low of 1.3 in 1983, remaining low from the mid 70's to the present. This together with greatly reduced commercial landings, led to a moratorium on striped bass fishing in Maryland in order to preserve the species.[13] This moratorium was administratively, not legislatively imposed, but required the acquiescence of a large number of legislators, such that bills removing the moratorium would fail. The moratorium came after results of the juvenile index had been highly publicized for years as the measure of the health of the Chesapeake Bay striped bass stock, and after the Department of Natural Resources in Maryland had gone to great lengths to explain the importance of this index to legislators, fishermen, and the general public.

Virginia had for several years - although not as long as Maryland -made its own survey of juvenile striped bass. It was until recently conducted by different methods, and did not show the same drastic downward trend. The principal scientific advisors in Virginia argued to the Virginia Marine Resources Commission and to the legislators and public that reproduction was not as critically low in Virginia rivers as it was in Maryland, and that less restrictive measures would suffice.[14] Virginia has imposed regulations which keep it within the strictures of the interstate management efforts of the Atlantic States Marine Fisheries Commission, but has resisted a moratorium.

Most of us are not in a position to deal with many of the underlying causes of divergence in political action taken by the various participants in a multijurisdictional resource management activity. We cannot change geography, and deep seated philosophical views on the role of government in resource management change only very slowly over time. We can, however, work to rectify inconsistencies in the quality and type of information available to decision makers.

The Chesapeake Bay Commission, is, in each of the examples noted above, working to rectify information gaps that it sees as barriers to effective actions. In 1986, the Virginia General Assembly called for an on-the-ground assessment of the quality of local implementation of the Sediment Control Law. That assessment is being conducted now. Also initiated in 1986 is a Land Uses Roundtable, a blue ribbon panel which will spend 18 months examining coastal land use problems in Virginia and make recommendations to the 1988 General Assembly. Calls for collection of consistent striped bass juvenile survey information by the two states have resulted in reconciliation of the two methodologies. The result confirms that trends in reproductive success are indeed different in the tributaries of the two states, and that problems are indeed much more severe in Maryland.

These examples demonstrate, I believe, that while a consistent information base will not cause consistent and equivalent political action, consistent action is not possible without it. The success or failure of legislation designed to improve sediment control and land use management in Virginia over the next several years will be one measure of its importance.

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[1] "Interstate Agreement on Chesapeake Bay." Annotated Code of Maryland, Natural Resources Article, Title 8, Section 8-302, 1983 Repl. Vol. and 1986 Cumm. Suppl. and Code of Virginia, Vol. 9., Title 62.1-69.5 through 62.1-69.20. 1982 Repl. Vol. and 1986 Cumm. Suppl.

[2] Laws of Maryland, 1985, Chapter 300. Acts of the Virginia General Assembly, 1985, Chapter 149. Acts of Pennsylvania, 1985, Chapter 25.

[3] U.S. Environmental Protection Agency. Chesapeake Bay: A Framework for Action. Philadelphia: 1983.

[4] Virginia Erosion and Sediment Control Law. Article 6.1, Sections 21-89.1 et seq. Vol. 4A, Code of Virginia. 1983 Repl. Vol. and 1986 Cumm. Suppl. Maryland Sediment Control Law. Natural Resources Article, Title 8, Subtitle 11, Annotated code of Maryland. 1983 Repl. Vol. an 1986 Cumm. Suppl.

[5] Chesapeake Bay Commission, Choices for the Chesapeake: the First Biennial Review of the Action Agenda: Work Grop Reports. Annpaolis, MD. 1985.pp 56-57.

[6] Section 8-1103, Annotated Code of Maryland, Natural Resources Article, Title 8, Subtitle 11. 1986 Cumm. Suppl.

[7] Report of the Chesapeake Bay Commission to the Governor and General Assembly of Virginia. House Document No. 28. Richmond, VA, 1985. pp 21-25.

[8] Acts of the Virginia General Assembly, 1986, Chapter 328.

[9] Virginia Senate Bill 403. 1978.

[10] "Chesapeake Bay Critical Area Protection Program," Annotated Code of Maryland, Natural Resources Article, Title 8, Subtitle 18. 1986 Repl. Vol.

[11] For a description of Maryland land use regulatory mechanisms, see Chapter VII. of the Maryland Coastal Zone Management Program. Maryland Department of Natural Resources, Annpaolis, MD. 1977.

[12] Atlantic States Marine Fisheries Commission. Interstate Fisheries Management Plan for the Striped Bass of the Atlantic Coast from Maine to North Carolina. 1980.

[13] Maryland Register, Vol. 11, Issue 22, October 26, 1984. pp 1907-1916.

[14] Herbert M. Austin, "Status of the 1985 Striped Bass Fisheries in Virginia after Implementation of the 1985 Amendment III to the 1981 ASMFC Interstate Management Plan for Striped Bass. Virginia Institute of Marine Science, Marine Resource Report N. 86-3, Gloucester Point, Virginia, 1986, and "Striped Bass 24 Inch Size Limit in Virginia," Unpubl. Report to the Virginia Marine Resources Commission, Newport News, VA, September 16, 1986.

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Abstract only

THE AQUATIC HABITAT INSTITUTE: A NEW CONCEPT IN ESTUARINE POLLUTION MANAGEMENT

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In order to preserve the beneficial uses of an estuary, many disparate sources of pollution to the estuary must be properly managed and controlled. The management of these sources is a highly controversial process that involves a series of scientific and policy/legal judgments concerning the degree to which each source must be controlled and/or reduced. Generally, this process is disorganized with dischargers, regulators, and environmental groups each generating their own scientific information base for use in the political/legal process. Not surprisingly, there is often substantial disagreement among these sets of information and their interpretations. Because managers do not have the ability to resolve the differences found in the available scientific information, management decisions are often made on strictly political/legal grounds without adequate scientific justification. The San Francisco Bay-Delta Aquatic Habitat Institute (AHI) is pioneering a new approach to estuarine environmental management. AHI is a nonprofit corporation designated by the State of California to act as a permanent focus for coordinating all Bay research and monitoring resources and to provide interested parties with coordinated and complete scientific information on the effects of pollution on Bay habitats and organisms. The unique feature of AHI is that its Board of Directors has balanced representation from industry, environmental groups, municipal dischargers, and local, state, and federal government agencies, while remaining totally independent of each of these entities. AHI has developed, and will maintain, a consensus among these interest groups concerning needed research and monitoring, and provides a mechanism for a future consensus on the cause-and-effect relationship between pollutants and adverse environmental effects and on the degree to which there is scientific certainty, or uncertainty, in our knowledge of these effects. If achieved, this consensus will simplify the subsequent policy/legal aspects of the management process and insure that better, scientifically-based management decisions are achieved. Considerable progress toward this goal has already been accomplished.

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DEVELOPING A TECHNICAL PROGRAM TO SUPPORT ESTUARINE MANAGEMENT: A COMPARISON OF THREE NORTHEASTERN ESTUARIES

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The Technical Advisory Process

The design of mechanisms to promote effective transmission of outside scientific advice to governmental decision makers has generated a number of approaches (Robinson, 1980). Much of the emphasis has focused at the national level; however technical advisory boards have become a common feature of governmental studies at the federal, regional, state, and local level. At the national level alone, there were more than 1,300 national advisory boards with 22,000 members in the mid-1970s (Spohn, 1983). Despite their widespread use at all levels of government, very little is known about what mechanisms maximize the most effective use of non-governmental scientists, nor, in fact, have any criteria been developed to determine such effectiveness.

The role of scientists is particularly troublesome because of the triad of roles they serve as (1) arbiters of the technical feasibility of a project, (2) a separate political constituency, and (3) potential contractors for the work which needs to be done. Scientists are often asked to review the technical merits of a proposed project, although in polarized situations few scientists are perceived as unbiased (Reich, 1983). In addition, the scientists asked to evaluate a project's technical feasibility may later be contracted to perform the work. The participation of scientists in the "Star Wars" debate is a recent example of these overlapping roles, where scientists opposed to the political ramifications of the project have refused to seek research funding while characterizing the program as technically unfeasible (Smith, 1985).

The Bays Program

In June 1984, Congress appropriated $4 million dollars for the U.S. Environmental Protection Agency (EPA) to carry out a water quality program including research, sampling, monitoring, and assessment for the Long Island Sound, Narragansett Bay, Buzzards Bay and Puget Sound. EPA decided to use an approach for this program which it had developed earlier in a large multi-year program on the Chesapeake Bay. The Chesapeake Bay Program (CBP) was based on an organizational structure which included all the major agencies responsible for implementing the study at a management level and representatives of constituencies using the Bay for recreational, industrial, or research purposes at an advisory committee level. In the three Northeastern estuaries, Long Island Sound, Narragansett Bay, and Buzzards Bay, EPA Region I was the lead agency for implementing the estuarine protection program. This case study relates EPA's experience in developing a technical advisory committee (TAC) structure in the three estuaries.

In evaluating the CBP experience, EPA realized that many of its recommendations could require costly implementation programs whose potential benefits would be difficult to predict with much scientific certainty. Technical Advisory Committees (TACs) were included from the inception of the program as a necessary part of the overall management structure. Regular oversight of projects in each bay was the responsibility of a Management Committee, consisting of members of the relevant federal and state agencies, and the chair of the TAC was included in this oversight group. Management Committee decisions were formally endorsed by a Policy Committee consisting of EPA's regional administrator and a Cabinet-level state representative. The TAC membership included representatives from the area's academic and governmental institutions. The TACs were formed to ensure that the research and assessment efforts and the recommendations resulting from them would be technically sound and would be supported publicly by the local and national scientific communities. In addition, the TAC structure was intended to build ties between the state agencies and the scientific community in order to facilitate the transfer of technical expertise to the state agencies to allow them to implement the program findings after the approximately five-year study phase of each individual estuary program. Scientists were solicited, then, for their roles as experts, an influential political constituency, and potential contractors working in conjunction with the states.

Buzzards Bay

In Buzzards Bay the scientific community is dominated by researchers from the several Woods Hole research institutions and a regional state university campus. Personal ties between the governmental and academic scientists were extensive. Both of EPA's coordinators for the program had had extensive contacts with the scientific community in the Buzzards Bay region as graduate students and post-doctoral fellows. Both state coordinators had attended the state university, and all the groups had worked together previously on the designation of New Bedford Harbor as a Superfund site. In addition, several Massachusetts agencies had good working relationships with other academic groups. One example was a long-term cooperative program with UMass Amherst, in which people from the state had served as student thesis advisors and many of these students had taken positions with the state after graduation.

In general, though, these relationships tended to be personal relationships, rather than institutional relationships. For instance, relationships with other academic institutions devoted to marine studies or even individual scientists was much less cordial at a state agency devoted to water quality engineering as compared to fishery management. Because of the overlapping jurisdiction between at least three state agencies and several departments within one agency, different individuals from different academic institutions had their own individual contacts within one or two state departments or agencies.

The strongest relationships were between individuals from the state agencies and academic institutions of the same disciplines, for instance, state fishery biologists and biologists at the universities. The state people had been students or colleagues of their academic counterparts. The weakest relationships occurred between state engineers and scientists from the academic community. Not only was the personal history of ties absent, but the additional difference in perspectives between scientists and engineers made communication difficult.

The full participation of academic scientists in the Buzzards Bay program was also hampered by its small budget. Buzzards Bay's appropriation of FY85 funds of $400,000 was only about 40% that of the other estuaries, a small amount of funds relative to the budgets of either the public or private scientific institutions. As a result, the academic scientists, while interested in participating, were reluctant to make any significant commitment of resources to the program.

Chairmanship of the TAC was declined by several upper level scientists and undertaken by a less senior scientist. In addition, the attendees of the organizational meeting indicated that their most appropriate function would be a quarterly or biannual evaluation of the scope and progress of the program. One scientist indicated that proposal review should be conducted by EPA --- "That's what you're paid for;" --- a statement indicative of the general tone of the meeting. Nevertheless, both academic scientists and state agency technical staff agreed to communicate frequently in the development of the program. In the succeeding months the state agencies and the academic scientists did cooperate in the collection of a bibliography of materials summarizing all information available regarding studies undertaken in Buzzards Bay. This task was a priority of the state and had long been contemplated by a researcher in Woods Hole.

An integrated review and coordination of sampling plans proposed by academic and agency scientists failed to take place. The state and the academic institutions had different priorities as to what sorts of data were most valuable --- the state emphasizing environmental characterization and the academic scientists emphasizing measurements of transport and transformation processes and rates. Since the TAC had indicated that proposal review should be done by another group, the Management Committee decided to form a subset of itself to review proposals to include those members of the Management Committee not competing for funds; the TAC chair did participate as well as scientists from EPA Region I and the EPA Narragansett Laboratory. Many Academic scientists complained that the proposals were too management-oriented and expressed interest in proposal review by the TAC in future years.

Narragansett Bay

There are several academic institutions surrounding Narragansett Bay, but the preponderance of coastal and estuarine science is conducted in Narragansett itself. In Narragansett there are a state university campus (URI), EPA's national marine research laboratory and a laboratory of the National Marine Fisheries Service. Ties between these institutions are close, as evidenced by joint appointments and research projects. In addition, the state campus has several ongoing programs with the Rhode Island Department of Environmental Management (RIDEM).

Initial development of the Narragansett Bay workplan was conducted by an EPA engineer and staff at the RIDEM. Strong concern was expressed by scientists at URI that the studies contained insufficient scientific input. In response to these concerns, the RIDEM brought on staff a mid-level scientist from the university who had received funding from the state to conduct research and modeling necessary to develop permit limits on one of the state's priority watersheds. At the same time, the state admonished EPA for not involving a scientist of similar credentials to coordinate the EPA portion of the program. EPA made some staff changes in the following months and hired another Ph.D. marine scientist to assist in Narragansett Bay's program development.

Shortly thereafter, the Narragansett Bay Project (NBP) TAC was formed. It was decided by the state and EPA that the chair should be the director of EPA'S research lab in Narragansett, who had participated in the CBP and understood the way the organizational structure functioned. Potential members were suggested by EPA, the state and several senior level scientists at the university. Some scientists were concerned that the membership of the TAC should consist solely of academic scientists. Governmental scientists felt that their technical viewpoint should also be represented on the TAC. This dispute was resolved through meetings of the state coordinator, some senior scientists at the university, the TAC chair, and a university dean who was a member of the Management Committee. After several iterations of negotiation it was agreed that the TAC membership would consist of a mixture of scientists, who represented a broad cross-section of study disciplines, half from the academic community and half from Federal and state agencies.

In contrast to Buzzards Bay and Long Island Sound, where approximately a dozen scientists were interviewed during workplan development at separate meetings at each of the scientific, government, or public advocate institutions concerned with the bay, the Narragansett Bay workplan was developed during a series of large meetings devoted to each of the scientific disciplines involved in Narragansett Bay --- modeling and circulation, chemistry, ecology, fisheries biology, and planning. As a result, nearly every scientist working on Narragansett Bay had a chance to present his or her study priorities. These meetings were summarized by the state coordinator, and the identified issues were ranked by the Federal and state management agencies. The prioritized issues were presented to the Management Committee which accepted the scientific recommendations, but requested an increased emphasis on public education and management studies. These changes affected the total budget by less than ten percent. Based on the workplan, the sampling and research, portions of the workplan were advertised by requests for proposals. The 30 proposals received were evaluated by the TAC during several afternoons of meetings. Their recommendations were completely endorsed by the Management Committee.

Long Island Sound

The project initiation process in Long Island Sound was markedly slower than in the other two estuaries because the process involved twice as many states, twice as many EPA regional offices, and an interstate agency. Because of the number of institutional players, it was decided at an early stage to concentrate on ensuring consensus among these lead agencies before attempting to organize the advisory committees. An unintended result of this decision was the perception among the academic community that the TAC process was simply "window dressing", and that the technical soundness of the study would be subverted to political concerns. In addition, the large number of state and local agencies which requested representation on the TAC far outnumbered academic membership and resulted in concern that academic influence would be diluted.

Early meetings of the TAC resulted in little participation by the academic community and an initial decision by the participants in the early meetings not to elect a TAC chair, nor to participate in the process except for informational sharing. A representative from EPA's Narragansett Laboratory was asked to act as liaison to the TAC. A major portion of the workplan development and selection of projects was thus completed with minimal involvement from the TAC. At the same time, extensive discussions took place between scientists from EPA and the Long Island Sound academic community attempting to increase their participation, and a follow-up TAC meeting elected co-chairs from the two major state universities. The elected individuals predicated their participation on the development of an appropriate charge, and submitted a proposed charge to the Management Committee defining the TAC's role. In addition to a formal statement of the TAC role, the academic scientists also lobbied to change the structure of the TAC to encourage greater participation by the academic community. The TAC was divided into two sub-groups; one concerned with coordination of all technical programs on the Sound with open membership and one concerned with proposal solicitation and review with membership equally divided among governmental agencies and academic scientists.

Nearly all the work funded for the first year in Long Island Sound consisted of collection and assessment of the historical data to be conducted by the Federal and state agencies and contractors. The TAC chairs decided that there was insufficient time to solicit and select research proposals through peer review in order to meet contractual deadlines. The TAC did review the proposals received from the Federal and state agencies and requested that the groups better integrate their individual proposals into a coherent program. Working groups were formed in the four major program areas --- toxics, eutrophication, living marine resources, and source characterization --- to develop a more coherent program.

The Management Committee accepted the TAC recommendations and agreed to develop a competitive research program as a part of the future program. Relationships between the academic community and the governmental agencies were further developed during a two-day meeting where managers presented their priority issues and questions in Long Island Sound, and scientists indicated the research required to address those questions.

Discussion

As the above case studies demonstrate, the effective involvement of academic scientists in the activities of the TAC and their impact on the development of the estuarine program was strongest in Narragansett Bay and weakest in Long Island Sound. Several measures demonstrate this ranking (Table 1): the number of TAC meetings relative to Management Committee meetings, whether proposals were chosen competitively, whether proposals were separately reviewed by the TAC, and the percentage of study funding received by the academic community.

TABLE 1. A Comparison of Procedures in Three Northeastern Estuaries

	Long Island Sound	Narragansett Bay	Buzzards Bay
Ratio of TAC/ Management Meetings	1	2	1
Proposal Review by TAC?	Yes	Yes	No
Funding Decided Competitively	No	Yes	Yes
Percentage Funds Received by University	0%	73%	23%

Maximizing agency-academic contacts

Three sorts of activities were key to the development of good contacts between the state agencies and the academic scientific community:

1. Building personal trust between groups;
2. Responsive action by scientists to managers' needs;
3. Responsive action by managers to scientists needs.

Building trust

Interviews with all groups involved with the formation of these TACs or similar programs in other locations emphasize the importance of building a trusting and personal relationship between scientists and managers. In all the examples, it was clear that structure of trust must be built afresh between each different agency department and academic department. Ties between one university department and agency branch were no guarantee of a cordial relationship between any other academic department or agency branch. The simple inertia of unfamiliarity with other groups prevented the initiation of ties and created suspicion of the intent of the other parties, resulting in comments such as: "Are the scientists genuinely interested in helping us manage the Bay, or do they want to grab all the money?"

Problems in communication also arose from the different perspective scientists and engineers bring to environmental problems, with scientists focusing more on rates and processes and engineers on characterization and implications for permit issuance. Even where the agency-academic process is running fairly smoothly, problems may still arise. A common issue is assigning credit for the development of results. For instance, in Narragansett Bay, an article appeared in the Providence Journal referring to work in the bay as a "RIDEM study" without mentioning the names of the scientists at URI who actually did the work, and simply quoting a RIDEM official. The situation was diffused through conversations between the government official and the affected scientists.

One major stumbling block preventing cooperation between agency and academic scientists is the potential competition for funds. As described in the introduction, academic scientists are potential contractors for research. In two of the estuaries, agency scientists expressed concern about competition with the academic community for funds. Only in Narragansett was this not a problem because the state had such a small staff that its capability for performing work in-house was limited. In addition, where there was potential for competition, the state coordinator insisted that the agency and academic scientists submit a joint proposal. Many state and Federal agencies feel that regulations prohibit them from competing for funds against non-governmental organizations. Whatever the legality, in practical terms governmental agencies are less experienced in proposal preparation than academic or consulting groups and are, therefore, in a competitive disadvantage. To minimize this potential threat to cooperation, the Bays Program developed a strategy of he Management Committee deciding at an early stage in the process how monies were to be divided among the categories of monitoring, research, and synthesis and policy development, and the procedures to be used to award funding. Certain funding categories (e.g., monitoring) were considered as most appropriately a governmental role, while other categories were opened for competitive, peer-reviewed funding.

Responsive action by scientists

A mechanism must exist in the academic organizations to permit and even encourage the participation of scientists in these studies. The TAC functions in these estuary projects are extraordinarily resource-intensive. They require a great amount of work on the part of the chairperson. This work is not generally allocated much importance by the university in the performance evaluation of staff scientists.

The Management Committee for Narragansett Bay included the dean from the graduate school at the state university's marine campus. This individual was seen as responsive to needs of state agencies. The dean took an active role in mediating disputes between academic scientists and state bureaucrats over membership of the TAC, made university facilities available for project activities, and negotiated a reduced overhead rate with the state for research funded by the project. The dean's active involvement in the NBP was also important in the message his presence sent to scientists at the university. It is demonstrated that their participation in the project was encouraged, and scientists at the university contributed the equivalent of several person-weeks of their time to workplan and proposal review and coordination. In the other estuaries, commitment from academic scientists often depended on the sense of responsibility or interest of the individuals involved and their ability to cajole the participation of colleagues.

The major challenge in soliciting scientific participation is enlisting scientists who are willing to focus on problems beyond their individual research interests. Initial discussions with scientists during the preparation of all three workplans often resulted in individual sales pitches by the scientists for the importance of their own work. The resulting workplans emphasizing research needs in an estuary sometimes reflected the background of the participating scientists. For instance, sedimentation processes received little emphasis in Narragansett Bay, where participation in the planning process by geologists was minimal, and a great deal of emphasis in Long Island Sound, where geologists were an integral part of the research planing process. The outcome was similar for organic geochemistry, though the two estuaries reversed positions. The TAC chairs and other scientists most responsible for the project's outcome were those individuals most able to broaden the scope of the project. In one instance, they actively encouraged the continued participation only of those scientists able to focus on how managers could best use the research results.

Responsive actions by managers

The single most important action by the state agencies which established their credibility with academic scientists was the appointment of established scientists from academic institutions to coordinate the project. The relatively large input by scientists in Narragansett Bay and increased acceptance of the project occurred once a URI scientist joined the RIDEM staff. The State of Massachusetts had a member on the Narragansett Bay Management Committee, and after observing the success of the state coordinator, he lobbied for a similar position in Buzzards Bay. In both instances, the scientist occupying the position reported directly to the relevant environmental Cabinet head rather than through the existing line agencies. Such a reporting scheme convinced the scientists that they had the "ear of the director", but also created the potential for friction if the line agencies felt they were being by-passed. In Rhode Island, it was decided to make the special Narragansett Bay office a long-range planning function while the line agencies were responsible or day-to-day functions. The distinction between the two functions is somewhat fuzzy, but the defined roles at least improved morale.

Besides this indication of concern at the Cabinet level, several day-to-day committee operating functions can also indicate to scientists the seriousness that the agency ascribes to the TAC process. Sindermann (1982) has suggested that scientists participating in TACs use "perceptive and aggressive game playing" to prevent advisory committees from becoming rubber stamps for agency policies. He suggests that TAC members insist on agendas in advance of meetings, approval of summary minutes and recommendations, increased meeting frequency and public release of committee recommendations.

Many of these same demands were made by scientists before they agreed to participate on the TAC. In addition, the Long Island Sound TAC chair negotiated a formal statement of the committee functions and membership before agreeing to participate. Determining TAC membership was also an area of negotiation in two of the estuaries. Agencies are reluctant to assign too many powers to an unproven committee structure, but the negotiations over the appropriate role of the TAC made clear the expectations of both sides and began the process of personal relationship building.

Finally, the academic community is always searching for funding assistance and responds favorably to small amounts of support. In both Buzzards Bay and Long Island Sound the TAC chairs made special pleas that money be set aside for the support of studies by graduate students. Such joint graduate education projects have long been used by state agencies to build ties with the academic community, either through classes for their employees or serving as faculty advisors for students at state universities.

Summary

Much of the literature evaluating the role of advisory committees debates the extent to which they influence policy development (Sulzner, 1971; Wolanin, 1975). I have discussed above how participation of the academic community can be maximized in technical advisory committees. Many of these recommendations are resource-intensive, both for the agency staff and the academic scientists. It may not always be in the interest of both groups to expend the resources necessary to effectively participate in this sort of organizational structure. For instance, in the early Buzzards Bay meetings, scientists hesitated to put much energy into the project. However, should the issues be of sufficient controversy or the funding of a large enough magnitude to warrant full participation, the effectiveness of the technical advisory system can be maximized by careful attention to building personal trust between groups and responsive actions by scientists and managers to each others needs.

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ACCOMMODATING COMPETING USES

Sarah Taylor, Chair

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CONSULTATIVE DECISION MAKING IN MANAGING THE ESTUARINE ENVIRONMENT, THE ROLE OF POLICY NEGOTIATION

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The Problem Facing Estuaries

Today the U.S. is witnessing a significant and accelerating decline of water quality and resource abundance in the majority of our major coastal environments. Over-exploitation of resources is one obvious problem. More than 99 percent of the world's marine fish catch is taken within 200 miles of land. In one estuary alone it is said that nearly one half of the nation's oysters are harvested.

It cannot be assumed that depleted stocks will recover naturally in the face of continued harvest pressure and loss of breeding grounds and nurseries, caused by pollution of coastal waters and the draining of wetlands for development.

This leads to a second, more insidious problem. In the United States alone, approximately 70 percent of the population lives within 50 miles of the coastline. The proportion is increasing by 5 percent each decade. If this trend continues for a few years, half the U.S. population will be living in coastal zones on only 5 percent of the total land. Because of moderate temperature, recreational opportunities and a certain natural ambiance these areas are drawing people like a magnet.

As a result our major estuaries are experiencing accelerated rates of exposure to the concentrated by-products of civilization: pollution from treated and untreated sewage, industrial waste discharges, and fertilizer and soil runoff from nearby agricultural lands.

There is an urgent and unprecedented need for management policies that will arrest the resulting environmental problems before marine systems are irreversibly degraded and their valuable resources irretrievably lost and multiple dwelling units elbow out recreational opportunities and natural habitats while asphalt substitutes for ambiance.

Framework for Managing Estuarine Preservation

The government's role

Protection of the nation's estuaries has been identified as a national priority. Congress has charged the Environmental Protection Agency with the responsibilities for restoring water quality and living resources through improved estuary management. To carry out the Congressional authorization, EPA established the National Estuary Program (NEP) within the Office of Marine and Estuarine Protection (OMEP). The national program is implemented through the EPA Regional Offices under the guidance of the OMEP.

To provide assurance of strong scientific support Congress has charged the National Oceanographic Atmospheric Administration (N.O.A.A.) through the National Estuarine Management Office to take responsibility for research into living resources and habitat protection.

The U.S. Fish and Wildlife Service and the Army Corps of Engineers make up the remainder of the responsible agencies of the federal government.

Most states bordering our nation's estuaries have established environmental management structures to deal with coastal and estuarine systems. For example:

Some states have taken the initiative to deal directly with the critical land areas within 1000 feet of shore. Towns and cities bordering coastal areas and bays have recognized their role as the first line of defense against estuarine degradation. Community and municipal officials have the direct responsibility for sewage treatment, land use planning, zoning and agricultural practices.

In some states, officials from towns and cities at the headwaters of rivers and streams have recognized their role in the restoration and preservation effort and have begun to address the problem of deforestation and land conversion on bays and estuaries many miles down stream.

This formal institutional structure is held responsible for defining the problem, developing a framework for action, setting goals and designing mechanisms for achieving those goals. Some way must be found for the these institutions and the people who man them to sustain the will and the necessary resources for the decades required to achieve water quality and habitat protection goals.

The private sector

The motivation for restoring and preserving our estuaries, has come, as well, from an aroused public. The ultimate success of any cleanup effort depends upon the public remaining concerned. Government efforts at estuarine protection must be monitored and participated in by the public to ensure that water quality goals are achieved. The public must build and sustain the constituency to help government environmental managers maintain the needed resources to complete the restoration effort.

"Users" of the estuary and of resources that affect estuarine quality — fishermen, boaters, the merchant marine, industries, farmers, tourists and the residents of the communities connected to the coast by land or streams abutting the coast must find ways to build comprehensive coalitions to support the needed action to restore and protect the coastal environment.

The scientific community

Government-sponsored science and research is revealing the status of water quality and living resources in major estuarine watersheds. However, baseline data has not been established for every estuary. The ultimate success of any restoration effort will depend upon the extent of the data base and the quality of research facilities focused on the estuary.

The purpose of this paper is to recognize how the traditional tools of regulation and enforcement are being employed by environmental managers today to find ways to manage the restoration and preservation effort and consider some new tools available to them which recognize the realities of today's "Nobody's in Charge Society". Beyond that we present for consideration what government decision makers will need to do to make environmental management decisions that stick as they get used to their leadership role in a world of "upside-down pyramids".

Leadership of the Informed

We are indebted to Harlan Cleveland, Dean of the Hubert Humphrey Institute of Public Affairs, University of Minnesota, for clarifying the problem for us in a speech at the World Future Society Conference, New York, July 1986, and in his book entitled: The Knowledge Executive — Leadership in an Information Society.

I will excerpt his principal points:

> Shortly after the attempted assassination of President Reagan in 1981, Secretary of State Alexander Haig announced on television from the White House that "I am in control here...." That statement produced neither reassurance nor anger from the American people: rather, the response was nervous laughter, as

in watching theater of the absurd. We, the people, know by instinct that in our pluralistic democracy no one is, can be, nor is even supposed to be "in control". By constitutional design, reinforced by the information-rich conditions of work, we live in a "nobody-in-charge" society.

In a nobody-in-charge society, where decisions are made by consensus and committee, policy is made by an upside-down version of the traditional pyramid of power.

More and more work gets done by horizontal process—or it doesn't get done. More and more decisions are made with wider and wider consultation—or they don't "stick". A revolution in the technology of organization—the twilight of hierarchy—is already under way.

In the old days when only a few people were well educated and "in the know", leadership of the uninformed was likely to be organized in vertical structures of command and control. Leadership of the informed is different: it results in the necessary action only if it is exercised mainly through persuasion and by consulting those who are going to have to do something to make the decision a decision.

Very large numbers of people empowered by knowledge—coming together in parties, unions, factions, lobbies, interest groups, neighborhoods, families, and hundreds of other structures—assert the right or feel the obligation to make policy.

Decision making proceeds not by "recommendations up, orders down", but by the development of a shared sense of direction among those who must form, the parade if there is going to be a parade. Participation and public feedback become conditions precedent to decisions that stick.

In the upside-down pyramid, where the people really do make the policy, leadership is continuous dialogue—not an act, but an interaction between leaders and followers.

Certainly every environmental manager has experienced the frustration of seeing carefully crafted regulatory policy being brought to court before it could be implemented. In other instances months of staff work has become the butt of criticism by private sector activists and the media.

Dr. Cleveland underscores the environmental managers' dilemma when he says—

> It's more and more obvious: those with visible responsibility for leadership are nearly always too visible to take the responsibility for change—until it becomes more dangerous to stand there than to move.

About Common Ground: Center for Policy Negotiation

Common Ground is an organization that is dedicated to finding ways to help government decision makers make public policy decisions that stick. It is concentrating at this time on environmental management decisions. It is seeking practical solutions to the leadership problem of an informed society.

Our organization is directed to help environmental decision makers, specifically, policymakers from government and the private sector:

— who need to make, or seek to have others make, public policy decisions that can be implemented and not challenged in the courts

— who need to demonstrate that true leadership today derives from effective "followership"

— who need to protect themselves from the reality that:

"those with visible responsibility for leadership are nearly always too visible to take the responsibility for change — until it becomes more dangerous to stand there than to move"

— who recognize that leadership of the informed can result in the necessary actions only if it is exercised mainly through persuasion and by consulting those who are going to have to do something to make the decision a decision

In short, the people who recognize that collegial, not command, structures become the more natural basis for organizing decision making and that conferring and "networking" not "command and control" become the mandatory models for getting things done. Our goal is to help environmental managers prove that, more and more, decisions are made with wider and wider consultation or they don't stick (ie. participation and public feedback become precedent to decisions that stick). Common Ground provides this help through a process called Policy Negotiation.

About Policy Negotiation

Policy negotiation is a conferring and networking mechanism which offers a non-threatening means for demonstrating to government decision makers the art of consultative decision making as an alternative to "command and control".

It is a neutral process that identifies a manageable number of knowledgeable people concerned with an issue and provides for their interaction in an orderly and structured manner until effective public policy can be developed and embraced by the visible leadership.

It is a transition process that recognizes the existence of hierarchies ("the system") and assists them to function more effectively in a changing society by learning and applying the art of consultative decision making.

It is a process which enables the government manager to participate informally, at first, without making any commitment until he has a chance to experience first hand the feeling of real power that derives from consultation. He can experiment by making consultative decisions and see how they work without premature visibility or accountability.

It is a mechanism to deal with the realities of the "upside down pyramid where the people really do make the policy — where leadership is a continuous dialogue — not an act but an interaction between leaders and followers".

It therefore contains within itself the chance to have an impact on the legislative process in a way that will produce laws which are designed to be implemented through consultative management rather than litigation. This means laws which provide means for interaction rather than compliance deadlines which are used as target dates for litigation.

Policy Negotiation and the Environmental Manager

The Center for Policy Negotiation is a nonprofit educational and scientific organization, founded 12 years ago to help people work together to build solutions to environmental and energy problems which reconcile their different interests. Policy Negotiation has been designed to help concerned individuals to define sharply a public policy problem and then meet to develop an action plan for resolving it.

All communication in a policy negotiation managed by the Center is "off-the-record", yet policy negotiations are coordinated with formal government decision making processes. In short, Policy Negotiation is designed to help people to work within the formal government decision making system in order to make the system work better.

Policy Negotiation is therefore critical to decision makers who need a comprehensive understanding of an issue before they make policy recommendations. Policy Negotiation helps decision makers to build strong constituencies and assures that policy recommendations can be implemented.

The Center's role is limited to identifying and fostering collaboration among interest groups, technical expertise and decision makers. The Center's work is done as soon as the parties are able to sustain a collaboration. It is a catalyst for what is in motion, not another layer in the management structure.

The Kinds of Issues Addressed

Policy Negotiation has been effectively used to address issues:

- where environmental and economic concerns must be integrated, reconciled and considered;
- where a considerable period of time may be required to define the problem, develop an action plan and implement the solution; and
- where the degree of uncertainty requires a high degree of scientific and technical expertise to inform the decision process.

Policy Negotiation has been utilized by Coastal and Estuarine Managers in the following instances:

Georges Bank

Between 1979-1982, the Center assisted U.S. EPA, NOAA and DOI to design and implement a program for monitoring the impacts of oil exploration upon the Georges Bank. The agencies were collaborating through the Georges Bank Biological Task Force.

Litigants from the diverse interests within the private sector and government were incorporated into a policy negotiation network and convened meetings. Policy Negotiation helped them to define joint goals and to work collaboratively until agreement was reached on an ecosystem monitoring plan. Government and private interests were helped to integrate science and technology in their final policy decision. After implementation was complete, the parties reviewed the implementation of the overall resource management plan and confirmed the quality of the government lease management process.

Chesapeake Bay

In 1981, the Director of the EPA Chesapeake Bay Program asked the Center to assist Bay Program staff and staff of the Citizens Program for the Chesapeake Bay (CPCB) to design and test the Resources Users Management Team (RUMT) Concept. The Center helped EPA staff to identify key participants for RUMT and to define the role of RUMT in planning a management synthesis of research findings. The Center assisted with the planning and implementation of the first two meetings of RUMT. The Center's assistance in the Chesapeake Bay Phase I effort was no longer necessary, once the members of RUMT were able to collaborate. The collaborative activity which followed was facilitated by U.S. EPA's Chesapeake Bay Program and the nonprofit Citizens Program for the Chesapeake Bay.

Today's Tools for Managing the Estuarine Environment

The principal void in managing the restoration and preservation of an estuary is a means to build a comprehensive coalitions of users and impacted parties from the private sector with a common goal and to assure that the coalition is utilized by government environmental managers in developing and implementing an estuarine protection plan.

The skills of "community of interest" building, meeting management, facilitation, mediation and negotiation have been combined to develop the process called Policy Negotiation. It can be utilized to build and sustain a comprehensive coalition within an estuary and to assist environmental managers to utilize that coalition to make decisions that will stick.

National Estuary Program

Currently the Center is developing a project for the Office of Marine and Estuarine Protection which will utilize policy negotiation to help build the coalitions that are needed to provide the framework for public/private sector collaboration. The Center will help the parties set goals and develop action plans in three of the nation's largest estuaries.

These tools applied in these ways can provide the kinds of continuous interaction between leaders and followers which is needed to make environmental management decisions that stick.

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CONSERVATION PLANNING: AN EFFECTIVE PROCESS FOR COASTAL LOCALITIES

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New Hanover County, which includes the City of Wilmington in coastal North Carolina, has attempted to face the classic problem of reaping the benefits of desirable growth while simultaneously protecting those natural resources and amenities which have served to stimulate much of the growth.

The County has developed and implemented a comprehension and innovative planning process to deal with this problem. This process has resulted in the effective implementation of a Conservation Overlay District (COD) as part of the Zoning Ordinance. This paper summarizes the problems that face the County, and the planning process and measures developed to rectify the problems. Finally, several concluding remarks are made concerning the first two years of implementation of the COD and of the effectiveness of the planning process in general.

(1) The Problem

New Hanover grew by approximately 25% between 1970-1980, with 17 of these percentage points due to net in-migration. The County is still growing by several per cent a year. The County is nearly surrounded by water. Its boundaries consist of approximately 37% coastal barrier island and sound shoreline, 56% estuarine river shoreline, and only 7% land. The principal biotic community in the County is some type of wetland such as salt marsh, swamp forest, or pocosin. These natural features have supported commercial and sport shellfishing and finfishing, provided attractive surroundings for second home and retirement development, and supported educational and scientific research.

Rapid development, however, has threatened these coastal resources by such means as alteration of natural drainage patterns, stormwater runoff pollution, and indiscriminate filling, dredging, and clearing. In 1983, for example, 41% of the Cape Fear River estuaries bordering New Hanover

County were closed for shellfishing due to pollution, compared to 15% for the State. The initiation of construction of a Countywide sewer system will greatly increase development pressure on wetlands, previously constrained by poor soils and a lack of septic system suitability.

Other County resources have also been threatened by rapid development. Concern has been expressed for maintaining the quality and recharge capacity of the aquifer system, which the majority of County residents are dependent upon for potable water. Rapid development has also drastically reduced much of the open space and woodlands. Many of the hundreds of water-oriented archeological and historical sites in the County have been lost to development. Protection of traditional agricultural lands from urbanization has also been voiced as an issue.

The County, State, and Federal regulatory frameworks for conservation of the above resources were considered inadequate before development of this conservation planning approach. Although the County's Land Use Plan has a number of policies expressing the need to preserve these conservation resources, these policies do not have the force of law but instead provide only guidelines. The County's Zoning and Subdivision Ordinances, which were adopted prior to the Plan, did not effectively reflect the policies. The Ordinances had very few provisions either for the conservation of coastal resources or for effective drainage controls for minimization of stormwater runoff impacts. State and Federal permitting activities, by means of the 1974 N. C. Coastal Area Management Act and the U. S. Corps of Engineers' Dredge and Fill regulations, provided some protection for certain projects but did not give the overall conservation resource protection desired.

(2) The Response: The Conservation Planning Process

In response to the threatened destruction of the County's coastal resources, the County formally initiated the conservation planning process in 1983 and acquired a Coastal Area Management Act (CAMA) grant from the State. The process culminated in the creation and implementation of the Zoning Ordinance Conservation Overlay District (COD). The COD and other products are discussed in the following sequential description of the planning process.

Step one: Description of the problem and of possible strategies
This first step of the process examined coastal resource problems facing the County and presented strategies for dealing with them. This step resulted in the production of a Conservation Planning Workpaper.

The Workpaper brought together information on coastal resource concerns, the extent of land development in the County, and existing deficiencies in County regulations. The Workpaper also evaluated and recommended regulatory and other alternative actions that the County could pursue, such as public purchase of fee simple title or easements; property tax incentives; and zoning to preserve environmentally sensitive land. These possible actions have been well documented by such organizations as the American Planning Association's Advisory Service (1975) and the National Agricultural Lands Study (1981).

Step two: Analysis of conservation resources
The County next performed a study of the conservation resource base in the

County. The resulting report, "Conservation Resources in New Hanover County", is primarily the work of a consulting ecologist, David M. DuMond. DuMond analyzed and classified the biotic communities of the County with emphasis on delineating wetland types and areas of special significance, such as shorebird nesting sites and Venus Fly Trap communities. DuMond also delineated the communities on aerial photographs (1"=400') in discrete units as small as one acre, and provided some field training to Planning Department staff.

Planning staff also collected information on significant archeological and historical sites, primarily from the State Division of Archives, and on primary nursery areas, which are critical habitats for juvenile shellfish and finfish. Table 1 lists the classes of resources examined.

<u>Step three: Public education and participation</u>
It is essentially impossible to perform a technical, completely objective analysis of the absolute benefits and costs of protecting the different conservation resources. Any attempt to determine the dollar value of an archeological site, for instance, would be an exercise riddled with assumptions and vagueness.

It became necessary, therefore, to obtain estimates of the subjective values held by the community relative to each conservation resource. The community needed to be asked, for example, whether it valued an archeological site more than a primary nursery area.

The County Board of Commissioners and the Planning Board were first educated concerning each resource with regard to its extent within the County, its importance to the County's economy and culture, and its sensitivity to development impacts. The Commission and Board were then brought together in a workshop and led through a simple, iterative Delphi process to attempt to reach a consensus concerning the relative importance of each resource. A micro-processor was used to provide rapid feedback and statistical analysis of each iteration during the workshop.

Consensus was reached that only the wetland communities, maritime communities, areas of special significance, significant archeological/historical sites, and primary nursery areas be given protection. The upland and anthropogenic communities were not considered valuable enough to preserve. The aquifer recharge areas, although considered valuable, could not be delineated with enough precision to defend it against challenges on a site specific basis.

<u>Step four: Drafting of the Conservation Overlay District (COD)</u>
The COD of the Zoning Ordinance is the major product of the conservation planning process. The COD, drafted by Planning staff, requires varying levels and means of conservation of coastal resources depending upon the importance of each resource. The key provisions of the COD include the following:

> "<u>Purpose</u> - The purpose of the Conservation Overlay District (COD) for conservation resources is to protect important environmental and cultural resources within the County. Protection of these resources is necessary to maintain the County's diverse and ecologically important natural systems; to preserve the County's estuarine systems important for finfishing

TABLE 1 CLASSES OF CONSERVATION RESOURCES

Upland Communities

Longleaf Pine-Turkey Oak Woodlands
Mixed Pine-Hardwood Forest
Pine Forest
Hardwood Forest

Wetland Communities

Swamp Forest
Pocosin (including white cedar swamp)
Savannah
Ponds (natural)
Fresh Marsh
Brackish Marsh
Open tidal water (fresh, brackish saline)

Maritime Communities

Barrier Island-Beach Complex (including dunes)
Maritime Shrub Thicket
Salt Marsh

Anthropogenic Communities

Pine Plantation
Dredged Material Deposits
Agricultural Land
Successional Land (reverted)
Utility Corridors
Urban-Developed Land
Impoundments and Lagoons
Ruderal Land

Areas of Special Significance

Important Animal Breeding Colonies
Important Animal Species Location
Important Plant Species Location
Potential Natural Areas
Important Community Complexes
Registered Natural Areas

Significant Archeological/Historical Sites

Primary Nursery Area (Finfish/Shellfish)

Aquifer Recharge Areas

and shellfishing; to provide open space; and to retain the County's archeological and historical heritage."

The COD applies to essentially all subdivisions and commercial or industrial developments that disturb more than one acre and that occur on parcels of record as of the date of adoption of the COD. The development of one detached single family home or one duplex or two mobile homes on a single parcel are exempt.

The COD requires three main means of protection of the conservation resources:
(1) A percentage of the resources, ranging from 50% (e.g. pocosin) to 100% (e.g. salt marsh) must be preserved in its natural state and designated as conservation space.
(2) The development site must be designed to meet performance drainage requirements for a design storm of 10 year frequency. The design must also provide for on site retention of up to the first 1.0" of impervious surface runoff. The required amount of retention depends upon the importance of the resource as determined by the workshop.
(3) All structures and impervious surfaces must be setback up to 100 feet from the conservation space.

The COD, however, provides flexibility to the developer in several ways. One, the COD permits a quasi-transfer of conservation space requirements from one resource to another of equal or greater importance. Two, access roads through conservation space are permitted if no other reasonable alternative is available. Three, certain minor improvements, such as boardwalks, are permitted to allow enhancement or enjoyment of the conservation space. Four, a residential developer is allowed to develop the same number of units as would have been allowed before the COD became effective, by means of clustering and modification of yard and lot requirements. Finally, if a developer wishes to develop a significant archeological/historical site, he may do so provided either a detailed site investigation is performed or acquisition and investigation rights are given to the County for at least 60 days.

The conservation space or an appropriate easement may be dedicated to the County, State, or Federal government, or to a qualified non-profit organization. Another alternative is for the parcel owner or homeowner's association to retain ownership, provided the conservation space is not disturbed.

<u>Step five: Public review and adoption of the COD</u>
The staff developed several demonstration projects of how the COD worked and presented them to the governing bodies and others, such as the local chapters of the Sierra Club and of the American Society of Civil Engineers (ASCE). One such demonstration showed how one existing residential development could have been redesigned with minimal impact to meet COD requirements.

The staff mailed out copies of the COD to all local developers and architects, requesting their input. The COD was also discussed at length at two public hearings, one before the Planning Board and one before the Board of Commissioners. Each governing body passed the COD unanimously in the fall of 1984.

(3) Conclusions

The COD has been in effect for nearly two (2) years. Between forty to fifty subdivisions and other developments have been affected by this ordinance. Only one interpretation of the COD by the County Planning Department regarding a subdivision has been appealed. This appeal, taken to the County Commissioners by the developer, was denied. Generally, most developers have been cooperative in working with the COD. Their cooperation may be due to several factors, including diligence by Planning staff in assisting developers with interpretation of the ordinance and with on-site delineation of conservation resources; recognition by developers that the additional costs imposed by the COD are not prohibitive in this high growth area; and the realization by developers that the delay and expense of contesting the COD in court probably would exceed the cost of compliance with the COD.

Generally, very little coordination has occurred between the County and either Federal or State agencies with regard to the meshing of COD requirements with State or Federal wetland requirements. This lack of coordination of three different sets of wetland regulations has been a legitimate sore point with developers. The County has felt justified, however, in keeping the COD because of continuing changes in State and Federal regulations, Federal and State loopholes and lack of Federal and State enforcement.

The COD still has several weaknesses. Although the regulations have been "fine-tuned" twice in two years, new development situations may arise where the regulations may appear too stringent or not stringent enough. In addition, the actual delineation or flagging of a conservation resource is still partially dependent upon best professional judgement.

In general, however, this conservation planning process can serve as a model for other localities to follow where natural resources are being threatened. The process is particularly relevant for coastal localities because of the COD's emphasis on performance drainage controls, setbacks, and preservation of valuable wetland. It is important to note that property rights in terms of both density and the ability to develop water-dependent uses have not been diminished.

The process realistically applies a number of classic problem-solving steps, as detailed earlier. One important step, the workshop with the County Commissioners and Planning Board, not only obtained an educated consensus of subjective values for the conservation resources from community leaders, but also gained their political support of the COD through their involvement in the process. Analysis of the conservation resources was also important in providing technical documentation and justification for the COD. Development of the detailed aerial photos and field training of the staff helps relieve the burden on the developer in determining the extent of conservation resources on his property.

The process is helpful by integrating into a single comprehensive set of regulations the protection of numerous environmental concerns, and applying the regulations to all major uses. The protection of wetlands, for instance, also preserves open space, maintains aquifer recharge areas, and performs other functions.

The COD is innovative as a performance zoning district. It requires preservation of natural areas not only for their role in maintaining economically important environmental functions such as supporting the fishing industry and minimizing flooding, but also for their inherent values as ecological communities. Savannahs, for example, contain numerous scientifically and educationally interesting collections of small plants. The COD's performance drainage standards, clustering capability, and other provisions give flexibility to the developer as long as the final result achieves the COD's purposes. The specificity of the COD's performance standards and review criteria, however, eliminate the potential burden of discretionary or arbitrary site review of developments by the County in the administration of the COD.

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Abstract only

BEHAVIORAL MAPPING OF BEACH USE AT FIRE ISLAND NATIONAL SEASHORE

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Behavioral mapping was used as one technique to assess visitor use patterns on beaches. Bi-weekly visitor use was monitored and mapped for the summer 1985 field season. Nearly 4,300 observations were made on the location of users using a standardized grid system and selected characteristics (gender, attire, age, activity).

Field data were then computerized and subject to multivariate statistical analyses. A series of computer maps were generated illustrating the patterning of users on the beach as well as the determinants of this spatial distribution.

Recent governmental actions ranging from the Paperwork Reduction Act of 1980 to the recently implemented budget reductions resulting from the Gramm-Rudman-Hollings law have adversely affected social science research in national parks. The use of questionnaire surveys, the mainstay of social science research, has been particularly restricted. Behavioral mapping is a particularly useful alternative, as it yields substantial observational data on actual behavior. At the same time, it does not need OMB approval, is rather simple to implement, and more importantly it is cost-effective to use.

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MANAGING ENERGY DEVELOPMENT IN A SENSITIVE COASTAL AREA

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Introduction

This paper traces the efforts of Santa Barbara County to develop a workable plan for a sensitive coastal dune-wetland complex and its subsequent use to regulate the siting and design of major energy development projects. An important feature of this paper is a description of the process followed by Santa Barbara County to develop an energy facility siting management plan for the dune-wetland system and the effect this plan had on subsequent project siting and design.

In 1977, eight years after the infamous Santa Barbara Channel oil spill, the County of Santa Barbara began a planning effort that would take five years to complete -- the preparation of a local coastal program, a component of the California Coastal Management Program. Because the coastal area onshore and offshore Santa Barbara County continues to be a major oil producing area, the issue of coastal energy development was a major consideration in the preparation of the Santa Barbara County Local Coastal Program.

The Nipomo Dunes, lying within northern Santa Barbara County and southern San Luis Obispo County, are a portion of the largest remaining coastal dune-wetland complex in California. Recognizing that its ecological and scenic values are of national significance, the U.S. Department of the Interior designated this area a National Natural Landmark. The Santa Barbara County Local Coastal Program designated the portion of the Nipomo Dunes within its jurisdiction -- the Mussel Rock Dunes -- an environmentally sensitive habitat area.

Normally the California Coastal Act severely limits development within areas having this designation; however, the Nipomo Dunes have high potential for energy facility siting because of underlying oil fields and nearby offshore oil production areas. Although the California Coastal Act is primarily oriented to resource protection, it also places high priority on energy resource development. The Nipomo Dunes, therefore, provide a classic example of conflict between public policies for protection of sensitive coastal resources and policies that encourage energy development.

History of Development

The open and shifting nature of the dunes has greatly restricted man's use of the area. The scenic qualities of the dunes and proximity to the ocean result in a significant potential for recreational use, although unauthorized off-road vehicle activity is a major threat to the ecological balance of the dunes. The impact of energy development within the dunes, however, has been the principal focus of the county's planning efforts in the area.

Two oil fields underlie portions of the Nipomo Dunes, and an offshore oil production area is in proximity. The past history of energy facility siting in the area relates to exploration and development of these fields.

The Guadalupe oil field covers approximately 2000 acres, all underlying the Nipomo Dunes. Most of the producing area is north of the Santa Maria River in San Luis Obispo County, although a small producing lease is located directly on the beach in Santa Barbara County. Recent development activity in this field has been closely related to enhanced recovery techniques, particularly thermal recovery by cyclic steam injection.

To the east of the Nipomo Dunes, in Santa Barbara County, is the Santa Maria Valley field. In 1980, the discovery of a westward extension of the field raised the possibility that it also extended beneath the Nipomo Dunes. Coastal permits were subsequently granted for exploratory wells just outside the dunes, but no facilities were allowed anywhere within the designated environmentally sensitive habitat area.

Offshore the Nipomo Dunes is the Santa Maria Basin. In May 1981, the federal government held OCS Lease Sale No. 53, which included the Santa Maria Basin area offshore northern Santa Barbara and southern San Luis Obispo counties. Exploratory drilling following the lease sale resulted in several major new oil discoveries. Plans for the development of these new fields included pipelines across the dunes to onshore facilities.

Development of Management Plan

In 1978, in response to an application for exploratory drilling within the Nipomo Dunes, the County of Santa Barbara sought to obtain more detailed information on the environmentally sensitive dune ecosystem through a special study of the area. The goal of the study was to provide adequate information for a management plan to ensure that anticipated energy development in the dunes is compatible with this valuable coastal resource and is consistent with the requirements of the California Coastal Management Program. The specific objectives of the study were:

1. An inventory of the natural resources of the dunes;

2. Scenarios of potential energy development in the area;

3. An assessment of the impacts of all potential energy development;

4. Performance standards for anticipated energy facilities including alternative siting strategies.

The outcome of the study was the development of an energy facility siting management plan for the Nipomo Dunes (Envicom, 1980).

In applying the specific policies of the California Coastal Act to the Nipomo Dunes, a basic conflict developed between one section of the Act that mandated strong protection for environmentally sensitive habitat areas and other policies setting the highest priority for coastal-dependent industrial development. In passing the Coastal Act, the California Legislature recognized that conflicts between the Act's policies may arise and directed that "such conflicts be resolved in a manner which on balance is the most protective of significant coastal resources." The basic strategy formulated in the development of the management plan for the Nipomo Dunes, therefore, is to ensure that: (a) only those facilities are permitted that absolutely require a site within the dunes to be able to function; (b) permitted facilities are sited so as to avoid those portions of the dunes with the highest resource value and sensitivity to disturbance; and (c) permitted energy facilities meet strict performance standards to minimize impacts to coastal resources to the maximum extent feasible.

A key element of the management plan, developed to minimize disruption of habitat values, is a resource sensitivity map that depicts the variation in habitat value and susceptibility to disturbance within the dune system. The concept of "habitat value" is not defined by a single resource value, but is a summation of all resource values that make that specific habitat area unique. These factors include vegetation, wildlife, scenic quality, archaeological sites, and geologic suitability. The usefulness of the resource sensitivity map as a planning tool is that it identifies those areas within this environmentally sensitive area that are least susceptible to disturbance, taking into account all factors of importance to its overall quality. Conversely the resource sensitivity map identifies those areas with the highest habitat value and susceptibility to disturbance and which, therefore, should be avoided for facility siting.

Plan Implementation

After several controversial hearings before the Santa Barbara County Planning Commission and Board of Supervisors, the management plan was adopted. On June 18, 1981, it was certified by the California Coastal Commission and became a component of the Santa Barbara County Local Coastal Program and the California Coastal Management Program. Since certification, it has been used in several major energy facility siting decisions.

Husky Oil project

In August 1981, shortly after adoption of the Nipomo Dunes energy facility siting management plan, the Husky Oil Company initiated development plan processing with the County of Santa Barbara for as many as 57 oil wells within their lease that encompassed a substantial area within the dune habitat area. To prepare its oil lease development plan, Husky Oil closely followed the policies of the management plan. To minimize the area to be disturbed, Husky Oil consolidated its 57 proposed well sites onto three drilling/production islands. The resource sensitivity map was utilized to locate the three drilling islands in the least sensitive areas. More importantly, the proposed oil lease development plan complied with the objective of the management plan by only siting facilities within the dune habitat area that were absolutely essential. All other facilities (e.g., storage tanks, processing equipment, etc.) were proposed to be sited in a location outside the dune habitat area. The only facilities to be located within the dune habitat area were pumping units, once drilling was completed.

In March 1983, after lengthy public hearings, the County of Santa Barbara approved the Husky Oil project, subject to 36 conditions reflecting the performance standards incorporated into the management plan. In addition, Husky Oil was required to delete one of the three drilling islands because of its proximity to the nesting area of an endangered bird, the California least tern.

Development of Santa Maria basin offshore area

Offshore the Nipomo Dunes, several major oil discoveries occurred in the Santa Maria Basin. One oil company submitted a plan to develop its offshore lease by installation of a large production platform several miles southwest of the Nipomo Dunes. To transport its oil to an onshore facility for processing and storage, a pipeline across the dune habitat area was proposed.

To comply with the intent of the dune management plan, a pipeline corridor was chosen with the least potential to disturb sensitive areas. The offshore to onshore pipeline landfall site was chosen in an existing oil production lease north of the Santa Maria River in San Luis Obispo County. Because San Luis Obispo County had followed a similar approach to developing a management plan for the portion of the Nipomo Dunes within its jurisdiction, siting of the pipeline corridor utilized the resource sensitivity map to carefully "thread" a route across the dunes to avoid disturbing sensitive areas. In addition, the oil company initiated a research program to develop methods for restoring coastal dune areas impacted by underground pipeline laying.

Aquaculture project

The most recent facility to proposed siting within the Nipomo Dunes habitat area was an aquaculture project for the commercial raising of abalone. Under the California Coastal Act, aquaculture is defined to be coastal-dependent and given high priority for siting along the coast. Unlike the previously discussed projects, however, the selection of the aquaculture facility site did not closely follow the policies or intent of the dune management plan. The proposed site was in a floodplain near the mouth of the Santa Maria River in a palustrine wetland. A survey of the site revealed the existence of a plant that was a state candidate for rare status.

Although the management plan was prepared to guide the siting of energy facilities, its policies are also appropriate for minimizing the impact of any major industrial facility. Because of the apparent inconsistencies with the intent of the management plan, particularly the proposed location within a wetland, considerable public agency and citizen opposition to the aquaculture project arose. Because of virtually certain denial of the project, the application was withdrawn and a new site was proposed in a nearby location, outside the wetland area, that much more closely complied with the intent of the management plan.

Conclusions

The development of the Nipomo Dunes energy facility siting management plan, and its subsequent implementation, provides several lessons that are appropriate to industry, government, and private citizens that are involved in similar siting decisions in environmentally sensitive areas.

1. Energy development in areas that have high habitat value will require measures by industry entailing substantially higher costs of doing business. The costs of complying with siting criteria and environmental performance standards will directly increase with habitat value, not always linearly. In some cases habitat value may be high enough to preclude development.

2. For government, the keys to a successful plan for managing development in an environmentally sensitive area are: (a) preparation of rules that are explicit, easily understood, and with minimum latitude for individual interpretation; and (b) sticking to the rules once adopted.

The Nipomo Dunes energy facility siting management plan was formulated at a time when lengthy waiting lines at gasoline stations emphasized to the public the need to develop domestic energy resources, but the memory of the effects of the Santa Barbara Channel oil spill was also still fresh in the public mind. The subsequent implementation of the plan has demonstrated that a workable solution is possible for managing development in sensitive coastal areas.

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Abstract only

THE USE OF ZONING REGULATIONS TO REDUCE COMPETITION BETWEEN COASTAL DEPENDENT USES AND NON-COASTAL DEPENDENT USES

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In New York State, as elsewhere throughout the nation, development pressure in coastal areas is substantial and increasing. The result is often to limit public access to, and recreational use of, the shore, as well as to drive out commercial and industrial operations which depend on a waterfront location. In New York, several types of development, but particularly residential development, compete with coastal dependent uses for waterfront land. Without regulatory controls and other government incentives, coastal dependent uses for increasingly scarce suitable waterfront sites.

It is state policy in New York, as expressed in the State's Waterfront Revitalization and Coastal Resources Act and its Coastal Management Program, to promote public access, recreation, and coastal dependent uses. While the State has several means for furthering this policy, local governments through their land use regulations are in the best position to manage this competition between uses; and zoning is the most appropriate tool at their disposal.

The range of approaches include single use zoning districts, e.g., a marine commercial district with all other uses prohibited, zoning districts which permit a range of compatible uses but not the principal competing uses, such as residential development; zoning districts which permit competing uses but afford incentives in the form of development bonuses to the desired coastal dependent uses; and zoning districts which require mixed use development, i.e., non-coastal dependent uses are permitted only if they also provide for coastal dependent uses. The specific approach, or combination of approaches, a municipality should take will depend upon the coastal dependent uses appropriate to its waterfront and, equally important, upon the degree of development pressure coming from non-coastal dependent uses.

Since implementing such regulations may often result in a reduction in property values and be contrary to the development expectations of property owners, need for care in drafting such zoning regulations is emphasized. The municipality must have a clear idea of precisely what uses are to be promoted, as well as the nature of development pressures that exist. It must particularly be able to draft regulations in a constitutional and legally authorized manner. The "due process" and "taking" issues must be considered.

Currently, under contract with the Department of State, more than 100 coastal municipalities are engaged in preparing local coastal management programs. Nearly all are engaged in major revisions to land use regulations along their coast.

CHESAPEAKE BAY

Virginia Tippie, Chair

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THE CHESAPEAKE BAY: EVOLUTION OF THE PLANNING PROGRAM - PHASE I

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Historic Perspective

At the end of the last ice age some 10,000 years ago, the Susquehanna River drained 64,000 square miles from the highlands of south central New York, west to the Appalachian divide, east to the Delmarva peninsula, and south to tidewater Virginia. As global warming melted glacial ice, the sea level rose, forming the Chesapeake Bay much as we know it today. The Bay, with its mixing of saline and fresh waters, shallow depth, and thousands of acres of wetlands and tidal marshes, is an extensive protein factory that is the nation's largest and most productive estuary. This distinction is threatened by the declines in biological productivity of the Bay caused by the cumulative stresses of human population growth in the Bay area.

Public and scientific concerns over the changes in the productivity of the Bay, human health effects, and the intrinsic value of the resource have generated a wide range of regional and national actions and responses. The most recent pulse of concern crystalized in the mid-1970's with the passage of P.L. 94-116. This provided funds and guidance to the Environmental Protection Agency (EPA) to coordinate a research program to identify the changes in the Chesapeake Bay and to recommend management strategies to correct the problem areas.

The EPA, after consultation with the scientific/technical community and the public, indentified ten program areas of concern. From these, three priority program areas were selected for study and review: submerged aquatic vegetation, toxic chemicals, and nutrient enrichment. After an intensive seven-year research program with an investment of 27 million dollars, the EPA found that the Bay was in fact stressed. Acreage of submerged aquatic vegetation was found to be the lowest in recorded history, with the prime suspect being reduced light. In sediments of certain parts of the Bay toxic chemicals were found in concentrations exceeding 100 times the natural background levels. In most of the Bay nutrient enrichment was reducing levels of the dissolved oxygen that is vital to the health of the Bay.

In addition to these three primary research topics, Bay scientists observed that over time there were shifts in the living resources of the Bay. Oyster harvests had declined dramatically, and there were shifts in the species diversity and composition of finfish. Populations of marine-spawning fish like bluefish and menhaden were increasing, while populations of fish that spawn in the freshwater subestuaries of the Chesapeake like striped bass, herring, shad, and white perch were significantly declining.

The findings of the Research Program documented and validated what many public officials and private citizens felt what was happening in the Bay. They formed the backdrop for a landmark conference convened by the Governors of Virginia, Maryland, and Pennsylvania, the Mayor of the District of Columbia, the Administrator of the Environmental Protection Agency and the Chesapeake Bay Commission. The conference not only solidified political and public support for a restoration and protection effort; it also established both goals for the Chesapeake Bay and the management mechanism to assure that those goals were achieved. The goals and management mechansim were articulated in the Chesapeake Bay Agreement of 1983, which was signed by the conference participants.

The conference in December of 1983 was the basis for the first phase of a plan of action to restore and protect the Chesapeake Bay. The problems had been indentified, a political commitment existed, federal and state funds were available, and the public supported action. Goals were established, and an approach was described in a publication "Chesapeake Bay Restoration and Protection Plan" issued in July 1985.

The programs of the Chesapeake Executive Council, which were contained in the 1985 Chesapeake Bay Restoration and Protection Plan continue today. They focus on efforts to reduce pollutant loadings through the use of known and affordable technology, including the institution of basinwide nonpoint source programs in priority watersheds, phosphorus treatment and phosphate detergent bans in critical portions of the Upper Chesapeake Bay, and reduced chlorine loadings to tributaries during critical stages in the development of young fish.

These programs and activities are supplemental companion tasks to the historic EPA programs, which maintain and upgrade the NPDES permit system, protect wetlands, plan for watershed Development and implement Superfund related tasks.

The 1985 Chesapeake Bay Restoration and Protection Plan is particularly significant because it contains goals in the areas of nutrients, toxics, living resources, related environmental programs, and institutional/management approaches. These goals, which remain current, include:

-Reduce point and nonpoint source loadings to attain nutrient and dissolved oxygen concentrations necessary to support the living resources of the Bay.

-Reduce or control point and nonpoint sources of toxic materials to attain or maintain levels of toxicants not harmful to humans or the living resources of the Bay.

-Provide for the restoration and protection of living resources, their habitats, and their ecological relationships.

-Develop and manage related environmental programs with a concern for their impact on the Bay.

-Support and enhance a cooperative approach toward Bay management at all levels of government.

The success of programs implemented under the Restoration and Protection Plan and information collected in the course of implementing them is providing managers with insights that help them to refine the goals of the program and plan for future pollution control strategies.

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A NEW DIMENSION TO THE PLANNING PROGRAM– PHASE II

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The renewed commitment to restoration of the Chesapeake Bay evidenced in the signing of the Chesapeake Bay Agreement in 1983, was followed by the initiation of the Implementation Phase and the development of the Restoration and Protection Plan. Achievement of the goals embodied in the Agreement and the Plan must accommodate institutional and geographic diversity, the complexity of the natural system, and expected continued population growth and accompanying demands on resources.

The Chesapeake Bay Agreement states and participating federal agencies are undertaking a refined application of the principles of implementation embodied in the Plan. Phase II is Bay-wide in scope but specific in its objectives. Water quality and habitat goals will derive from quantitative requirements of living resources. Hydrodynamic and water quality modeling will be used to guide the determination of nutrient load capacities for specific geographic areas of the Bay and its major tributaries. A strategy for toxics control focuses on the implementation of current toxicity assessment and reduction policies. Technological and management alternatives for achieving point and non-point source load reductions will be evaluated systematically, both in terms of effectiveness and cost.

The products of Phase II, a quantified, comprehensive assessment of the magnitude of the clean-up effort and the means and resources required to effect it, will enable managers to formulate courses of action that can accommodate the pressures of population growth without sacrificing the health of the Bay.

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THE CHESAPEAKE BAY PROGRAM'S COMPREHENSIVE MODELING STRATEGY

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Since 1950, there has been an increasing trend in the accelerated eutrophication of the Chesapeake Bay. Accompanying the increased eutrophication, there is evidence that the area of anoxic Bay waters has also expanded. In order to effectively deal with the water quality problems of the Bay, State and Federal environmental managers must ultimately find answers to the following key management issues;

1. Can the eutrophication and anoxia problems be alleviated through control of phosphorus? or nitrogen? or both?

2. Do both point and nonpoint sources need to be controlled?

3. What level of control should be implemented?

4. Where (location) should controls be implemented first to have the greatest impact?

5. How long will it take and how much will the Bay improve once controls are implemented?

The Chesapeake Bay Program has initiated a comprehensive modeling strategy in order to provide a scientific framework within which the management issues can be addressed. The modeling strategy includes the development and application of a nonpoint source loading and transport model, a steady state two-dimensional eutrophication model and ultimately a three-dimensional eutrophication model of the Bay and major tributaries.

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RESTORING CHESAPEAKE BAY LIVING RESOURCES

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Restoring Chesapeake Bay Living Resources

Introduction

Chesapeake Bay's legendary "bounty" has dwindled alarmingly, especially over the last ten to twenty years. This decline has been judged in large part attributable to man-related causes, in particular, degraded waters. Accordingly, the last decade has seen a well funded, determined attempt to try to better understand, and then ameliorate, poor water quality in the Bay. This paper presents a methodology which is intended to be used to develop realizable goals for both water quality and the key species dependent upon it.

Resources at Risk

A number of species in the troubled Chesapeake Bay ecosystem are typically singled out as experiencing great difficulty. Anadromous fishes as a group are characterized by the common necessity of their young requiring high quality fresh or brackish water. Some of these are highly prized, commercially. The Atlantic sturgeon, once the mainstay of early Chesapeake area colonists (along with oysters), has been a rarity for some time, but other species, perhaps hardier, have been more abundant until recently. The striped bass fishery has become so troubled as to warrant a current complete harvesting ban in Maryland and a partial one in Virginia. American shad, affected by river dams as well as poor water quality, are also harvest banned, in Maryland. Another important anadromous fish, the forage species river herring, is also down in numbers.

Harvest figures for these fishes admittedly are not ideal gauges of abundance, owing to other types of mortality in other waters, climatic factors and cycles, etc., but they are seen popularly and politically as representative of the Bay's decline. Harvest (commercial and recreational) figures for 17 major species are available, by region or river basin, dating back to 1929, and earlier in some cases. (Bonzek and Jones, 1982)

An important habitat in Chesapeake Bay has historically been its submerged aquatic vegetation (SAV), which performed several valuable ecological functions. SAV's decline has been precipitous, from 1965 to the early 1980's. Analysis of cores from areas of traditional SAV beds reveal no similar, widespread, multiple species decimation, though individual species have waxed and waned.

At or near the top of the food chain, certain waterfowl have also experienced very significant reductions in numbers, believed indirectly at least partly attributable to degraded Bay waters. Populations have been measured during the U. S. Fish and Wildlife's (FWS) annual winter surveys of overwintering ducks, swans and geese, since 1948. Species such as the canvasback and, in particular, the redhead duck, are a small fraction of earlier numbers. The latter species depends primarily on SAV plant parts for winter sustenance, and has been forced to move south to other waters, to obtain enough food to survive. Redheads averaged 35,000/yr over the entire period of surveys, but only 3500/yr in the 1980's.

Understanding Resource Problems

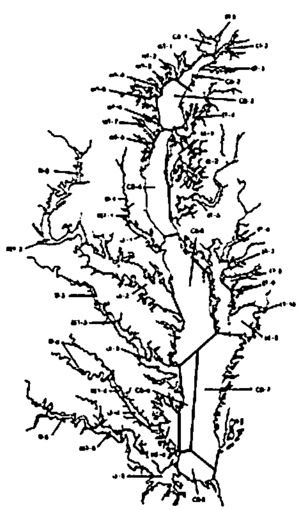
A useful tool which can be used to help understand the reasons for a particular species' or habitat's decline has been developed by the U. S. Fish and Wildlife Service. The tool, Cumulative Impact Analysis (CIA), takes a designated problem experienced by a living resource and then thoroughly probes the literature, field data, unpublished file data, etc. to yield likely causes which are believed to contribute to the problem. A similar process traces consequences believed attributable to the problem, both direct and indirect. A phase of the Analysis also studies ways to lessen causal factors and to ameliorate effects.

As a simplified example of CIA, the major cause of SAV loss is thought to be turbidity. In turn, nutrient excess producing high algal numbers, and suspended sediments from farm and urban runoff, shore erosion and wind-induced bottom resuspension cause turbidity. Steps such as sewage effluent reduction in nutrients, agricultural Best Management Practices (BMP's), etc. can then be postulated to relieve turbidity causes. Similarly, effects of SAV loss such as reduced shelter for fishes and invertebrates can be examined.

Water Quality Data

Once the location and other information describing or explaining living resources is known and entered into a suitable data management base, the extensive water quality information already acquired and stored during previous years' field work can then be examined and linked, where possible, to living resource data. This is the key process in the methodology being proposed - developing the linkage between these major components of the Chesapeake Bay ecosystem.

The linkage described also serves as a major tenet in the Environmental Protection Agency's concept of "Phase II" of its mid-1980's Implemention Plan to restore the Bay's resources. Although other factors can strongly affect these estuarine waters, e.g., a climatic episode such as storm Agnes in 1972, these may be uncontrollable by man. In many respects, "day-by-day" water quality is largely determined by the activities of humans, however. In the case of Chesapeake Bay, a rapidly expanding surrounding human population has indisputably degraded the waters, and in turn the living resources. Degradation having these origins can be reduced.



EPA produced in 1981 a valuable segmentation map, shown at left. Using historical data and also some data from its then-ongoing research phase of Chesapeake Bay Program work (1977-1983), the agency characterized in specific ways water quality in the various segments shown on the map.

These baseline data are valuable for at least two reasons. They can be used to match up with known historical and geographical information about living resources, in order to determine how the degraded (or clean) water may be affecting the organisms in question. The CIA process mentioned earlier can assist in such comparisons and analyses.

For instance, an EPA segment might be known from field data to have high levels of DDT metabolites in its sediments. This could then be correlated with lack of breeding success of osprey, eagles or even breeding black ducks known to attempt to reproduce in the area.

In the especially important area of toxics, knowing which toxicants are located where, and in what concentration, will be vital information in determining both a key organism's "health", and also the strategy or water quality goal to effect improvements. For heavy metals EPA has developed toxicity indices for areas of the Bay, and also a standard sediment "Contaminant Index" which will be useful to this end. Similar work is needed for organic toxicants.

The second way in which earlier baseline water quality data will be useful will be in the comparison with the comprehensive Bay monitoring program set up in 1984 by EPA and the States. The voluminous data now being acquired will be indispensible in assessing how various measures such as BMP's, nutrient reductions in Sewage Treatment Plant effluent, NPDES permit modification, etc., are working to improve water quality.

Requirements of Living Resources

In order to assess how specific water quality conditions are affecting living resources we need to know what those resources require, to survive, reproduce, etc. Much already exists in the literature, for example adult oysters can survive only five days with dissolved oxygen at 1ppm or less. 100% mortality in larval oysters occurs at 3ppt of total suspended sediments. The Fish and Wildlife has developed "Habitat Suitabilty Indices" for some of the important Bay species (e.g., black duck) which also will be valuable in helping to determine the characteristics of habitat and water quality needed for survival in water or shoreline regions of the Bay.

Maryland's Department of Natural Resources, which has been given the responsibility of chairing a "Living Resources Task Force" for the Bay by the Chesapeake Bay Implementation Committee, has come up with a list of proposed basic water quality criteria needed to protect egg/larval/juvenile/adult life stages of several groups of typical, important Bay organisms - estuarine resident and migratory finfish species, anadromous fishes and shellfishes. Virginia has recently added a somewhat more extensive list of associations-species.

The criteria covered temperature, dissolved oxygen, fecal coliform bacteria (most relevant to shellfish), pH, turbidity, and suspended solids. These criteria are, at this writing, out for finalization by Task Force members. The members have also been asked to select indicator species to which to apply criteria, to describe geographic areas of most sensitive life stages and to identify times of critical life stages, for species selected.

In addition to species' life requirements, incorporated into proposed or actual water quality criteria, we need to build into the criteria quantitative data regarding life-threatening substances. These are needed to determine the maximum concentrations of toxicants which the key species can endure, before being adversely affected at either the acute or (preferably) sub-acute level.

A useful document done for EPA (Kaumeyer and Setzler-Hamilton, 1982) looked intensively at bioassay tests conducted on 18 key Bay species. The toxicants included heavy metals as well as various organic pesticides, industrial solvents and other harmful sustances. These types of data, bolstered where necessary by new or recent data acquired from stepped up biomonitoring or other biologically oriented field data acquisition in Bay/tributary waters, would be included in determining species life requirements.

Water Quality Standards

Knowing, or learning, what Chesapeake Bay's living aquatic resources need for survival (and prosperity) in the waters surrounding them tends to be easier than actually achieving that water quality. Nevertheless, two major sections of the 1972 Clean Water Act (CWA) appear to provide a logical way to proceed to better water quality. If the EPA and states work vigorously and effectively, then "water quality which provides for the protection and prapagation of fish, shellfish and wildlife" (an interim goal of the Act generally not realized by its original target date of July 1, 1983) can conceivably be achieved. The Implementation phase of the Bay Program in fact aims to do this.

Section 303 of the CWA directs states to develop, establish and, if appropriate, revise their water quality standards. EPA then reviews the state standards to assure that the states' criteria and use designations (which together make up a standard) are at least as stringent as the federal criteria. EPA also has authority to replace inadequate state standards with federal ones (though generally this is not done).

Section 304 of the CWA directs EPA to publish and periodically review water quality criteria for (among other things) aquatic life. These criteria are then used by the states to formulate water quality standards.

Pennsylvania, Virginia, Maryland and the District of Columbia have incorporated a few simple water quality standards applicable to aquatic life, including for minimum dissolved oxygen, pH range, temperature maxima (aside from ambient) and fecal coliforms. Maryland and D.C. have turbidity maxima and Pennsylvania a TSS limitation.

After this the situation is highly variable. Maryland is the only jurisdiction with criteria in aquatic life use waters for toxic organic compounds. Pennsylvania has a comprehensive set of criteria for heavy metals in its "warm water fishes" usage category. Virginia's metals and insecticides criteria apply enforcibly only to public water supply. D.C.'s protection for its rather short stretch of Potomac receiving waters includes an extensive list of metal and insecticide/industrial materials criteria.

The four jurisdictions differ widely also in the way they define water use classification systems. The criteria levels for particular pollutants can differ sharply as well: the trout waters in Maryland have a 0.002 mg/l chlorine limitation whereas Pennsylvania's limitation for trout waters is 0.15 mg/l.

With so much latitude allowed in water standard setting by the states contributing runoff and effluent loads to the Bay it is clear that no effective prevention of degradation of aquatic life is uniformly in place. Either the states and D.C. will need to improve their water quality protection frameworks or possibly run the risk of EPA-imposed standards, seeking more uniformity and possibly more rigorous criteria than those now in place, for the greater good of the Bay and its living resources.

EPA has in fact turned out a number of guidelines, for water quality criteria, beginning with its 1976 list of maximum allowable concentrations for over 20 pollutants. During the late 1970's criteria documents for 64 pollutants listed in Section 307(a)(1) of the CWA were developed. By the 1980's the list had expanded to 129 top "priority pollutants," a figure which could doubtless be further expanded, and no considerations are as yet known or built into the currently simple, single substance, limitations which could then account for synergistic (mixed or multiple) impacts of toxicants on living creatures. Criteria for allowable toxicant concentrations in sediments also need to be developed further.

Finally, on the subject of standards and criteria, EPA published in December 1984 a set of useful "Guidelines for Deriving Numerical Aquatic Site Specific Water Quality Criteria by Modifying National Criteria" (EPA-600/53-84-099). As yet not implemented, these include procedures for determination of indicator species' (resident and non-resident) sensitivity to ambient waters, a concept which is at the heart of the methodology discussed generally in this paper. In short, water quality needs to be married to the status of living resources, preferably on a geographical basis, in order to bring about improvement of the latter in Chesapeake Bay.

Setting Goals

Movement from the current low-status of both water quality and living resources in Chesapeake Bay is sorely needed, many parties agree. To move from this status toward improvement necessitates setting goals, or "targets", in the sense of numbers to aim for. It may well be that the targets selected will never be attained, or at least not for considerable time, nevertheless the need for direction and movement is urgent. By achieving incremental progress toward stated goals (see below), program activities and expenditures will be justified, and the public and political wills tend to be sustained over the long haul toward restoration.

An overall set of strengthened standards could be assigned for the entire Chesapeake Bay ecosystem, as one option. The present set of four or five pollutants for which general standards exist in all states appear adequate as far as it goes, though further review is appropriate to cover the probably more stringent safeguards needed for very young life stages of any key species selected for this process (example: threats from high TSS levels to oyster or fish larvae).

As a general rule of thumb, when setting new standards for other pollutants, two orders of magnitude below the current known bioassay toxicant for the assigned key species, is desirable as a standard. Sub-acute response, if available , is preferable to acute, and in obtaining a figure, the species selected (from the literature) should be the one with the most susceptibility to each toxicant.

Practically speaking, a second option which involves setting improved water quality standards and linked living resource goals on a prioritized, geographical basis may be more workable than the overall Bay approach (this relates to the EPA guidelines document approach referred to earlier for "site specific" criteria). In doing this, much better use of the known store of information both for water quality and living resources can be made.

Prioritizing makes best use of the EPA segmentation scheme mentioned earlier. For those segments much previous, baseline information on water quality exists which can in turn be compared directly with a wealth of living resources data. To cite three examples, the SAV summer field survey sampling locations closely match or cover the various segments, the fisheries data going back to 1929 is by river basins and the FWS winter waterfowl survey flight areas closely parallel the segments.

Much additional living resource data exists, for example, oyster spat set locations are mapped, striped bass spawning areas known, juvenile indices derived for fish caught in repeated survey areas, etc. All these data can easily be matched with water quality information as known from the past and as it becomes available in the future.

A policy for prioritization needs to be set up. For example, segments with good resources and good water quality could be deemed so valuable as to warrant most effort to protect and maintain for the future. Or the reverse policy, restoring the worst segments, could be adopted. Other segments matching poor water quality with good resources, or vice-versa, would warrant intermediate prioritization.

Actual numerical goals for living resources have been suggested, in a preliminary "straw man" document, issued by Maryland DNR in summer 1986, as follows:

Striped bass - 3 year running average juvenile index of 8.0
Other Anadromous fish - average harvest equal to mid-1960's
Estuarine finfish species - Maintain current levels
Oyster - Average harvest equal to late 1960's
Blue Crab - Average harvest equal to early 1980's
Softshell clam - Average harvest equal to mid 1970's

To this could be added the restoration of canvasback and redhead ducks to mid-1950's numbers.

It must be stressed again that such figures are merely targets, establishing movement and direction. Such goals can be "softened" by specifying rough incremental gains to be reached on a shorter time span basis. To give an example, Bay-wide acreage of SAV could be projected to improve by 5% of the difference between higher 1960's acres and present abundance, annually for the next 20 years, to reach eventually the earlier acreage of Bay grasses. Individual year variation (often heavily influenced by climatic factors in the case of this habitat resouce, as well as for most individual species resources) can be "averaged" over 3-or 5-year intervals.

To such specific goals would be linked the corresponding water quality improvement. The SAV example would see a looked-for Secchi disk reading improvement of 0.25 meter each year, or some similar improvement (total suspended solids numerical reduction could also be used). The living resource and water quality improvements would be on a geographical, segmented basis and, in effect, "ratcheted" to one another, such that improvement in one or both entities triggers and demands continued subsequent improvement.

Monitoring

The only practical means by which to measure future success of the linked methodology described is to use the comprehensive Bay monitoring program put into place in 1984 and somewhat enlarged in 1985. Both water quality parameters and some living resources (phyto-and zooplankton, benthos) are included in the program, and sediment samples for toxicant content covered as well. A total of 28 Virginia and 22 Maryland mainstem stations are included in the program. Equally important, for living resource monitoring especially, considerable tributary monitoring is also being carried out.

Nutrients are featured in the water quality monitoring. Although these appear to have little direct influence on higher trophic levels, in fact as the source of the remarkably (and unwanted) high primary productivity by algae in the Bay, nutrient monitoring is vital, if water quality is to be seen to improve.

The zooplankton portion of the monitoring program is also of great value, given the great importance of these organisms (especially) as food for certain fishes. Improvements in the numbers of these and other key parameters or organisms measured each year will indirectly attest as to whatever various basic programs aimed chiefly at water quality improvements are succeeding.

Other monitoring activities have already been mentioned, such as yearly SAV surveys and photography-mapping, the FWS winter waterfowl surveys, state juvenile fish index surveys, oyster spat surveys, etc. - When all are figured in, a potentially quite reasonable sum total of resource information is available against which to match water quality changes, as the overall Bay restoration program goes forward.

Summary - A description has been given of potential and probable linkage between water quality and certain kinds of living resources in Chesapeake Bay. The kinds of data which can be used to document past quantities of each of these ecosystem elements are reviewed. Suggested quantitative goals are mentioned, as "coupled" targets to shoot for, in achieving better water quality standards and increasing populations of living resources on a geographical segmented basis.

Looking ahead, the monitoring of Bay water quality and some living resources in the present program, as well as some living resource data available from other ongoing programs, will be invaluable in gauging future success of all restoration activities. Other monitoring programs are discussed briefly in the paper.

The Chesapeake Bay's problems are basically these linked to large human populations. Such environmental problems (particularly perceived as living resources failures), since they originate with people, can also be solved by people, given their will and energy (and adequate funding). By noting incremental improvements, as discussed in the paper, patience for the long pull toward eventual restoration is more likely to be maintained.

Degradation of the Bay has taken a long time and cannot be overturned quickly. The nutrients problems are more solvable than the toxic ones, which represent a real "time bomb" or "wild card" in the Bay's future. Most urgent of all activities is thus the need to bring about strong water quality standards protecting living resources from toxic impacts in all areas of the Bay.

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TRACKING NPS IMPLEMENTATION FOR ENVIRONMENTAL IMPROVEMENT

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NPS Funds and Guidelines for Use of Funds

The decision to address the Nonpoint Source (NPS) problems in the drainage basin of the Chesapeake Bay was based on results of the research and technical studies and the overall progress being made with the point sources within the basin. The research and study effort came to a close wtih a Governor's Conference, held in December of 1983, and with the signing of an agreement establishing the current cooperative program for the clean-up of Chesapeake Bay. The federal government, via the White House, pledged $40 million over a four year period to assist with the implementation of measures to address problems that were not being funded with construction grants funds and to fund an office to assist the States with the effort. The Executive Council earmarked a major portion ($7.25 million) of the annual funds for grants to be used for the control of NPS problems. They also developed a set of guidelines for the use and distribution of the money as follows: 1) of the total implementation funds, 30% is to go to each of the three States (only Pennsylvania, Virginia, Maryland, and the District of Columbia signed the agreement) and 10% to the District of Columbia; 2) the projects must address problems identified in the Restoration and Protection Plan for the Bay, a document listing problems and corrective activities for the Bay; 3) at least 75% of the funds for each grant must be used for NPS activities, the other 25% could be used for point source projects that cannot be funded using construction grant funds; and 4) federal funds must be matched dollar for dollar.

The federal funds are managed by EPA, Region III, the Chesapeake Bay Liaison Office, and are subject to the grant rules and regulations for project grants. As such, the grants require the same accountability as any federal grant. However, since the funding of NPS implementation on such a large scale is new for EPA and for that matter for most other federal agencies, additional tracking is carried out to follow the process being made with the installation of Best Management Practices (BMP's) through out the basin.

State and Federal Implementation Programs

Inorder to understand the scope of the various implementation programs that are currently underway in the basin, a short description of the State and Federal programs follows:

Pennsylvania; The program that is funded by the implementation grant is limited to agricultural NPS problems and has targeted the first efforts and funds in the lower portions of the Susquehanna River basin. The major problem here is though to be excess nutrients from animal manures, therefore the major thrust for the program is nutrient management. The program is structured to require a subbasin plan before a contract for other cost shared BMPs will be developed for him. The State does not have a similar program in other parts of the state to date, therefore the staff is free to spend full time on the Chesapeake Bay Program.

Maryland: The program that is funded with the implementation grant is both agricultural and urban. The current urban program has been limited to demonstration projects in an effort to develop an understanding of which BMPs are best for the urban problems in the Bay drainage. The agricultural program is a statewide program funded mostly by State Bonds, with about one million dollars of implementation grant funds each year going to agricultural BMPs. The agricultural program selected 40 watersheds within the State as priority areas and are spending the majority of the bond funds in these areas and all of the grant funds in the top 20 areas. These watersheds were selected because of their potential to deliver sediment and nutrients from the land to nearby streams. Another area that is receiving attention is shoreline erosion, with both state and federal funds being used for demonstration and cost share projects. Stormwater management is already a very strong program within the State, therefore very little of the grant funds are being used for this ongoing program.

Virginia: The program that is funded with the implementation grant is both urban and agricultural in scope and is part of the statewide NPS program, but covers only that portion within the Bay drainage basin. The urban program is also a demonstration and evaluation effort. The agricultural program selected two major river basins and a portion of a third as the areas to receive attention. Cropland is the target within the two major basins and animal waste is the target within the two major basins and animal waste is the target to other area. A geographic information system (GIS) is being built over portions of the cropland areas and is being used to target funds to the actual acres that need BMPs. This system, as it now operates, can target the planning efforts to the correct field and can compare different proposed BMP contracts for cost effectiveness. As this system is expanded and refined it will be able to do a very good job of directing funds to the actual acres needing BMPs.

District of Columbia: The program funded with the implementation grant, is as expected, totally urban in scope. The District has had soil erosion management for construction sites, but has not been able to enforce water quality after the project was completed. The first step taken by the District has been to hire staff for a stormwater management program and to develop a set of requirements for permits. An educational effort has also been started to help reidents with home and lawn control, contractors are also a target for this program. These programs are to be active over the entire District, but initially are targeted in the Annacostia River area. The District has a construction effort underway in the Annacostia to remove sediment from stormwater runoff. They are also working with the State of Maryland on the entire Annacostia watershed to control erosion and water quality.

The federal role in the implementation of NPS control programs has many facets. EPA is charged with the role of the lead federal agency and as such has the responsibility for the 10 million dollars and how it is spent each year. There are six other federal agencies that have agreements with EPA to direct their current programs to assist with the restoration of the Bay if at all possible. The type of assistance provided varies, but some agencies such as the Soil Conservation Service provide hands on service to the implementation effort by doing most of the farm plans that are used to select BMPs and that are the basis of the cost share contracts.

Tracking Systems for Implementation of BMPs

Once a grant is funded, considerable time and effort goes into the tracking of its progress over time. Along with the normal accounting type of tracking, we are trying to track the actual installation of each BMP installed within the 64,000 square mile drainage basin of the Bay. The decision to develop the tracking system has at least two major objectives, one being the need to follow the use of funds in the targeted or critical areas and the second being to use the location of the BMPs to make simple load reduction calculations early in the implementation program. The tracking system as it now operates just accounts for the agricultural BMPs as the contracts are certified and the money is paid to the farmer. There is a need, and the plans are ready, to obtain the same information regarding the other BMP programs such as USDA's Agricultural Conservation Program.

The BMP tracking system contains a large amount of information about each BMP contract that is funded, such as: BMP location by county and by subwatershed, BMP type, acres served by the BMP, number of animal units served, tons of manure stored, tons of soil saved per acre, pounds of nutrients saved per acre or ton, total cost of the BMP, cost to the farmer, and the cost share amount by funding source. As can be seen, with this amount of information and a computer to store it in, one can utilize this data to develop many different analysis, such as: how are different programs or funding sources working together in the various areas, the amount of sediments or nutrients being retained on the land within a specific subwatershed, the cost per unit of pollutant retained by different BMPs and therefore the efficiency of the BMP, or one can look at the dollars spent by funding source, by county or subwatershed. As other data sets from other BMP programs are brought into the system, a clear picture can be had regarding the actual amount of implementation that is taking place in the area of interest. One problem that can occur is that older reporting systems will not usually contain as much data as we are getting and may be limited to county information and not subwatershed as we have. Also, if you are just starting to develop such a tracking system it would be helpful to locate BMPs by coordinates for later use in a GIS. This would also help load implementation information into the landuse data base for model use. One word of warning, at the present time USDA does not use coordinates on most of their BMP reporting systems, therefore contact with local USDA agencies would be advisable before a system is installed.

The tracking system described herein is based on having the BMP contract with the farmer completed and all bills paid. This means that the work is complete on the contract and that all components are complete. This is true only if the payments are made on whole contracts and not on partial contracts, which is done in some cases. Therefore, one must be very careful to totally understand the system used in the field. The tracking system also does not give a true picture of progress for the first two of three years, as a program is getting started, because we are counting only completed contracts and the most important items early in a program will be the number of acres served by signed contracts, the type of BMPs used in the contracts and the amount of money committed. This causes the program to have large amounts of money within the system but not paid out. The problem this causes is that funds must be given to the contracting agency by a grant or an appropriation before they can enter into a legal contract with a farmer for a farm plan. Once the plan is completed and a contract signed, it is very unlikely that the installation of the BMP's could be completed within one year and in some cases it will take two years to complete the work. Given unfavorable weather conditions, the time may extend even longer.

For all of the above reasons it becomes important to have a second BMP tracking system which looks at the BMP contracts that are signed but not completed and looks at an estimate of the number of contracts that will be signed in the next few months. This data allows a program manager to account for the funds that are in the system and gives an indication of funds needed in the near future. It also provides some insight into the progress that is being made with the farm plans and where additional technical assistance is needed or not needed.

As we gain experience with NPS implementation programs and the funding of BMP contracts with farmers, we may be able to "over contract" by a certain percentage of the total funds for one year. This would be desirable because we are seeing a very poor farm economy that has put some farmers in the position of not having the cost share money needed to complete the contract. Most of them are not able to borrow money to install BMPs when they can't even borrow money to put out next year's crop. This means that NPS implementation programs are loosing some good contracts each year, even though we are using high cost share rates on some of the major BMPs. As you can see, getting BMPs installed is not easy and there are many reasons why a farmer does not contract with us, but having a good tracking system and using it can help understand just what is causing problems and it may give some insight into how to deal with each situation.

The tracking system that can be developed with information that is contained on the contacts and that is available in the local district office can be a very powerful tool in the management of several aspects of an implementation program. It can be used to look at the distribution of BMPs by subbasin within a watershed, and may show some areas where BMPs are not being used. If they should be used in these areas, then a manager can look for a reason for the problem, it might be a lack education in that area, the cost share rate may be too low (not likely), or it the specific BMP may not work with the soil type or farming rotation used or the technical assistance being provided may not understand how to design the BMP for the area. All of these are questions that could not have been asked early in a program without a good tracking system, and as you can see the system only pointed out the potential for a problem and allowed the manager to make the proper evaluation of the situation.

Summary

In summary, it is easy to understand the need for a system that allows for the accounting of funds being used for NPS program grants. That is the normal accounting type of bookkeeping that every agency requires. However, the need to keep track of the actual location of the BMPs that are being bought and paid for is a little different from our past experience in fundings of sewage treatment plants. The data that can be collected regarding the contracts and the BMPs in the contracts is very useful for a manager and may be used to evaluate the many aspects of the total implementation program. Not only can the location and effectiveness of the BMPs be tracked, other items can be investigated such as the reasons for BMPs being used too an excess or not used at all. It must be understood that while a tracking system may not be able to answer all our questions, it can and should cause us to ask questions that we would otherwise not have reason to ask. A tracking system used in conjunction with a good, detailed GIS should be able to provide the basic input data for evaluation models that are not now being used because of lack of a good data base. The need for and the uses of a good tracking system make the time and effort necessary to start and to keep one up to date, small compared to what can be accomplished with such a system.

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AERIAL PHOTOGRAPHY DOCUMENTS SIGNIFICANT INCREASE IN ABUNDANCE OF MARYLAND SUBMERGED AQUATIC VEGETATION IN 1985

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Introduction

Communities of submerged aquatic vegetation (SAV) are an integral part of the Chesapeake Bay ecosystem. They provide an important habitat for many species which use SAV either as a food source or as protection from predators, e.g., a nursery. They reduce currents and baffle waves, allowing for deposition of suspended material. In addition, they bind sediments with their roots and rhizomes to prevent erosion of the underlying material, and are important in nutrient cycling both through the absorption and release of nitrogen and phosphorus (Thayer, et al., 1975; Kemp, et al., 1984; Orth, et al., 1984; Ward, et al., 1984).

Interest in SAV communities was generated in the 1970's because of their dramatic baywide decline. In 1976, the U.S. Environmental Protection Agency Chesapeake Bay Program identified the decline and disappearance of SAV as one of three major areas that required more in-depth research in order to understand the state of the health of the Chesapeake Bay. A key aspect of the SAV research programs, begun in 1976 and currently being funded by several Federal agencies and the State of Maryland, entails an annual aerial monitoring of all SAV beds in the Maryland Chesapeake Bay and its tributaries. A similar effort, which is closely coordinated with the Maryland program, is annually carried out in the Virginia portion of the Bay.

The first aerial survey of Maryland SAV beds was conducted in 1978 and resulted in a comprehensive report on the SAV distribution in Maryland (Anderson and Macomber, 1980). In that year a similar survey was conducted for the Virginia waters of the Chesapeake Bay (Orth, et al., 1979). In addition, an annual Maryland Department of Natural

Resources (DNR) boat survey of SAV in the Maryland waters, which began in 1971, indicated a decline in Maryland SAV.

In 1984 an aerial survey of the Maryland and Virginia SAV communities was again conducted. In addition, ground survey information available for 1984 was included to provide as detailed a picture as possible of the distribution of SAV that year (Orth, et al., 1985). Results of this study indicated that SAV was still declining in 9 of the 13 sections of the Maryland Chesapeake Bay. The most positive note was in the upper Potomac River where SAV has been increasing rapidly in recent years.

An aerial photographic survey for SAV adjacent to the shoreline of the Maryland and Virginia Chesapeake Bay and its tributaries was repeated in 1985. This paper summarizes methodologies used for the aerial surveys and documents the dramatic changes seen in SAV abundance in Maryland in 1985. It also discusses possible reasons for the resurgence in SAV seen in some portions of the Maryland Bay.

Methods

Aerial photographic interpretation and mapping

Aerial photographic interpretation was the principal method used to assess the distribution of SAV in the Maryland Chesapeake Bay and its tributaries in the 1978, 1984 and 1985 studies. Predetermined flight lines for photography of areas that either had SAV or could potentially have SAV (that is, all areas where water depths were less than 2 m at mean low water) were drawn on 1:250,000 scale U.S. Geological Survey (USGS) maps to ensure both complete coverage of SAV beds and inclusion of land features as control points for mapping accuracy.

The general guidelines used for mission planning and execution address tidal stage, plant growth, sun elevation, water transparency and atmospheric transparency, turbidity, wind, sensor operation and plotting and allowed for acquisition of photographs under near optimal conditions. The guidelines are critical because significant distortion of any one item could significantly decrease the ability to detect the SAV or to interpret the photography properly as to the presence or absence of SAV.

Color aerial photography at a scale of 1:12,000 was acquired for SAV mapping in 1985. The camera used was a Zeiss Jena LMK 15/2323 with a 153 mm (6.02 inch) focal length Zeiss Jena Lamegon PI/C lens. The film used was Kodak 24 cm (9 1/2 inch) square positive Aerochrome MS type 2448.

SAV beds were identified on the photographs using knowledge of aquatic grass signatures on the film, areas of grass coverage from previous flights, and ground truth information. Mylar topographic quadrangles at a scale of 1:12,000 were used as base maps. Delineation of SAV bed boundaries onto the mylar maps was facilitated by superimposing the appropriate mylar quadrangle over the transparent photograph on a light table. Where minor scale differences were evident between the photograph and quadrangle or where significant shoreline erosion or accretion had occurred since production of the map, a best fit was obtained, or shoreline changes were noted on the quadrangle. Areas of SAV beds were digitized from the 1:12,000 scale draft SAV maps, on a Calma Graphic Interactive Image Analysis System.

In addition to the boundaries of the SAV bed, an estimate of percent cover within each bed was made visually in comparison with an enlarged Crown Density Scale, similar to those developed for estimating forest tree crown cover from aerial photography. Bed density was classified into one of four categories based on a subjective comparison with the density scale. These were: 1. very sparse, <10%; 2. sparse, 10 to 40%; 3. moderate, 40 to 70%; or 4. dense, 70-100%. Either the entire bed, or subsections within the bed, were assigned a number (1 to 4) corresponding to the above density categories. In addition to the density scale, each distinct SAV unit was given a two letter designation to insure proper identification for future comparisons.

Discussion of the distribution of SAV in Maryland has been organized into two zones and thirteen sections (Figure 1), a subset of the twenty-one sections for the entire Bay as established by Orth and Moore (1982). The Upper and Lower Zones correspond approximately to the polyhaline and mesohaline segments of the Chesapeake Bay. The thirteen sections denote relatively distinct parts of the Bay that are readily identifiable from a map. Although the major rivers and smaller tributaries of the Bay have their own salinity regimes, the distributions of SAV in each river are discussed within the section where it connects to the Bay proper. Section thirteen is modified in that only data from the Maryland portion of the section is reported.

Ground truth and other data bases

Ground truth data was provided principally from two SAV surveys conducted in 1984 and 1985, and from two SAV transplanting and research projects. A shoreline survey was conducted by the USGS (Rybicki, et al., 1986) in the Potomac River, and included the area from the Chain Bridge at Washington, D.C. to Quantico, Virginia. Earlier surveys of the Potomac River by the USGS included sections of the river south of Quantico to the mouth of the Potomac River (Haramis and Carter, 1983; Carter et al., 1985a,b; Rybicki, et al., 1985). The survey was conducted in September and October, by boat, using rakes to collect samples for presence or absence of SAV. Data from this survey was reported as species and percent cover for each species on USGS quadrangles of the study area.

The second survey is the annual large scale multi-station survey conducted by the Maryland DNR. This survey, ongoing since 1971, is conducted from June through August, and samples 600+ permanent stations throughout the Maryland Bay from the Susquehanna Flats to Smith Island. At each station species presence or absence, as well as standing crop, are recorded.

One of the SAV transplanting and research projects is being conducted on the Susquehanna Flats by Stan Kollar of Harford Community College. Information provided includes species presence and percent cover, primarily by visual estimates, location of transplant sites and location of beds too sparse to be detected by aerial photography. A second SAV research group at University of Maryland's Horn Point Laboratory (UMdHPL), directed by Court Stevenson, also provided ground truth data. An annotated map of their study sites on the Choptank River indicated the status of SAV from 1982 to 1984. Annotated aerial photographs for 1985 gave species information for their study sites in that year.

In addition to the aforementioned surveys, citizen volunteers participated in identifying SAV beds by checking areas in the Bay for SAV. The Maryland Charter Boats Association participated in the effort, funded by the Maryland DNR's Watermen's Assistance Program. Boat captains were provided with reduced SAV quadrangle maps and data sheets for each SAV bed identified on the maps. SAV samples were identified to species on site or sent to the DNR for identification. Citizens also volunteered to assist in the SAV ground survey under guidance of the Chesapeake Bay Foundation (CBF), Citizens Program for the Chesapeake Bay (CPCB), and U.S. Fish and Wildlife Service (F&WS). This program entailed identifying and recording the location of SAV in the Bay, using an identification guide of SAV and maps of their area of interest. Each volunteer was asked to identify the location where

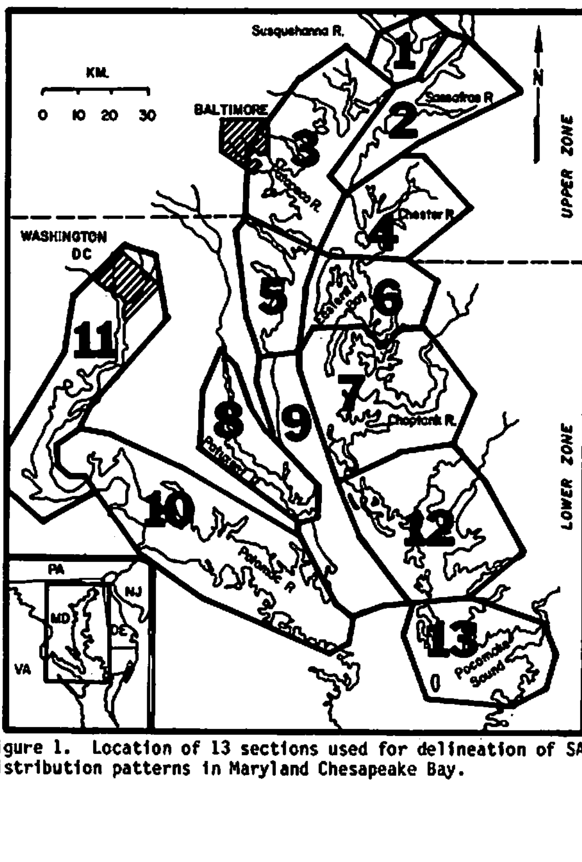

Figure 1. Location of 13 sections used for delineation of SAV distribution patterns in Maryland Chesapeake Bay.

SAV was sighted as well as water conditions, how many and which species, approximate grassbed size, percentage of area covered with SAV and location description.

All ground survey information was included on the 1:12,000 SAV maps to show positions of the survey stations in relation to the beds of SAV mapped from the aerial photographs. Each different survey was designated by a unique symbol on the maps. Where species information was available, it was included on the map. These maps, which could not be included in this report can be found in the 1985 SAV final report (Orth, et al., 1986).

Results

A total of 9,270 hectares (Table 1) of SAV was mapped in the Maryland Chesapeake Bay in 1985, a 65% increase in SAV over that reported in 1984. The Upper Zone had 3,025 hectares of SAV in 1985, representing a decrease of 4.5% from that reported in 1984 (3,168 hectares). The Lower Zone showed an increase of 155%, from 2,451 hectares in 1984 to 6,244 hectares of SAV in 1985. All sections in this zone except the Smith Island Complex showed an increase in SAV for 1985. Following is a discussion of SAV trends in each of the 13 sections of the Maryland Bay (refer to Figure 1 and Table 1).

Upper Zone

The distribution of SAV in the Susquehanna Flats (section 1) decreased by 6.5% in 1985, from 2,150 hectares in 1984 to 2,011 hectares in 1985 (Table 1). Mapping of SAV in this section was accomplished both by the use of aerial photography and information provided by Stan Kollar where the SAV was too sparse to be detected from the aerial photos. Seven species of SAV were found in 1985 with *Myriophyllum spicatum* the most abundant. Other species of importance were *Heteranthera dubia*, *Vallisneria americana*, and *Hydrilla verticillata*. *Hydrilla* appears to be increasing in abundance along the Susquehanna River, and in the Havre de Grace area.

The Upper Eastern Shore (section 2) showed a 142% increase in SAV from 1984 to 1985. A total of 104 hectares was mapped in 1985 as compared to 43 in 1984 (Table 1). Most of the increase in SAV in 1985 occurred along the Elk, Bohemia and Sassafras Rivers. Of the 7 quadrangles mapped in this section, only Galena showed a decrease in SAV.

The 1985 aerial survey indicated there were 238 hectares of SAV in the Upper Western Shore (section 3), a decrease of 2.4% from that estimated in 1984 (Table 1). Aerial coverage of this section was complete in 1985, thus the estimated 1984 coverage may have been fairly accurate, since little increase or decrease was generally seen on the Western Shore in 1985. Aerial photos indicated that SAV was present in all river systems (Gunpowder, Bush, Back, Middle and Magothy) in the section. Generally, most of the SAV was present along the lower section of the river.

In 1985, 671 hectares of SAV were mapped in the Chester River (section 4), a decrease of 8.2% from the 731 hectares mapped in 1984 (Table 1). Again, most of the SAV mapped (87%) occurred on the Langford Creek quadrangle. In all, 8 of the 9 quadrangles in the section had SAV

Table 1. Numbers of hectares of bottom covered with submerged aquatic vegetation in 1978, 1984 and 1985 for different sections within the Maryland Chesapeake Bay (Data for 1978 from Orth et al., 1979, and Anderson and Macomber, 1980; data for 1984 from Orth et al., 1985).

Section	1978	1984	1985	
1. Susquehanna Flats	804*	2,150	2,011	Upper Zone
2. Upper Eastern Shore	29	43	105	
3. Upper Western Shore	484	244	238	
4. Chester River	1,475	731	671	
5. Central Western Shore	241	0	26	Lower Zone
6. Eastern Bay	1,800	66	356	
7. Choptank River	1,740	82	1,528	
8. Patuxent River	34	9	44	
9. Middle Western Shore	11	0	23	
10. Lower Potomac River	410	194	381	
11. Upper Potomac River	0**	600	1,440	
12. Middle Eastern Shore	210	33	1,188	
13. Smith Island Complex	945	1,467	1,259	
Total	8,183	5,619	9,270	

*1978 data from Susquehanna Flats remapped and digitized to allow for greater compatibility to 1984 data.

**No aerial photography was taken of this area in 1978; the absence of SAV is based on ground survey observations by the USGS.

present in 1985. Five species of SAV were reported by citizen and Maryland DNR field surveys. These species were *Ruppia maritima*, *Zannichelia palustris*, *Potamogeton perfoliatus*, *Potamogeton pectinatus* and *Myriophyllum spicatum*. *Potamogeton perfoliatus* and *Ruppia maritima* were reported most often.

Lower Zone

A total of 26.3 hectares of SAV was mapped in the Central Western Shore (section 5) in 1985, when none was seen in 1984 (Table 1). Seventy-two percent of the SAV reported was located in Herring Bay on the North Beach quadrangle. No SAV was mapped in any of the river systems in this section except for a small bed near the mouth of the West River.

In 1985 a total of 356 hectares of SAV was noted in the Eastern Bay (section 6), an increase of 441% over the 66 hectares reported in 1984 (Table 1). *Ruppia maritima* was the most abundant species reported in field surveys by citizens and Maryland DNR personnel. *Potamogeton pectinatus* and *Potamogeton perfoliatus* were also reported, but other species reported in 1978, such as *Myriophyllum spicatum*, *Elodea*

canadensis and Zannichelia palustris were not seen.
In 1985, a total of 1,528 hectares of SAV was noted in the Choptank River (section 7), as compared to only 82 hectares seen in 1984 (Table 1). This represents a 1,760% increase over the previous year. Ten of the 13 quadrangles in the section had SAV in 1985, compared to only 6 in 1984, and 6 had over 100 hectares of SAV. A total of 6 species were reported to occur in this section. Ruppia maritima was by far the most abundant species reported in field surveys. Other species found were Potamogeton perfoliatus, Potomageton pectinatus, Zannichelia palustris, Najas guadalupensis and Vallisneria americana.

Qualitative information provided by UMdHPL found SAV at 5 of their 6 monitored areas, as compared to only 2 in 1984. Horn Point was the only station not vegetated, while dramatic increases were noted at the other stations. Species present were Zannichelia palustris in May and early June followed by Ruppia maritima in late June and July.

In 1985, 44 hectares of SAV were noted in the Patuxent River (section 8), as compared to only 9 in 1984 (Table 1). SAV was noted on 4 of the 5 quadrangles in this section.

A total of 23 hectares of SAV was noted in the Middle Western Shore (section 9) in 1985 (Table 1). Ninety-nine percent of the SAV occurred in areas where aerial photography was not available in 1984. Four of the eight quadrangles in this section had vegetation, with 71% of it occurring on the Point No Point quadrangle. Most of the mapped SAV in this section occurred in small marsh ponds that drain into the Bay.

In 1985 there were 381 hectares of SAV in the Lower Potomac River (section 10), as compared to 194 mapped in 1984 (Table 1). This represents a 69% increase, of which 9% is accounted for by quadrangles that were not mapped in 1984 because of a lack of photo coverage. Only 9 of the 20 quadrangles in the section had SAV, and 2 that had SAV last year, Colonial Beach South and Stratford Hall, had none this year. Seventy-four percent of the SAV mapped in 1985 occurred on the Mathias Point quadrangle.

Once again in 1985 the Upper Potomac River (section 11) exhibited a significant increase in abundance of SAV (Table 1). In 1985, 1,440 hectares of SAV were noted on the aerial photography as compared to 600 in 1984. This represents a 140 percent increase. The vegetation is still largely confined to the upper reaches of the section between Alexandria, Virginia and Marshall Hall, Maryland. Ninety-five percent of the mapped SAV occurred on the Alexandria and Mount Vernon quadrangles, which cover the upper reaches previously described. Ten species were found in this reach during the USGS monitoring program, in which 60 transects were sampled in spring and fall and a shoreline survey was made in fall.

In 1985, USGS estimated that areal coverage of SAV in their study area was approximately 1,457 hectares, based on shoreline survey information and aerial photographs. The aerial mapping effort at the Environmental Photographic Interpretation Center (EPIC) for the same area calculated 1,372 hectares of SAV which, without the benefit of a ground truth survey, is only 5.6% different than the USGS estimate. Since 1984, the vegetation has spread almost two kilometers further downriver. In almost all water less than 2 meters deep, at least 4 SAV species are present. The most abundant and most widely occurring species are Hydrilla verticillata, Myriophyllum spicatum, Heteranthera dubia, Ceratophyllum demersum, Vallisneria americana and Najas guadalupensis. Hydrilla verticillata, Myriophyllum spicatum and Ceratophyllum demersum occurred in 79%, 55% and 47% of the transect samples, respectively, in the fall of 1985. Hydrilla verticillata dominates Hunting Creek, Swan Creek and the Dyke Marsh area. Results of the USGS shoreline survey show that Hydrilla was more abundant than all other species in 25% of the vegetated areas, accounting for 62% of the total fall dry weight.

In 1985, there were 1,188 hectares of SAV in the Middle Eastern Shore (section 12), as compared to only 33 hectares in 1984 (Table 1). This represents a 3,504% increase, the largest increase seen in any section of the Bay. Twelve of the fifteen quadrangles in the section had vegetation in 1985, while only 5 had vegetation in 1984. One of the most significant increases was the 265 hectares, mostly occurring in one large bed, in the Barren Island Gap region, where no SAV was seen in 1984.

The Smith Island Complex (section 13) contained 1,259 hectares of SAV in 1985, the third largest amount of SAV in the Maryland waters, which is slightly less than the amount reported for 1984 (Table 1).

SAV beds are concentrated in distinct areas in the section: the east side of Great Fox Island and in the shallows around Smith Island. Dominant species in this section are Zostera marina and Ruppia maritima.

Discussion

The distribution and abundance of submerged aquatic vegetation (SAV) was mapped for the Maryland Chesapeake Bay in 1985 using color aerial photography at a scale of 1:12,000. The Maryland Chesapeake Bay had 9,561 hectares of SAV in 1985 compared to 5,769 hectares in 1984, a 66% increase.

The upper Maryland Bay (sections 1-4) had 3,025 hectares of SAV in 1985 (15.6% of the total SAV in the bay). This represents a decrease of 4.5% from that reported in 1984. Three of the four sections in this zone showed a slight decrease in SAV abundance, while a 142% increase was seen in the sparsely vegetated (104 ha) Upper Eastern Shore section, principally along the Elk and Sassafras Rivers. It is not known why there was an overall decrease (although it was small) in this zone. The 4.5% change that was detected may only represent natural fluctuations in the SAV communities and may not be significant. It is interesting to note that the only section in this zone to show an increase is located on the Eastern Shore, an area which overall showed a tremendous increase in 1984, while the other three sections, located on the Western Shore, showed slight decreases.

The lower Maryland Bay (sections 5-13) had 6,536 hectares of SAV in 1985, which represents a 151% increase from that reported in 1984. All sections in the zone except the Smith Island Complex showed an increase in SAV, with almost one half (3,072 ha) of the SAV and the greatest percent increases occurring in the Eastern Bay (441%), Choptank River (1,760%), and Middle Eastern Shore (3,504%) sections, all of which are located on the Eastern Shore of the mainstem of the Bay.

Reasons for the tremendous resurgence seen on the Eastern Shore are not as yet understood. It is postulated by some scientists that because of the abnormally dry weather in the spring and early summer of 1985, and resultant reduction in runoff, there were less sediments and nutrients in the water that could have a negative effect on the growth of SAV, either by reducing light levels or causing increased algae blooms and epiphytic growth on the SAV. In the Choptank River, Court Stevenson (1986) notes that the reduced runoff increased salinities above normal levels, thus giving Ruppia maritima an opportunity to invade a wide range of habitat. Stevenson also notes that nitrogen and phosphorus levels noted in the lower Choptank could be target levels for dry years, but more research is needed. In addition, low seston and light attenuation values appeared to correlate positively with increased SAV growth.

Both Potomac River sections increased in SAV in 1985, with the largest increase (140%) occurring in the Upper Potomac River section. The return of SAV in the Upper Potomac River continues to be of significance with regard to its rapid spread in a short time frame. In less than five years, SAV has increased from almost nothing to 1,440 hectares. Reasons for this dramatic turnaround in the Upper Potomac are not clear, but may be tied to the nutrient removal being performed by the Blue Plains Sewage Treatment Plant. It appears that in recent years algae blooms have been less severe, and secchi depths have improved.

The strong resurgence of SAV seen on the Eastern Shore of the Maryland Chesapeake Bay has probably occurred, in part, because that area has numerous bays, coves and inlets, thus giving it a much larger habitat suitable for SAV than occurs on the Western Shore, which has large expanses of very exposed shoal and shoreline areas. In addition, human development and pollution are much greater on the Western Shore. Thus, rivers along that shore are probably more heavily polluted by sewage treatment plant inputs, which are not affected by dry years and in fact would increase the pollution problem due to the decreased dilution factor afforded by increased rainfall. On the other hand, the Eastern Shore, which is heavily agricultural, has a much lower population density. Therefore, decreased runoff has a positive effect on pollution levels by reducing non-point source inputs from agricultural runoff.

Analysis of historical SAV trends in the Bay have indicated that disappearance first occurred at the heads of streams and rivers and from the north end of the Bay southward. The pattern of reoccurrence (if it indeed is a pattern) seen in 1985 in the main Bay would be following the expected pattern, as the strongest resurgence was seen in the Lower Eastern Shore of Maryland, in the area of mesohaline salinity. In addition, repopulation was greater near the mouths of several rivers and creeks (i.e., the Choptank River, Gunpowder River, Middle River, Seneca Creek and Saltpeter Creek). The only contradiction to this pattern is noted in the Potomac River, where a strong resurgence of SAV has occurred in the freshwater section just below Washington D.C., while the estuarine sections of the river are only sparsely populated. Reasons for this are unclear, but as previously stated, recovery in the Upper Potomac may be related to reduced nutrient inputs, while lack of resurgence in the Lower Potomac is at present still a mystery.

It is still too soon to tell if the resurgence of SAV seen in 1985 is a sign of improving water quality or just a fluctuation brought on by a climatic event. Continued monitoring and analysis is needed. Hopefully a USF&WS proposal to study SAV trends will shed more light on the problem. In addition, a 1986 SAV monitoring program is in place, imagery and ground truth data have been acquired, and preliminary reports indicate that SAV abundance in most areas is similar to that seen in 1985.

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DEVELOPING THE RULES AND EVALUATING THE ECONOMICS

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REGULATING, PURCHASING, AND TAKING PROPERTY RIGHTS IN THE COMBAT OF NONPOINT SOURCE POLLUTION

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As the environmental impacts of extracting our agricultural bounty has become more apparent, farmers' use of natural resources have become subject to more careful review and regulation. Farmers' rights are in a state of transition. "Rights to use land are being conditioned on effects that uses have on others, principally users of water and aquatic environments (Braden, 1982)."

Consideration of alternative programs or policies to control nonpoint pollution would alter the current allocation of property rights, as well as the rules under which those rights are protected and exchanged. This paper will discuss assignment of property rights, major program alternatives, and tax expenditures in the combat of nonpoint pollution.

Control of Nonpoint Source Pollution

Control of nonpoint source[1] pollution, under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (U.S. Congress, 1972), was to be undertaken by area-wide planning. Under this process, an area-wide plan is developed by a planning agency at the state level and submitted to the Environmental Protectoin Agency (EPA) for approval. A regional operating agency is then designated to carry out the plan. These regional

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[1]Nonpoint source pollution is: (1) Generated by diffused land use activities, not identifiable activities. (2) Conveyed to waterways through natural processes such as storm runoff or ground water seepage, rather than deliberate, controlled discharge, and (3) Not susceptible to "end of pipe" treatment, but controllable by changes in land management or process practices. (41 Federal Reg. 24709-24710 (1976)).

operating agencies may be either existing or newly created local, regional or state agencies or political subdivisions (March, Kramer, and Geyer, 1981).

The area-wide plan must specify a process to identify agriculturally related nonpoint sources of pollution and methods to control these sources. Given the general inapplicability of permits and other forms of effluent limitations to nonpoint source pollution, an alternative control technique is required. The control technique authorized by the Clean Water Act (CWA) and the EPA is the implementation, by farmers, of "best management practices" (BMPs). BMPs have been defined by EPA as those methods, measures or practices to prevent or reduce water pollution which include but are not limited to structural and non-structural controls, and operation and maintenance procedures (March, Kramer, and Geyer, 1981).

Most agricultural BMP programs are of a voluntary nature. The programs provide for education and information about agricultural nonpoint source pollution, its damages, and its controls. The programs also include a cost sharing strategy to assist farmers in installing often costly pollution control practices. Cost sharing of BMPs has also been instituted because of the off-farm nature of the benefits of BMP adoption. However, questions have been raised as to the effectiveness of the voluntary cost sharing program for pollution control. Despite the availability of cost sharing, there is little incentive for farmers to voluntarily adopt BMPs when they will not recognize, directly, the benefits of their investments. Also, cost sharing funds are limited, further reducing the likelihood of widespread BMP adoption.

A Discussion of Property Rights

Whether nonpoint source pollution control programs continue to solicit voluntary cooperation, albeit in a modified approach, or whether some regulatory approach is adopted, it appears that changes in the current nonpoint source pollution control programs are forthcoming. Such a transition is seldom a smooth process. In the case of nonpoint source pollution, the transition is further frustrated by the corresponding problems of identification, definition and enforcement of changing property rights allocations.

A right ("entitlement") confers favor among individuals or groups making competing claims to an object or privilege (Calabresi and Melamed, 1972). In defining rights, two matters must be decided: a) initial ownership (allocation) of rights, and b) rules under which they may be exchanged. The allocation decision must reflect accepted tenets of social relations, including distributional equity and judicial consistency (Calabresi and Melamed). An entitlement should be made to the party best able to evaluate its social worth or, secondarily, to the party who can act most cheaply to correct errors in its initial allocation (i.e. evaluate and initiate exchange) (Braden, 1982).

Bromley (1978) considered (1) property rules, (2) liability rules, and (3) inalienability rules as the rules by which rights are protected. His framework is as follows. Given two parties, A and B, if: 1) A owns the entitlement-- When A is protected by a property rule, A may interfere with B and can only be stopped if B buys off A. When A is protected by a liability rule, B may stop A from interfering but must compensate A. 2) B owns the entitlement-- When B is protected by a property rule, A may not interfere with B without B's consent. When B is protected by a liability rule, A may interfere with B but must compensate B. When B is protected by inalienability, A may not interfere with B under any circumstances and the stopping does not imply compensation. Bromley (1978) also notes that transactions costs will be higher when entitlements are protected under property rules rather than liability rules because the property rule requires a prior agreement among the parties. He suggests that, as a result, interference will likely be greater under the latter.

Property Rights and Nonpoint Source Pollution Control

The allocation of property rights to water and its use is not explicitly defined. There is precedent to suggest that these rights are owned in most cases by the farmers. Indeed, under the current program of voluntary BMP implementation, it can be argued that farmers have been endowed with the rights to the "use" of water. With the current program, those rights are protected under a property rule, and may be "purchased" by the public if farmers choose to exchange their rights to create nonpoint source pollution for cost sharing assistance in controlling the pollution.

Alternative Programs

Along with the questions regarding the effectiveness of the current nonpoint control program have come suggestions for alternative programs.

Major Program Alternatives include:

(1) Cross compliance - government farm program;

(2) Regulatory schemes - BMPs - required by law;

(3) Soil loss tax;

(4) Tax credit, tax deduction, tax expenditure;

(5) Enforcement of common law;

(6) Purchase of rights.

1. Cross compliance

An alternative to the current voluntary BMP program is a cross-compliance strategy. Cross-compliance would require farmers to comply with a specific BMP program in order to receive government sponsored agricultural program benefits. Specific programs which could be reduced or eliminated for non-complying farmers include federal price support, crop insurance, access to extension services, and loan subsidy programs. In addition to financial penalties, cross-compliance could also be designed to increase program benefits for participating farmers. The effect would be threefold: the commitment to government spending with regard to income-support and subsidy programs need not increase, the imposition of costs (penalties) on non-participants, and indirect cost-assistance to complying farmers in the form of higher price supports. Fines and/or reductions in program benefits would occur in event of farmer violation of the specified BMP program.

Under cross-compliance, the farmer still remains entitled and protected under the property rule. Although the benefits and costs associated with "owning" a particular entitlement have shifted, there is no fundamental change in rights. Farmers may still continue to use (pollute) the water if the compensation society is willing to pay is not sufficient.

Any change from the current voluntary program will involve an increase in costs, but implementation and administrative costs in regard to cross-compliance need not be excessive. The existing administrative framework could be upgraded to incorporate the program (Benbrook, 1979). Farmers will also face increased costs with either adoption of a BMP program or a reduction in benefits. BMP costs could be offset if additional benefits are provided for those who comply.

An important policy consideration is at what magnitude to adjust federal income support programs. If insufficient penalty or reward is associated with compliance, farmers with highly erosive land will continue to pollute the water. Whether cross-compliance will reach the heavy users (polluters) of water remains inconclusive (Ervin, Heffernan, Green, 1984). Also, since no direct cost sharing assistance is provided, farmers of undulating land will be at a significant cost disadvantage. The negative effects on the owners of highly erodable land raises another question: which farmer owns this land? For example, research in Indiana suggests small farms are more likely to be located on undulating land (Miller, Gill, 1976). Cross-compliance is likely to benefit large, high equity operators relative to small young farmers (Ervin, Heffernan, Green, 1984). The impact of cross-compliance walks a fine line; the more drastic the reduction for non-compliance the more serious the inequalities, but if reductions are only marginal pollution will continue.

2. Regulatory programs

A number of regulatory proposals have been put forward in attempts to contain nonpoint source pollution. A regulatory approach would require farmers by law to comply with erosion control plans or to meet a specified soil loss limit. The farmer, in return will receive cost sharing and technical assistance in attempts to reduce pollution. Twelve states have moved toward increasing regulations in response to nonpoint pollution problems (Braden, 1982). Regulations with a guarantee of financial assistance would still leave farmers entitled, but protection is downgraded to a liability rule.

Administrative and implementation costs would increase directly with the level of monitoring. States with regulatory statutes in place, however, normally respond only to complaints and/or obvious pollution problems (Braden, 1982). Transaction costs could partially set off other costs with a move from the property rule to the liability rule (Bromley, 1978). The public would also have to bear the additional government expenditures on cost assistance, but the price of cost sharing would likely decrease in the long run once many of the permanent erosion structures (terracing, landscaping, drainage systems, and similar systems) are in place.

Farmer income would decrease inversely with the level of cost sharing assistance. Regulatory action could result in significant costs with regard to smaller farms and would likely increase with the imposition of more restrictive regulations (Miller, Gill, 1976). Cost sharing could smooth the discrepancies. Cost sharing could be calibrated to reflect some ratio of the cost of adopting anti-pollution measures to net farm income or cost per acre.

Regulations are attractive for another reason, flexibility. The federal government could set some general guidelines with states adopting specific lines of action to match their needs. Regulations and the level of cost sharing could be offered to attain workable solutions. Although cost to the public and farmers will rise, a significant reduction in pollution could be achieved.

3. Soil loss tax

One of the most economically efficient alternatives is the imposition of a soil loss tax. Such a tax represents the cost of pollution imposed on society from farm sources. Entitlement would be reallocated to the public under the liability rule. Farmers would be allowed access to the public entitlement (water) provided they compensate society for the interference. Such a drastic shift in rights would be met with strong farmer resistance.

Although the soil loss tax best equates the cost with the crime, there exist some structural limitations. Monitoring soil loss would require vast amounts of both time and money and could only be accomplished indirectly through measurements like the universal soil loss equation. Benbrook states that "reliance on the USLE for this problem, however, is problematic" (Benbrook, 1979). Braden adds, "a reallocation of rights away from landowners would entail prohibitively high costs of enforcement on every parcel of affected land" (Braden, 1982). The financial burden of the tax would also result in a substantial reduction in farm income. Still another technical question is at what level should the tax be set to assure accurate compensation of social cost.

4. <u>Tax credit</u>, <u>tax deduction</u>, <u>tax expenditure</u>

Altering tax expenditures in conjunction with other proposals or as a separate action could reduce the level of nonpoint pollution. Redefining the tax code would not change the allocation or exchange of rights but would shift the costs and benefits of owning an entitlement. Positive steps could be advanced in controlling pollution without an increase in government cost or involvement by removing tax subsidies for chronic pollutants.

Tax expenditures could be reduced in several areas crucial to polluting farmers. Elimination of tax expenditures in areas of investment tax credit, ordinary and necessary business expenses, and depreciation of capital investment undertaken in conjunction with the use of offending land activities could provide significant financial incentive for the adoption of pollution control measures. In addition, capitalization of offending expenditures such as land clearing expenses could also be disallowed. This would remove any positive tax expenditures for offending activities.

The advantage in shifting tax expenditures to encourage better land use is no additional administrative and implementation costs. The program could be carried out under the IRS and existing BMP programs, or easily incorporated in other proposed programs. The wide variety of tax provisions allows policy makers a range of workable alternatives. The cost to the farmer will likely increase. If tax penalties are too severe, inequities could emerge for small farmers on undulating land. Marginal changes in the tax code, on the other hand, will not ensure erosion control.

5. <u>Enforcement of the common law</u>

In addition to statutory law, common law theories such as nuisance and trespass may be called upon to address nonpoint source pollution. Under common law, a public nuisance is an unreasonable interference with a right of the general public. A private nuisance is an interference with another individual's use of or enjoyment of property. The notion of pollution as a public nuisance may, in some cases, arise directly from a constitutional provision (Rogers, 1977). Under the private nuisance theory, farmers have been sued for allowing cattle and hogs access to streams and for allowing livestock wastes to reach the streams or wash onto plaintiff's property. Similar cases have involved chemicals and sedimentation.

The theory of trespass is another common law approach to pollution control. Trespass involves an intentional physical invasion of someone's exclusive use of his land (Prosser, 1971). Water transportation of dirt and animal carcasses have been held pollution trespass (Davidson, 1981).

Although the common law theories are operative, their enforcement in cases of nonpoint source water pollution is complicated by the requirements of proof and damages. Determining the exact source of pesticide or fertilizer contamination is most likely impossible. Similarly, an accounting of the damages from the nuisance or trespass of some parts per million of a chemical is, at best, a rough estimate. Therefore, the enforcement of common law may be less desirable and less effective than legislative intervention.

6. Purchase of rights

A tax credit as provided by the Commonwealth of Virginia is an example of a law designed to allow the "purchase" of property rights by the public. The law provides that a credit be allowed against state taxes of 25 percent of all expenditures for the purchase and installation of conservation tillage equipment up to a total of $2,500 (Va. Code Sec. 58.1-334 and 58.1-432). Replacing these current programs with one of the alternatives discussed above would result in a change in the definition and/or allocation of property rights. In many cases, current holders of the rights are likely to oppose a change. Purchase of conservation easements or the condemnation of easements to grow certain types of crops would be examples of the purchase of property rights.

Property Rights and the Implementation of Alternative Programs

The cross-compliance strategy would not entail a fundamental change in the allocation or protection of rights. Such a program would redefine farmers' rights to use land and water resources and would likely reduce their value. Redefining what farmers have a right to do and receive changes the benefits associated with owning a certain entitlement. Making participation in federal income-support programs dependent upon pollution control activities would impose on farmers substantial costs, either in BMP adoption or loss of program benefits. Cross compliance was adopted by both House and Senate as a part of the 1985 Farm Bill (P.L. 99-198).

A soil loss tax would shift the entitlement from farmers to the public. Under such a tax, farmers would be allowed to interfere with the public right but would be required to compensate (pay tax to) the public. The public's entitlement would be protected under a liability rule. A reallocation of the entitlement away from farmers would likely be strongly opposed by the farmers, especially because of their sudden loss of a valuable right (right to lose soil) without any compensation for that loss. In fact, they would have to pay for the loss of soil.

Alternatively pollution entitlement could be left in the hands of farmers but the rule would be changed to require compliance by farmers with pollution control regulations in return for guaranteed cost sharing assistance. This is the type of change which has been made in the soil conservation program in Iowa (Iowa Code Sec. 467 A). In this case, the farmer remains entitled but is protected by a liability rule. Such a change would be expected to reduce pollution significantly as compared to the current program. A mandatory pollution control policy would not go unchallenged by farmers. Given adequate cost sharing assistance, farmers could be forced to comply. Iowa's soil conservation statute was challenged. The court concluded:

> ...the test is whether the collective benefits (to the public) outweigh the specific restraints imposed (on the individual)...It is important therefore to consider the nature of the public interest involved and the impact of the restrictions placed on defendants use of their land...It should take no extended discussion to demonstrate that agriculture is important to the welfare and prosperity of this state. It has been judicially recognized as our leading industry... The state has a vital interest in protecting its soil as the greatest of its natural resources, and it has a right to do so...While this (legislation) imposes an extra financial burden on defendants, it is one the state has a right to exact. The importance of soil conservation is best illustrated by the state's willingness to pay three-fourths of the cost...The remainder to be paid by defendants...is still substantial, but not unreasonably so. A law does not become unconstitutional because it works a hardship...(Woodbury, 1979).

It appears, then, that where a significant need for pollution control is combined with a willingness to compensate the farmer, a mandatory program could be legally enforced.

A mandatory program which required pollution control but did not provide cost sharing assistance (or provided limited cost sharing on a first come-first served basis, as with the current program) would reallocate the pollution entitlement from farmers to the public. The public's entitlement would be protected by a property rule. If Congress passed such a law, it could be upheld in a court of law, despite strong opposition from farmers. In one case, the Virginia State Water Control Board filed suit to prevent Virginia municipalities which did not receive financial assistance from the government from having to comply with effluent limitations for publicly owned sewage treatment plants by the specified date (State, 1977) The court upheld a bill which empowered EPA to extend the 1977 deadline for up to two years in cases where compliance is physically or legally impossible. It did not limit the applicability to those facilities receiving financial assistance. Moreover, even the provision authorizing case-by-case extension of the deadline was later deleted without comment by the Conference Committee. This clearly provides strong support for the conclusion that Congress meant for the deadlines to be rigid and that it did not intend that sewage treatment plants not receiving timely federal grants should be exempt from that deadline (State, 1977).

A shift in pollution rights away from farmers could be upheld by the courts without requiring compensation of the farmers. Such a reallocation of rights without compensation could be considered by farmers to be a taking. However, it is not clear that farmers could avoid compliance with pollution control standards based on this issue. In upholding the natural use of land as its highest and best use, a Wisconsin court concluded that restrictions on the use of land to maintain its natural use did not constitute a taking of property rights. The Court stated that the real issue is whether the wetlands-filling restrictions are unconstitutional because they amount to a constructive taking of land without compensation (Just, 1972).

The exercise of the police power might require the maintenance of a body of water in its natural state. It may well be considered a duty of adjacent landowners. The protection of public rights may be accomplished by the exercise of the police power unless the damage to the property owner is too great and amounts to a confiscation. An owner of land has no absolute and unlimited right to use it for a purpose for which it was unsuited in its natural state and which injures the rights of others. This is not a case where an owner is prevented from using his land for natural and indigenous uses. The uses consistent with the nature of the land are allowed and other uses recognized and still others permitted by special permit (Just, 1972).

If highest and best use is defined for water as use in an unpolluted state, then this case raises questions as to farmers' rights to allow nonpoint source pollution to emanate from their land.

<u>Some Additional Considerations</u>

Farmers' dissatisfaction with the allocation changes associated with adopting a mandatory nonpoint source pollution control program would not be the only difficulty accompanying such a change. Enforcing water quality regulations is especially difficult for nonpoint pollution because extensive monitoring is required and complicated linkages between water quality and land use practices must be established. Each parcel of land has a unique potential for contributing to pollution. Enforcing a reallocation of rights away from farmers would be very expensive.

Transaction costs associated with alternative programs should also be considered. Leaving the entitlement in the hands of the farmers but changing from a property rule to a liability rule for protection could be expected to reduce transaction costs, as suggested by Bromley. Such a reduction might offset somewhat the costs associated with compensation of the farmers under the required cost sharing. If the rights are reallocated so that the public is entitled, the soil loss tax strategy would likely be preferable to the regulatory program in terms of lower transaction costs. This assumes legally acceptable measures of control. However, the allocation, as well as distribution, of the costs would be an additional issue with which the government would have to deal.

<u>Summary</u>

A right ("entitlement") confers favor among individuals or groups making competing claims to an object or privilege. In defining rights, two matters must be decided: (1) initial ownership (allocation) of rights, and (b) rules under which they may be exchanged. Collective enforcement of both the initial allocation and the conditions for exchange is required of a legal system to have meaning. The rules for exchange of rights include: (1) property rules, (2) liability rules, and (3) inalienability. Current and proposed programs to reduce and eliminate nonpoint source pollution impact the allocation and use of rights.

As the environmental impacts of extracting our agricultural bounty have become more apparent, farmers' use of natural resources have become subject to more careful review and regulation. Farmers' rights and the rights of others are in a state of transition. Proposals for nonpoint pollution control would condition farmers' rights to use land on effects that uses have on others, principally users of water and aquatic environments. Many of these proposals would change the property rule of allocating rights to a liability rule. Proposed programs which fall into one category or the other have been outlined. Alternative methods of reducing tax expenditures for offending pollutants could increase the cost of pollution to farmers.

Any change from the current program will be costly. There are two kinds of costs associated with nonpoint source water pollution - the costs of doing something and the costs of doing nothing. Changes in property rights will involve administrative, enforcement and compensation costs. As public concern over nonpoint source water pollution continues to mount, changes become more likely. However, such change must be effective, enforceable and ethical. As Braden (1982) has asserted, an acceptable program will be one which provides a mechanism by which the public interest can be served while providing fair compensation to owners whose rights are exchanged by fiat, retains the flexibility of individual ownership, and is consistent with the national ethic of maximum individual liberties consistent with the general welfare.

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WATER RIGHTS FOR ESTUARIES: THE TEXAS EXPERIENCE

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Estuaries are a complex ecosystem in which a number of physical and biological processes are interrelated. Although scientists are unsure of the exact nature of many estuarine relationships, it is generally believed that freshwater inflows are a major determinant of estuarine productivity. Inflows maintain the necessary salinity balance and also provide valuable nutrients. There are seven major estuary systems and several minor ones spread along 370 miles of Texas coastline. Eleven major river basins have estuaries of major or secondary importance.

The Texas fishing and shrimping industries, as well as sport fishing, depend on the estuaries to provide a proper habitat for fish propagation and development. In addition to the fish and wildlife which spend their entire lives in the estuaries, many other species inhabit these areas during their juvenile stages. Some 97% of all fish and shellfish harvested along the Texas coast depend on estuaries at one or more stages of their life cycles (Texas Department of Water Resources 1982).

The Texas legislature has funded a number of studies concerning the influence of freshwater inflows on estuaries, and has concluded that they are an important factor in estuarine productivity (Texas Department of Water Resources 1982). Revisions to the Texas Water Code in 1975 and 1985 emphasized the importance of freshwater inflows but did little to ensure that such inflows are maintained. The protections instituted by these laws are largely discretionary, and many have argued that they are insufficient. The water code still ranks recreation, wildlife preservation and aesthetics well below other water uses in terms of priority and there is not always enough water available to satisfy the lower priority uses.

Freshwater inflow into bays and estuaries remains a low priority use of water in Texas. Nevertheless, there are a number of approaches to estuarine protection which could be pursued under the current law. Minor changes in the law could make protection easier, and major changes could facilitate it still further. Little scholarly research has been done on legal approaches to maintaining freshwater inflows. However, lawyers and conservationists throughout the U.S. have identified a number of legal strategies which are applicable to a related water allocation problem - the preservation of minimum stream flows. As more and more surface water is diverted or stored in impoundments, the amount of water remaining in downstream river segments is sometimes insufficient to support fish and wildlife or water-based recreation, or to dilute pollutants. Many of the strategies which have been used to combat the instream flow problem could also be used to maintain freshwater inflows to estuaries.

The strategies to protect estuarine inflows can be classified into three groups: (1) direct acquisition of water rights, (2) administrative approaches such as reservation, conditional permits, and redefined water use priorities, and (3) application of the public trust doctrine.

Texas Surface Water Law

Texas is one of several states which recognizes both riparian and appropriative rights to surface water. Full riparian rights, including the right to irrigate, apply only to lands which (1) were originally granted by the Republic or State of Texas between 1840 and 1895, and (2) have retained their riparian classification since the original grant was issued. The Water Rights Adjudication Act (Tex. Laws 1967, ch. 45) required riparians to register their rights and limited their claims to the maximum amount put to beneficial use in any year between 1963 and 1967. In this way, riparian rights have been absorbed into the appropriative system, with priorities based on the dates of the original land grants. The adjudication process, which followed the 1967 act, allocated Texas surface water on the basis of all known water rights claims. That process is now basically complete and the state of Texas has, for the first time, a unified system of water rights.

Rights to state water under the prior appropriation system are allocated by the Texas Water Commission. Permits can be issued only for beneficial uses, and the state water code includes a list of water use preferences in which domestic and municipal purposes are rated highest, followed by industrial, irrigation, mining, hydroelectric power, navigation, recreation and pleasure, and other beneficial uses (TEX. WATER CODE ANN. §11.024). Texas follows the other requirements of the prior appropriation system, namely the "first in time" rule and the "non-use results in loss" rule.

Direct Acquisition

The simplest means of protecting freshwater inflows to estuaries is to appropriate water for that purpose. This approach has the advantage of fitting neatly into the existing regulatory system, with all its inherent safeguards for existing appropriators. The major disadvantage in Texas is the lack of unappropriated water. Permits cannot be granted unless there is unappropriated water available in the water source.

Historically, a valid appropriation has required an actual diversion of water. Most western water law experts agree that this requirement no longer serves any function which cannot be served by other water law doctrines (Tarlock 1978). Nevertheless, some states have refused to appropriate water for instream purposes on the grounds that there is no diversion of water. In California, for example, the courts have ruled that a permit cannot be granted unless the permittee has some form of physical control over the appropriated water (California Trout Inc. v. State Water Resources Control Board, 90 Cal.App.3d 816, 153 Cal.Rptr. 672 (1979); Fullerton v. State Water Resources Control Board, 90 Cal.App.3d 590, 153 Cal.Rptr. 518 (1979)).

The question of instream appropriations has not yet arisen in Texas, and it is not clear whether Texas law requires an actual diversion. The water code is ambiguous on this point, and the current rules of the Water Commission indicate that appropriations require some form of diversion or storage. Unless the legislature chooses to specifically authorize instream appropriation, the only way to determine if such an appropriation is possible is to apply for one. If the application were denied, or if an instream appropriation were challenged, the state courts would have to decide whether the water code requires physical control over appropriated water.

Appropriations also have to be applied to a beneficial use, but there is little doubt that Texas recognizes estuarine protection as a beneficial use. The most likely state agency to appropriate water for estuarine uses is the Texas Parks and Wildlife Department. It has the necessary expertise and would be able, because of its independence from the process of water rights adjudication, to act as an advocate for environmental concerns without becoming involved in a conflict of interest. State law already specifies that water from some new reservoirs will be appropriated to the Parks and Wildlife Department (TEX. WATER CODE ANN. §16.1331), so there is no question about the department's authority to appropriate water.

Administrative Approaches

Withdrawal

Some states, such as Oregon, Washington, Kansas and Montana, have acted to preserve instream flows by establishing a base level of water in specified river segments, below which no further water can be appropriated. This type of withdrawal from appropriation can be done through legislative fiat or through administrative action.

The Texas Water Commission could withdraw water from appropriation in order to ensure adequate inflows to estuaries. Such a reservation could be accomplished using the Commission's power to deny permit applications which are detrimental to the public welfare. The same power could be invoked to limit the possible uses of water from particular streams in a type of water use "zoning", or to impose a moratorium on issuing permits. However, the Commission is unlikely to take any of these actions because of their political nature. Reservation of water for inflow purposes is unlikely to occur unless the legislature declares that it is state policy to favor estuarine protection over other water uses, at least in certain circumstances.

Withdrawing water has the same disadvantage as direct appropriation: there is a lack of unappropriated water available for withdrawal. This could be overcome if the legislature mandated that all water freed by cancelling existing rights be reserved for freshwater inflows, until such time as the minimum required inflows were withdrawn.

Permit conditions

The Water Commission currently has the power to condition new permits, and is mandated to include conditions necessary to maintain inflows to affected estuaries in any permits issued within 200 river miles of the Gulf coast (TEX. WATER CODE ANN. §11.147). However, the commissioners' decision to condition a permit depends largely on their perception of the public welfare. They are instructed to include conditions "to the extent practicable when considering all public interests", and are not obligated to prefer estuarine protection over any other public benefits. The Commission could, include in any permit which might interfere with freshwater inflows, the condition that it was issued subject to the superior needs of any affected estuary system.

Preferred uses

Texas, like many other states, statutorily lists the order in which various water uses are to be preferred when competing applications are filed for different uses of the same water. Trelease (1977) has argued that such laws should be avoided. They are seldom effective, since the coincidence of incompatible uses is rare. They too often reflect the economic and social thought of the moment of their enactment, and they prevent the intelligent weighing of alternative and relative values.

Water use preferences in Texas were instituted in 1931 and have not been altered since then, apart from the addition of "other beneficial uses" at the bottom of the list. The last named use is recreaion, and aesthetic and environmental purposes are not specified at all. The list should be revised to give higher priority to non-economic uses, or different priorities could be established for different river basins or segments. This approach of classifying rivers for different uses is used in Oregon (Sherton 1981). Alternatively, the legislature could abolish the list and rely on the Water Commission to evaluate different uses on a case-by-case basis.

Incentives to Conservation

The present system of water appropriation discourages water conservation efforts on the part of rights holders. Only that portion of water which is put to beneficial use is considered appropriated. If water users purchase improved irrigation technology, line canals, repair leaky pipework, remove water-loving "weed" plants from the land, or otherwise reduce their water requirements, they cannot recoup their investment. That portion of water which is no longer required becomes subject to cancellation. An incentive scheme for water users is required which will encourage conservation and discourage waste. Some possibilities are direct reimbursement or allowing a change of use for the unused part of the appropriation.

The Public Trust Doctrine

The public trust doctrine is an ancient theory for protecting certain properties which were held by the sovereign in trust for the people (Sax 1970). In recent years the doctrine has been reinvigorated and expanded to cover a number of additional public resources, including those without specific economic value. Some states, notably Wisconsin and California, have developed a substantial body of case law on the subject.

The most far-reaching public trust case to be decided in recent years is National Audubon Society v. Superior Court of Alpine County (33 Cal.3d 419, 658 P.2d 709, 189 Cal.Rptr. 346 (1983)). In this case, which closely parallels many aspects of the freshwater inflow problems in Texas, the National Audubon Society brought suit to enjoin the diversion of freshwater inflows to a saline lake, on the theory that the shores, bed and waters of Mono Lake were protected by the public trust. The California Supreme Court remanded the case to the superior court to decide in light of the principle of minimizing harm to interests affected by the public trust.

Two important points concerning the public trust doctrine arose from the Mono Lake decision. First, the court said that the state must affirmatively protect public trust interests "whenever feasible". The significance of this ruling will depend on whether "feasible" is interpreted in terms of available alternatives or simply in terms of economics and convenience. The second important point is the ruling that the trust imposes a duty of continuing supervision over the use of water after an appropriation has been made. The court said that the state is not confined by past allocation decisions which may be incorrect in light of current knowledge or inconsistent with current needs. If such a ruling were applied in Texas it might allow the cancellation, without compensation, of existing permits for uses which are no longer considered beneficial.

In Texas the scope of the public trust doctrine is poorly defined. The cases in which it has been used have been mainly concerned with the tradionally protected resources of submerged land and access to navigable waters. It has not yet been invoked to contest the state's handling of water resources, and the judiciary's position on the doctrine and on the issue of third party standing has not been determined. However, several commentators have indicated that the doctrine could be a useful tool in protecting Texas estuaries (Morrison and Dollahite 1985, Weaver 1985).

Conclusions

Existing provisions in the Texas Water Code make it possible to afford some protection to freshwater inflows into estuaries. However, there are two major limitations. First, most of the available protection is at the discretion of the Water Commission, which must evaluate proposed water uses against a list of statutory preferences.

Recreation and environmental uses are at the bottom of this list. Second, even if the Water Commission wanted to allocate water for freshwater inflows, there is little if any unappropriated water available. Existing water permits provide vested rights which cannot be altered and which can be cancelled only after abandonment or ten years of non-use.

Given these limitations and the nature of the statutes designed to protect estuaries, any efforts at maintaining adequate freshwater inflows have to be made on a case-by-case basis, which results in piecemeal protection. This fragmented approach also requires a considerable investment of time and money from any group or agency trying to preserve the state's estuary systems, because their efforts must be repeated each time a new threat arises.

Because the public trust doctrine is not well developed in Texas, and the issue of third party standing has not yet been settled, it is difficult to predict the outcome of a suit to protect freshwater inflows into estuaries. A court could easily determine that standing would depend on showing special injury. Even if standing were granted, there are some grounds for arguing that the trust doctrine in Texas has been subsumed into the state water code, which prohibits appropriations that are detrimental to the public welfare and requires

The Commission, before issuing a permit, to consider the effect of the permit on bays and estuaries.

Any litigation is expensive and time consuming. If a suit were brought to preserve freshwater inflows, the courts could reach a decision which limits the power of the public trust doctrine and thereby establish a precedent which would restrict future efforts. Even if a case were settled to the benefit of the estuary, it might be determined on factors peculiar to one situation without producing any broader gains or guidelines. On the other hand, a broad and positive ruling involving the doctrine would result in extensive gains for estuary protection and for other natural resources as well. For example, a ruling like that in the Mono Lake case could give freshwater inflows a much higher priority than they have under the current water code preferences, and might also be instrumental in freeing up water on overappropriated rivers through the revocation fo existing permits.

Both the costs and the potential gains of public trust litigation are high. Since the attitude of Texas courts is currently so unclear, such litigation might best be postponed until other options have been attempted or until the courts give some indication of favoring the public trust approach.

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LEGAL ANALYSIS OF ARTIFICIAL REEF DEVELOPMENT

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Introduction

The analysis herein is taken from the legal component of a five-part study of artificial reef planning and development for a three-state area in the Northern Gulf of Mexico, the specific area being the Florida Panhandle and the Alabama and Mississippi coasts. The study was directed by Dr. James I. Jones of the Mississippi-Alabama Sea Grant Consortium, co-sponsor of the project with Continental Shelf Associates, Inc., of Tequesta, Florida. Funds for the project were provided by the National Marine Fisheries Service, and Ron Schmied of NMFS' St. Petersburg office served as program monitor.

The legal aspects of the study has both regional and national characteristics, and the author has attempted to present both in this paper. The subject matter covered by this paper includes permitting and legal liability, while development incentives and international navigation law were also covered in the study. The regional/national dichotomy is clearly apparent in the section on permitting, since the areas specifically studied have joint federal/state permit applications for artificial reef construction. The section on liability is more general in nature, but does cover certain aspects of the local law of the three states involved, such as sovereign immunity.

Federal Permitting

The U.S. Army Corps of Engineers (Corps) is the primary permitting authority for artificial reef construction and maintenance. Actually, it is the only such federal authority, because, even though numerous other agencies are involved in the process, the Corps is the only federal agency that actually issues a permit. Other federal agencies have a consulting and commenting role involving fish and wildlife, environmental protection and historic preservation. The Corps' permits are issued under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Outside three miles from the coastal baseline, the 404 permit does not apply, therefore the only permit issued by the Corps is the Section 10 permit.

The Corps' offices in both the Jacksonville and Mobile districts have developed a regional permit for artificial reefs. This permit means that the normal individual permit process does not have to be followed and therefore the time required is substantially reduced, at least theoretically, from about two months to two weeks. (This does not mean, of course, that any state permitting or certification process is similarly shortened.) The regional permit means that the activity covered is considered of minimal impact to the environment, both individually and cumulatively, and therefore no individual permit is necessary. The time period is shortened by eliminating the public notice, comment and hearing procedures. However, if any of the agencies with consultation authority object or the Corps itself finds some problem (e.g., the Endangered Species Act), then the permit is "kicked out" into the individual permit process. In all three of the states involved in the study, the regional permit application is a joint federal/state application and the process is effectively a joint procedure. In Florida, there is a general state permit for artificial reefs, which means that the state permitting process for an artificial reef is more streamlined than other projects. Mississippi and Alabama's permit procedures are considerably more time-consuming.

Because of the regional federal permit and the probability that most reefs will not raise objections, it is somewhat unnecessary to discuss the substantive and procedural requirements of the individual federal permit process. The public review procedures are detailed and can be easily located in the regulations. Major projects may benefit by utilizing a pre-application consultation, the practical equivalent of submitting an original application. This procedure may help to avoid problems and to enhance the success of the project.

Under the 404 program (33 U.S.C.A. §1344), guidelines are developed by the Environmental Protection Agency (EPA) pursuant to criteria in §403(c), therefore the EPA has some substantive input in the initial part of the permit process. The EPA also has a "veto" power under Section 404(b), although this power is rarely used. The Administrator of EPA is authorized to use this veto power when he determines, after public hearing, that the proposed activity would have an adverse effect on "shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas." The EPA does not have any permitting authority under the National Pollution Discharge Elimination System (NPDES) (§402 of the Clean Water Act), through the EPA's aquaculture project regulations (§318 of the Clean Water Act), or under the Ocean Dumping Act (Title I of the Marine Research, Protection and Sanctuary Act).

There are several other agencies which have consultation roles in the Corps' permit process. The Fish and Wildlife Coordination Act requires federal agencies to coordinate their activities with either the Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) of the Department of Commerce. The Endangered Species Act requires the Corps to consider any possible threat to an endangered species, and to consult with either the Secretary of Interior or the Secretary of Commerce when such a threat appears. Both Interior and Commerce also have consultation authority under the Marine Mammal Protection Act. Under the Marine Sanctuary Act (Title III of the Marine Protection, Research and Sanctuaries Act), the Secretary of Commerce is authorized to designate national marine sanctuaries. Although an artificial reef may not itself be a threat to a marine sanctuary, the activities surrounding the reef likely would be a threat and would be severely restricted.

The Coast Guard has a simple, but significant role in artificial reef development, i.e., the approval of locations and buoy plans for reefs. This approval must be obtained before the Corps will grant a permit under either or both Section 10 of the Rivers and Harbors Act or Section 404 of the Clean Water Act. District offices of the Coast Guard should be consulted to determine buoy requirements, since local conditions affect actual requirements. Also, there is vested in the District Commander a certain amount of discretion concerning relief from buoying requirements. The New Orleans District covers most of the specific area of this study, although the Miami District covers the area east of Apalachicola Bay. Coast Guard approval normally can be obtained in one day.

Although there will be certain exceptions, the basic rules are set up according to specific water depths. If there will be less than eighty-five (85) feet of clearance above the reef, the Coast Guard will usually require a lighted buoy. An unlighted buoy is required between eighty-five (85) and two hundred (200) feet of clearance, unless the reef is within five hundred (500) yards of a shipping fairway. According to the New Orleans office, a minimum of one mile distance from shipping fairways is preferred if the reef has less than eighty-five (85) feet of clearance. If the structure is near an established fishing area, the clearance must be greater than two hundred (200) feet or a buoy is required.

The Department of Defense has established certain restricted areas which are off limits for reef construction. The Sport Fishing Institute has developed a guide which contains descriptions of these areas in the Gulf of Mexico. Several other agencies also have such information, such as the Corps, Coast Guard and the Minerals Management Service.

The Minerals Management Service also should be contacted in areas in which there is oil and gas exploration and development activity to determine the existence of offshore leases and pipelines. Although leases are not in themselves an impediment to reef construction, the potential activity should be planned around. Naturally, one would not want to locate a reef near an oil or gas pipeline.

If an obsolete vessel is used for an artificial reef, the permittee should consider the EPA's requirements for dumping of vessels for disposal. The EPA must certify that "the proposed use of the vessel will be compatible with water quality standards and other appropriate environmental protection requirements." In all likelihood, the EPA requirements for dumping of vessels will be applicable to use of vessels for artificial reefs. The regulations require emptying and reflushing all fuel lines and tanks to the lowest suction point before disposal of the vessel.

State Permitting

States generally have a certification role in the issuance of Section 10 and Section 404 permits, under the authority of Section 401 of the Clean Water Act (water quality) and the Coastal Zone Management Act (consistency of federal program with state coastal program). The geographical limits of the 401 water quality certification are the territorial limits of the state, i.e. the boundaries of the United States. The normal limits of three miles apply in Alabama and Mississippi, but the Gulf boundary line of Florida is three marine leagues or nine nautical miles. Mississippi's boundary is measured from the barrier islands lying south of the mainland.

Within the territorial limits of a state, any applicant for a permit issued by a federal agency must certify that the activity to be permitted is consistent with the state's coastal program. If the state objects, the permit will not be issued unless the Secretary of Commerce, on appeal, decides that the activity "is consistent with the objectives of this chapter or is otherwise necessary in the interest of national security." Outside territorial waters, federal agencies are required to conduct or support activities directly affecting the coastal zone "in a manner which is, to the maximum extent practicable, consistent with approved state management programs." All the coastal programs of all three states involved in this study expressly encourage and approve reef development.

Florida has an aquatic preserve program similar to the Marine Sanctuary Act. Some of these sanctuaries are located in the Panhandle area, therefore the Florida Department of Natural Resources should be consulted concerning special requirements for these areas.

Another possible area of state certification is that of historic preservation areas. Although one does not normally think that offshore waters would contain many historic areas, there are apparently hundreds of shipwrecks in the Gulf. There has been a recent move to introduce legislation in Congress to enact a Historic Shipwreck Act. This is a consideration that should be taken into account when siting a reef.

Liability

The facts and the actors are important in any consideration of legal liability. The facts determine the legal theories involved and the status of the actors, all of which in turn dictate the causes of action and defenses available to the parties. It is important then to consider the facts involved in a reef development project. The first decision made is to build the reef, then follow decisions concerning the type of materials, the location of the structure and so on.

There are several periods in a reef project which involve different types of risks and different types of actors. The material to be used in the reef must be obtained from somewhere and hauled to the reef site. It must be properly and accurately placed on the reef site. After the placement of the material, buoys may have to be maintained, and there may be some responsibility to inspect the reef to insure that it is good condition. For example, both the Mobile and Jacksonville Corps permits require the permittee to maintain "the structure . . . in good condition. . . ."

Throughout the common reef project there are different phases in which various risks are present. Many of these are the standard, "run-of-the-mill" risks present in numerous other activities, and the liability potentials are determined by well-known rules of law. For example, liability for injuries to maritime workers and seamen will be governed by statutes such as the Jones Act, the Longshoremen and Harbor Workers Compensation Act, state worker's compensation laws and the Death on the High Seas Act, plus certain common law remedies, such as, maintenance and cure and the warranty of vessel seaworthiness.

These remedies cover personal injury, but property damage is another type of liability that must be considered. Property damage could involve a collision between two vessels or a vessel and some fixed structure or the land or it could involve the blocking of a shipping fairway due to the sinking of a vessel or the "tow" (the barge carrying materials or a platform itself). The law of towage and the law of collision provide well-known rules that govern liability in such circumstances.

The parties that are subject to potential liability during the above phases are primarily the donor of materials and the party hauling the materials to the reef site. The donor's liability will depend to a large extent on the complexity of the tasks involved in loading the materials onto a barge or securing a platform for towing and the amount of its participation in these tasks. The donor's risk of liability will be much greater if it is actively involved in this phase than if it contracts with some other party to perform the tasks. In the latter case, the other party will generally be responsible for liabilities incurred during the work.

Once the material is at the reef site, the primary responsibility of the parties involved is to see that the material is placed in the proper location. At this point, the permittee may have some responsibility to insure that this happens. Once the material is in place, most of the potential for liability shifts to the permittee who has the duty of inspection and maintenance.

During the placement and maintenance stages, the potential liability of the participants would be governed by ordinary principles of negligence law (negligence is also the normal standard in collision cases). Negligence is defined as a breach of a duty of reasonable care owed to some person, which breach is the proximate cause of injury to that person. The injured party must show that he is owed this duty and that the other party breached this duty, causing him to be injured. There are many aspects of negligence rules, and it is beyond the scope of this paper to explore the topic fully.

The National Fishing Enhancement Act (NFEA) seeks to encourage reef development by limiting the liability of the participants in certain areas. Primarily, this limitation of liability applies to the donor of reef materials and to the permittee. Oil companies have been involved to some extent in donating obsolete platforms for reefs, and many people feel that these platforms will be a plentiful supply of reef material in the future. The oil companies apparently are willing to participate in the program, but do not want to expand their operations into an area of unknown liability.

Consequently, the NFEA seeks to limit the liability of donors of materials, in fact, to end it at the point that title to the reef material is transferred. However, the act may actually impose a standard of strict liability rather than ordinary negligence on the donor of material for a defect in the material at the time title to it is transferred. The NFEA states that a donor of materials "shall not be liable for damages arising from the use of such materials in an artificial reef, if such materials meet applicable requirements of the plan published under section 204 [the national reef plan] and are not otherwise defective at the time title is transferred." This does not take into consideration the fact that the donor of material may not have been able to determine if there was a defect in the material at the time title was transferred, and the fact that this defect may not have been created by the actions of the donor.

A probably typical example would be the removal of an obsolete platform from the ocean floor for towing to an artificial reef site. In the process of removal, particularly if the platform is toppled, the platform could be damaged. The oil company may exert great effort to determine if any structural damage has occurred, but finds nothing. After the platform is in place as a reef, a portion of it collapses on a diver or washes away to end up in a fishing net. The injured party may be able to show that there was a defect at the time title was transferred. The oil company would then be held to a strict liability standard, although it exerted great effort to protect itself.

Some might argue that such questions are theoretical rather than practical. It does little good to respond to such a problem by attacking the practicality of such a situation or the difficulty of proving that a defect existed at a specific time. The risk of liability is the problem, not the odds of the situation actually arising. There are legal rules that would allow the injured party to argue that there must have been some defect or otherwise the accident would not have happened. This is known as the res ipsa locquitur doctrine - "the thing speaks for itself." The answer is not to debate the possibility, but to amend the statute so that the standard is not so strict.

The permittee's risk of liability was also considered in the Act, and it states that the permittee "shall not be liable for damages caused by activities required to be undertaken under any terms and conditions of the permit, if the permittee is in compliance with such terms and conditions." (Emphasis added.) The Act goes on to state that the permittee "shall be liable, to the extent determined under applicable law, for damages to which paragraph (1) [the above] does not apply." This second provision makes clear the fact that ordinary negligence rules will still have an impact on reef programs. As mentioned above, the Jacksonville and Mobile Corps' permits required the maintenance of permitted structures in good condition. There may be no liability for activities conducted to insure that the reef is in good condition, i.e., inspections, but if the inspection is negligently performed and a problem is not discovered, liability may arise if an injury later occurs because a negligent inspection is not in compliance with the terms and conditions of the permit.

There are certain risks involved in construction and maintenance stages that should be considered in planning a reef. The area involved and the type of material used must be matched so that the materials are suitable, a requirement of the NFEA. Materials must also be free of pollutants in order to meet the suitability requirement.

If a state or one of its political subdivisions (a county or municipality) is the permittee, it may be able to assert the doctrine of sovereign immunity. The immunity, if applicable, is absolute and will operate to defeat the claim of the injured party. States are generally immune from all types of negligence actions, although state officials have only a limited privilege of individual immunity. In the typical reef scenario, individual official actions can be divided into those that are discretionary in nature and those that are ministerial. Discretionary decisions are normally covered by immunity, while ministerial actions are not. Discretionary decisions would include the initial decision to construct a reef and the choice of location and materials. Ministerial actions would include the placement of the materials and the maintenance of the reef, including negligent inspections.

The immunity of a county or municipality of a state is derivative, and therefore is not as strong as the state's immunity. Sovereign immunity can be explained by characterizing the actions of such entities as governmental or proprietary. Governmental actions are generally those considered to be necessary to the public welfare, while proprietary actions are those not actually necessary, even though they do benefit the public. An artificial reef would fall in the latter category.

Thus, in those instances where a permittee is not protected by the provision concerning actions required to be undertaken by the permit, normal rules of negligence apply. Sovereign immunity is one defense that may be available, a strong defense in the case of a state as the permittee, but a weaker possibility when a county or city is the permittee.

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PUBLIC RIGHTS IN COASTAL LANDS: USING COMMON LAW THEORIES TO GUARANTEE PUBLIC ACCESS TO MISSISSIPPI'S BEACHES

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Introduction

As part of efforts to control development of Mississippi's beaches and provide the public with recreational access, the Mississippi Bureau of Marine Resources is developing a sand beach master plan for Harrison and Hancock counties. One of the issues identified during the course of the study is public access to beaches. Ostensibly, beach access for the public in Harrison County was guaranteed in 1970 by Judge Cox's final order in U.S. v. Harrison County. Two subsequent U.S. Supreme Court decisions, as well as a conflicting Mississippi Supreme Court ruling on the same beach, have rendered the applicability of the 1970 ruling suspect. No similar case law applies to beaches in Hancock county. As a result, the extent of public legal rights to use these beaches is unclear.

Continued controversy over public use of the beaches of Deer Island further illustrates the problem of beach access. Deer Island is a 500-600 acre island located in the Mississippi Sound, just offshore from the coastal city of Biloxi. A private developer has attempted to restrict public access to all put a small portion of the island that is owned by the city of Biloxi. Prior to the developer's acquisition of the property, the public freely used the island for boating, swimming, camping, and other recreational uses without interference. As a result, an uneasy tension now prevails over public recreational use of Deer Island beaches.

This paper reviews the current status of Mississippi's public trust doctrine on public access to coastal beaches. In addition, alternative common law theories of dedication and custom are offered to support the right of public access.

Public Trust Doctrine

Mississippi's public trust doctrine places ownership of tidal lands below mean high tide in the state, which holds it in trust for the public. Public rights specifically protected by the Mississippi Supreme Court under the trust include commerce and navigation, fishing, bathing, swimming and other recreational uses, and the development of mineral resources. (Cinque Bambini, 1986) However, the court has never extended the trust upland beyond the mean high tide line. As a result, it is unlikely that the public trust doctrine protects members of the public who venture onto the dry sand area from incurring liability as a trespasser.

Not only has the court failed to extend public trust rights to include beach access, it has permitted the state to sell tidal trust lands to private persons when doing so is "in the public interest." (Treuting, 1967). The Treuting decision involved the sale of submerged lands adjacent to Deer Island to facilitate private resort development on the island. In upholding the sale, the court found that the legislature was justified in authorizing the sale of these lands to private individuals as "incident" to the overall public interest and purpose. "If the totality of the development promotes the public interest in general, the incidental private ownership of individual lots does not negative [sic] the comprehensive public purpose." (Treuting, 1967). The public purposes served by the development, as recognized by the court, were commerce, tourism, recreation, and accommodating an expanding population. The court concluded further that the proposed development was consistent with formerly established trust purposes of navigation, fisheries and commerce.

Although this decision was limited to its facts by the Mississippi Supreme Court in 1972, it has never been explicitly overruled. (International Paper, 1972). Such decisions do not bode well for future extension of the public trust doctrine to include a right of beach access. It is therefore necessary to explore other common law tools to apply.

Implied Dedication

Dedication is a common law doctrine that makes it possible for a landowner either to transfer full ownership of his land to the public or to grant an easement to the public for certain uses. A legally enforceable dedication of land to a public use requires two elements: an objectively manifested desire of a landowner to devote property for such purpose, and a valid acceptance by the public. Whether both elements are present in a purported dedication is a question of fact for the courts, with the burden of proof resting on the party asserting a dedication.

The owner's intent is the linchpin of dedication. An owner may expressly dedicate the land, or his intention may be impled from his failure to object to continued use of his property by the public. It is crucial that this intention be clearly and unequivocally manifest. Once the court finds a valid offer to dedicate, the focus of the analysis shifts to the public's acceptance of such an offer. Acceptance may be either express or implied, by formal action or public use.

Application of the doctrine of implied dedication to beach access is a relatively new one among state courts. Historically, the doctrine was applied to the dedication of roads and parks. Mississippi is no exception. Therefore, it is necessary to draw parallels from such situations. Armstrong v. Itawamba, a case dealing with the issue of whether a road across private land had acquired public road status, is an enlightening example. The court found that a dedication had resulted from continual public use and maintenance of the road at public expense for nearly twenty years. Although the facts clearly show an implied dedication, the court did not categorize it as such.

Its first specific discussion of implied dedication arose when members of a community attempted to prevent the city of Louisville from using a particular tract of land in a manner that was inconsistent with its use as a public park. (Hull, 1974). The test set out by the court requires "long use for a specific public purpose, the discontinuance of which constitutes a violation of good faith to the public and to those who have acquired property with a view to the use contemplated by the dedication." (Hull, 1974). Here, the city's prior inconsistent use demonstrated that there was no intention to dedicate the property for a specific public purpose (i.e., a park). Therefore, it was just as reasonable to conclude that the city had intended to continue use of the land as a park only until it was needed for other purposes as it was to imply that the property had been dedicated.

How then, would public access to Mississippi's coastal beaches fare under the Itawamba and Hull standards of implied dedication? In order for the court to find an implied dedication, requirements as to duration and character of use must be met. The character of the use must be adverse to, and exclusive of, the rights of the property owner (except as a member of the public). Unlike prescriptive rights, which vest in individuals, the claim of right being asserted must be on behalf of the public as a whole. The use must be with the knowledge of the property owner, or under such circumstances that would warrant charging him with knowledge. With the exception of the current owner, previous owners of Deer Island have long acquiesced in the public's use of the island beaches for recreational purposes. Similarly, few objections have been lodged against the open public use of the sand beaches of Harrison and Hancock counties since their establishment. Under the Hull standard, it would be a violation of good faith to the public to discontinue such long use for the specific public purposes of navigation, bathing, fishing, and other recreational activities.

As noted above, public use can constitute acceptance of an offer to dedicate. Because such use does not need to be constant, the fact that the beaches are less populated in winter months does not interrupt continuity of the use. And on Deer Island, the public continues to utilize Deer Island, effectively ignoring efforts of the current owner to restrict such use. It should be noted that a succeeding landowner takes the property with the burden of an established dedication. Finally, at least for the beaches of Harrison and Hancock counties, government funds are used to maintain them. Continued use over a period of time, combined with maintenance at public expense, was sufficient for the Armstrong court to find implied dedication of a road; it should certainly suffice here.

Although the Mississippi courts have yet to apply implied dedication concepts to beach access issues, other state courts have set the precedent for such a decision. The leading case in Texas, Seaway Company v. Atty. General, concerned the right of the public to use the dry sand area of a beach located on Galveston Island. The primary use of the beach by the public was as a roadway. In finding an implied dedication, the court held that the owner had acted in such a way as to induce a belief in the public that he intended to dedicate. He fostered this belief by faling to protest public use over an extended time period. The public, in turn, accepted the dedication by continued use of the beach over time without asking permission. In addition, evidence was introduced that county authorities had contributed to maintenance of the beach since 1929. In assessing the weight to be given particular uses, the court stated that maintenance and patrolling were "some evidence of an intent to dedicate" but that continued open use over time was the key element.

Florida courts have added an interesting factor to the offer/acceptance elements of implied dedication. It permits the public to acquire an easement in beaches through implied dedication if the owner of the beach front parcel loses something by virtue of the public's use of the beach. (Tona-Rama, 1974). The court did not elaborate upon this requirement. Georgia's rule necessitates that the public's use result in exclusion of the landowner, a circumstance that would be almost impossible to establish. (Lines, 1980). California has added a unique twist to the acceptance prong of the test. If the public use has not continued for more than five years, actual consent of the owner must be proven. (Gion, 1974).

Custom

Another common law doctrine available to protect public access to beaches is custom. Mississippi law on custom is sparse. And to date has been applied almost exclusively in business situations. Therefore, it is hard to draw analogies pertinent to beach access. A review of the applicability of the doctrine of custom by Oregon and Florida courts gives a clearer picture of the pertinent legal issues.

As defined in the leading beach access case in this country, State Ex Rel. Thornton v. Hay, custom is "such a usage as by common consent and uniform practice has become the law of the place, or of the subject matter to which it relates." The court identified seven requisites to support the existence of a custom. The right must be ancient, continuous, free from dispute, reasonable, certain, obligatory, and consistent with law.

Antiquity is established through a showing of long and general usage. Here, public use of the dry sand beaches of Oregon had existed since the time of the early white settlers, as well as earlier by the Native American Indians. The next two requirements, continuity and freedom from dispute are interrelated. Together they require consistent use by the public (again, one need not sunbathe in January to be consistent) without interruption by the landowner. "Reasonable" means usage appropriate to the land and the usages of the community. Here, evidence that city police had intervened whenever people's behavior was inappropriate was held sufficient. These showings should not be difficult in the case of Mississippi's beaches.

Certainty is a more difficult requirement because of the mobile boundaries of the shore. The Oregon court held that "the visible boundaries of the dry sand area and . . . the character of the land, which limits the use thereof to recreational uses connected with the foreshore." (Thornton, 1974). Limiting the area to the foreshore made the boundaries more definable, but natural topography assisted in this distinction. There are no cliffs on Mississippi's coast. The sand beaches have receded and been replenished over time, particularly as a result of several major hurricanes. And on Deer Island, the beach area has been used for beach activities and the woods for other recreational activities such as camping. These factors could create problems of certainty.

The Thornton court found that a custom was obligatory so long as the landowner did not have an option to recognize the public right or ignore it. Two points of inquiry are relevant to obligation: (1) were the lands trusted as of right and uniformly with similarly situated lands, and (2) did the landowner object? Public behavior on Mississippi beaches evidences a belief that there is a right to use beach areas, particularly in light of a lack of objection on the part of private landowners. Finally, the custom must be consistent with the laws and customs. The Oregon court's analysis provided no guidance on this prong of the test as they found the custom to be consistent without giving a rationale.

Florida has also applied custom to protect public rights to beach areas. (Tona-Rama, Inc., 1974). However, the court identified only four elements: antiquity, reasonableness, continuity, and freedom from dispute. At issue was whether the owner could build an observation tower on the dry sand area. Even though the requirements for custom were met, the court ruled in favor of the owner because presence of the observation would not conflict with other recreational uses of the beach by the public.

The doctrine of custom, then, is a viable legal tool for guaranteeing public access, but the burden of proof for those asserting the public right is more difficult than under implied dedication.

Conclusion

Under the public trust doctrine, the public has the right to swim, wade, or otherwise reasonably use the tidal waters of Mississippi so long as they remain below the mean high tide mark. Even though submerged lands in some instances may be reclaimed and sold, it is unlikely that the court will allow wholesale divestiture of public trust property. But if the public is to have a legally protected right to spread a blanket on the sand, or engage in other recreational activities, a theory other than the public trust doctrine is needed.

The theory of implied dedication is tailor-made for protecting beach access rights in the public. It requires behavior on the part of the owner that evidences an intent to dedicate and the public's acceptance through acquiescence to public use. The rights thus gained can be in the nature of fee title, or an easement to use the property for particular purposes. If an easement is found to exist, the owner is forbidden from acting inconsistently with the rights of the public. And at the same time, the public must limit their activities to those that come within the scope of the dedication.

In the alternative, the doctrine of custom can be asserted. Two potential problems exist in the use of custom. First, Mississippi courts tend to use it sparingly. As a result, there is little guidance for meeting the burden of proof, and the court may be reluctant to apply it to beach access issues. Second, those courts that have applied custom have established tests that are even more rigorous than for implied dedication. However, it remains a viable common law theory whose principles fit well with the need to protect beach access.

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ESTABLISHING ENVIRONMENTAL CRITERIA

Thomas Bigford, Chair

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PUGET SOUND ESTUARY PROGRAM TOXICS CONTROL STRATEGY URBAN BAY APPROACH

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Executive Summary

The urban bay approach is proving to be effective in solving chemical contamination problems in Puget Sound. It is action-oriented. It uses existing data to identify problem areas and begins to control sources contributing toxics early on. Control actions include inspections, issuing and revising permits and orders, enforcement actions, and installation of best management practices. It has a geographic, problem-oriented focus. Work plans are developed for urban bays where sources of toxic contamination are concentrated, and the critical problem areas within these bays are addressed first. All program authorities, including water quality, RCRA and Superfund, are used as needed to effectively control sources. The success of this urban bay approach, however, requires a commitment to action on the part of the state. Its focus on sediment contamination, toxics control in permits, and toxics controls for stormwater runoff puts it in the forefront of the application of emerging state and EPA policy.

Problem Identification

Urban bays are the most highly industrialized areas of Puget Sound, and discharge and dumping of waste materials, including metals and organic compounds, have affected the chemical quality of waters and sediments in many portions of these bays.

Scientists from NOAA's Northwest and Alaska Fisheries Center in Seattle have documented a high prevalence of liver and kidney lesions in bottomfish such as sole in urban bays. The nearshore and tideflats area of Commencement Bay, which serves Tacoma, a large industrial city south of Seattle, was included in the National Priority list of hazardous waste Superfund sites due in part to chemical contamination found in the sediment. Subsequent analysis of additional data in the marine sediments in Elliott Bay off Seattle has shown equal or greater levels of contamination for some chemicals.

These urban bays, like much of Puget Sound, support important commercial and recreational fisheries. Many of these fish and invertebrates live in contact with the bottom sediments resulting in a high potential for uptake of sediment-associated contaminants. There is public concern over the potential human health impacts of eating contaminated seafood, and local health departments have issued advisories against eating fish caught in certain areas near urban centers.

Industrial pollution is the major source contributing to the contamination in the urban bays, but the pollution does not always come from a pipe. Twenty-seven NPDES-permitted sources discharge to Commencement Bay that include two sewage treatment plants. In Elliott Bay there are also 27 permitted sources but they are limited to fugitive emissions of sandblasting material from shipyards, cooling water, and stormwater. All other industrial wastewater is discharged to Seattle Metro's sewer system and is subject to Metro pretreatment permits.

There are also numerous unpermitted sources adding contaminants to the urban bays including combined sewer overflows (CSOs), storm drains, and small dischargers. Improper management and storage of hazardous materials on industrial sites can cause contamination of surface and ground water flowing from the site. Studies of Commencement Bay indicate that there are over 425 drains, pipes and seeps that are potential pollutant sources within that bay alone.

The information on pollutant loading and location of sources is far from complete. In many cases existing data allow for only incomplete identification of inputs or loading. Nor is effluent data sufficient. Contaminate concentrations in the particulate portion of the effluent may be orders of magnitude higher, causing sediment contamination. Most permits do not directly limit emissions of toxic chemicals, and even if they did, many sources are not permitted at all. Nor is the extent of the contamination known.

Overview of the Approach

Implicit in the urban by approach are certain assumptions. The approach focuses on toxic contamination in sediments. Nutrients, though a problem for certain shallow embayments in Puget Sound, do not appear to be a problem Sound-wide. Toxic contamination tends to accumulate in the sediment, and can accumulate at levels potentially associated with adverse biological effects. These assumptions are being further evaluated through some of the characterization studies being funded through the Puget Sound Estuary Program.

The Urban Bay Approach is designed to do the following:

1. Identify and prioritize problem areas within an urban bay, using a

compilation of existing data. Areas receive a ranking of high priority if they exhibit a particularly high level of chemical contamination of the sediment, sediment toxicity, and/or biological effects including bioaccumulation, fish pathology and changes in the benthos. Problem chemicals and the contaminant sources for each priority area are identified to the extent possible with existing data.

2. Identify and implement corrective actions to eliminate known problems. These actions are specified in an "interim action plan" that also identifies which agency has responsibility for each action. Primary responsibility for implementing the interim plan rests with the Action Team located in the regional office of the State Department of Ecology (DOE). The responsibility of the Action Team is to control or eliminate sources of toxic contaminants in a timely manner through negotiation with responsible parties, permitting mechanisms, or compliance orders.

3. Identify major data gaps and design a sampling and analysis plan to supplement the existing data base in terms of location and extent of contaminated areas in the urban bay being studied, and to ensure adequate identification, prioritization and characterization of pollutant sources.

4. Conduct sampling and analysis to fill major data gaps.

5. Revise the schedule of actions in light of any new information obtained through the sampling and analysis. Issue a revised, more complete Action Plan.

6. Initiate additional actions to resolve the remaining problems, including remedial actions. State and local agencies have primary responsibility for implementing the action plan.

Identification and Prioritization of Problem Areas

The decision-making process to evaluate toxic contamination problems follows seven steps:

- Characterize sediment contamination, sediment toxicity, and biological effects
- Quantify relationships among sediment contamination, sediment toxicity, and biological effects
- Apply action levels developed from these relationships to identify/prioritize problem areas
- Identify suspected problem chemicals in high priority areas
- Define to the extent possible the spatial extent of problem areas
- Evaluate sources contributing to problem areas
- Evaluate, prioritize, and recommend problem areas and sources for corrective and/or remedial action

Potential problem areas are evaluated using several indicators of sediment contamination and biological effects. When the results of these independent measures corroborate one another (i.e., there is a preponderance of evidence), a problem area is defined. There may be special circumstances where a single indicator may provide the basis for recommending source control and corroboration is not needed.

It is assumed that adverse effects are linked to environmental conditions resulting from source emissions and that these links may be characterized. Relationships between sources and effects are quantified where possible, for example, by correlations between specific contaminant concentrations and the occurrence of adverse biological effects for a given area. Direct cause-effect relationships in the sense of laboratory verification studies are a research need and are not within the scope of the Urban Bay studies.

The primary kinds of data used in the decision-making process are shown in Table 1. Although many other variables are evaluated throughout the decision-making process, those shown in the table form the basis for problem identification and priority ranking for the interim work plan.

Each type of data is needed to help identify and prioritize problem areas, and only that data which is needed is collected. All recent data for the subject bay is reviewed by the contractor and that which meets quality control criteria are used in the initial analysis. Study areas exhibiting high values of environmental indicators relative to a reference site (i.e., "clean" area remote from urban centers) receive a ranking of "high priority" for evaluation of pollutant sources and remedial action.

TABLE 1 PRIMARY KINDS OF DATA USED IN PROBLEM AREA IDENTIFICATION AND PRIORITY RANKING

GENERAL CATEGORY VARIABLES	DATA TYPE	SPECIFIC INDICATOR
Pollutant Source	Industry Type Mass Emissions	• Pollutant Concentrations • Discharge Flow • Chemicals used or manufactured
Habitat Condition	Sediment Quality	• Pollutant Concentrations
Indigenous Organisms	Bioaccumulation	• Contaminant Concentrations in Tissues of English Sole and Crabs
	Benthic Community Structure	• Total Abundance • Species Identification • Species Richness • Dominance • Amphipod Abundance
	Fish Pathology	• Prevalence of Liver Lesions in English Sole
Toxicity	Acute Lethal	• Amphipod Mortality

To rank areas based on observed contamination effects and to evaluate the relative magnitude of these effects, a series of simple indices has been developed for each toxicological and biological effect category (i.e., sediment toxicity, bioaccumulation, pathology, and benthic community structure). The indices have the general form of a ratio between the value of a variable at a site in the urban bay being studied, and the value of the same variable at a reference site. The ratios are structured so that the value of the index increases as the deviation from reference conditions increases. Thus, each ratio is termed an Elevation Above Reference (EAR) index. These are organized into an "Action Assessment Matrix" which is used to compare study areas or "hot spots". Problem areas are ranked according to the number of indicators that are elevated from reference conditions and the magnitude of the elevation (Tetra Tech, 1985).

Interim Action Plan

Having identified and prioritized the problem sites within an urban bay, the next step is to develop the schedule of short-term (interim) actions to address the highest priority problems. Before the interim action plan is developed, the contractor summarizes in a report the ongoing activities and plans of agencies presently involved in solving problems of toxic contamination in the bay being studied. By also identifying gaps in existing activities and plans, this report serves as a guide for improving current regulatory and management activities, and for developing new ones.

Development of the Interim Action Plan

The schedule of actions included in the Interim Action Plan are identified and agreed to by the agencies responsible for implementing the plan. The Interim Action Plan is unique in its approach to controlling contamination, in that its development brings many regulatory and management organizations together in an Interagency Work Group to take coordinated action to address particular problem areas and specific sources of contamination. In a series of meetings, representatives of the various agencies, including cities, county health departments, municipal sewer agencies, the state Department of Ecology, the Corps of Engineers, and the port authorities evaluate data for each site, identify potential sources, review existing plans and agree to a strategy of corrective actions. A citizens' advisory committee, consisting of representatives of all environmental, neighborhood and user groups, is also actively involved in development of the plan.

The type of actions included in the Interim Action Plan are shorter term and focus on enforcement activities and field work. For Elliott Bay these include:

1. Inspections: Over 73 compliance inspections have been conducted in the priority problem area of the Lower Duwamish and Harbor Island.

2. Enforcement actions. 22 enforcement actions have been initiated. Some of these are to require more monitoring data from permittees, some are for noncompliance of existing permits, some are for discharging without a permit.

3. Permitting. 5 permits are being written for previously unidentified, non-permitted sources. 4 companies are going to a recycling system to eliminate discharge and the need for a permit.

4. Modification of permits. 12 permits are being modified, tightening monitoring requirements, adding requirements for stormwater runoff, including BMPs for industrial processes such as drydocks.

Implementation of the Interim Action Plan: the Action Team

Carrying out the Interim Action Plan is the primary responsibility of a team of personnel located in the Regional Office of the Washington State Department of Ecology. For Elliott Bay, this "Action Team" has focused initially on the Duwamish waterway where the priority hot spots and the heaviest industrial development are found. Moving up the waterway, for each hot spot they list all possible sources, and determine which are permitted. Site inspections are done on all facilities to determine if they are complying with their permit and to check for illegal discharges. Permits are reviewed and stormwater and other controls are added if needed. Unpermitted facilities are required to obtain permits if they are found to be sources of pollutant discharges.

If necessary, a warning letter is sent specifying what the facility needs to do to correct any problems. Administrative orders are used to get the facility into compliance, and can include a penalty. If a site is contaminated, the Action Team will attempt to get the facility to clean up the site using whatever authority is available through state law or local ordinances. If all else fails, they will turn it over to the state Superfund program.

Enforcement and permit responsibility for all environmental programs under Ecology is located within the regional office, and there is close coordination between the members of the Action Team and other regional enforcement staff. This coordination enables them to bring to bear whatever program authority is applicable to addressing each hot spot. It is an efficient approach - instead of several inspections, they do one, and instead of several different enforcement actions, they can combine them into one.

The coordination extends beyond just Ecology. The Action Team has a close working relationship with the water pollution control and industrial waste sections of the local sewer utility, Seattle Metro. Metro's assistance includes data-gathering, joint inspections, chemical analyses of samples, site cleanup projects, and Metro enforcement actions for companies violating municipal discharge requirements. Ecology and Metro staff meet on a monthly basis to discuss enforcement activity and coordinate future site inspections.

Development and Implementation of the Sampling Program

The objective of the urban bay sampling program is to fill major data gaps in order to better define toxic hot spots, identify associated sources, and prioritize problem areas and sources for control actions. Sampling stations for each study component are positioned to fill gaps in spatial coverage of previous studies, and to provide characterization of pollutant sources. Each study component provides data for a specific environmental indicator (e.g., sediment chemistry, benthic infauna). The use of common sampling sites, (e.g., sediment for chemical analyses and bioassays are taken from the same samples), sampling methods, and sampling times is used to assure that valid comparisons may be made between the parameters measured at each station.

Sampling and analysis of pollutant sources is also conducted. These new data are used in conjunction with existing data to evaluate the relative importance of different sources of pollution in terms of input of individual contaminants (or chemical classes). When possible, environmental impacts are related to specific sources. CSO and storm drain sampling are conducted to determine maximum and minimum contaminant loadings to the waterways. The Action Team does supplemental sampling within storm drains where necessary to trace contamination to the individual sources.

Revised Action Plan

With the completion of the supplemental sampling and analysis, the Interim Action Plan will be revised to reflect the additional data and greater precision. The emphasis on early, short-term actions will also shift to include more long-term actions designed to eliminate sources of pollutants. These include the following:

Additional characterization of those storm drains and CSOs which are sources of contamination. In Commencement Bay, for example, the City of Tacoma, working with Ecology, is surveying potential sources to identify the location of toxic inputs to specific storm and CSO drains. As control measures are applied to each source, the drain is monitored to track improvements in sediment and water quality. Similar work is being conducted by Metro and the City of Seattle for Elliott Bay. Control of CSOs is required for all municipalities under state law by the earliest possible date.

Upgrading of permits to include biomonitoring requirements and toxics limitations. Under the Commencement Bay Remedial Action Plan, NPDES industrial source permits are being amended to require investigation of sources of toxics within their systems. As part of these amendments, effluent particulate matter will be analyzed for problem chemicals and further sampling and analysis of the sediments off the facilities will be required. In addition, a tiered approach to biomonitoring for Puget Sound dischargers is being developed by EPA with the involvement of the Department of Ecology. The biomonitoring requirements will be applied to those permittees known to discharge toxics to priority problem areas.

Evaluation of remedial actions to clean up major sites of historical pollution will begin. The Action Plan is not designed to serve as a feasibility study for remedial actions, but it will include a schedule for the evaluation of remedial actions. A remedial action feasibility study is being done for the Commencement Bay nearshore/tideflats area since it is Superfund site. The work that is done there should be transferable to other action plans. That study will evaluate different options such as dredging and capping. It will determine if removal of contaminated sediments is warranted and how it can best be achieved (Tetra Tech, 1986).

Municipal treatment facilities will be upgraded to secondary treatment. A number of Puget Sound utilities have not yet attained secondary treatment levels, but are under enforcement orders to reach compliance with secondary treatment requirements over the next several years.

Summary

In several ways, the Urban Bay Approach takes a different and much more powerful approach to environmental problem solving than many regulatory programs.

First, it has a geographic, rather than program orientation. The problem area is the urban bay, and specific problem sites within that area are identified. To address those problems, a variety of program actions are applied. An analogy is a repairman who uses whichever of his tools is appropriate to his task. Those "actions" may involve permit revisions, enforcement actions, additional monitoring or other cleanup or remedial activities. The permits may be water permits, RCRA, air permits, or shoreline permits. The remedial actions may be covered under Superfund or other authorities.

Second it requires the close coordination and involvement of several programs and agencies, at all levels of government. These agencies must devote staff and resources to the particular urban bay for the strategy to work effectively. To facilitate that coordination, an Interagency Work Group is created for each bay with representatives from all affected agencies and governments. A citizen advisory committee is also formed. Both groups, established at the very beginning of the project, are actively involved in every step of the plan development.

Third, the Urban Bay Approach places an emphasis on taking action early to address known problems using existing data where possible. An interim action plan with a schedule of actions is being implemented before the detailed sampling and analysis is completed. Essentially the process is iterative. A historical search and analysis of data is conducted first. Based on this information, problem sites are identified and prioritized. Corrective actions for identified problems are proposed and implemented. As additional data become available, through sampling and source site investigation, the action plan is revised and refined. But the emphasis is placed on taking early action to solve identified problems.

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THE SITE SELECTION PROCESS FOR A CHESAPEAKE BAY NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM*

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Introduction

In 1985 Amendments to the Coastal Zone Management Act of 1972 rename the National Estuarine Sanctuary Program as the National Estuarine Reserve Research System (hereafter referred to as the System). In addition to the name change, the amendments place greater emphasis on the need for biogeographic and ecologic representation within the System, clarify the System's research responsibilities and call for enhanced public awareness and understanding of estuarine areas through education and interpretation. The original intent of the System to serve as "natural field laboratories" is still fully supported and will be better served through the guidance given in the Amendments.

The System currently consists of 16 designated sites and contains 253,500 acres of estuarine submerged lands, wetlands and adjacent watershed uplands. When the System is completed, is completed, it will include representation from the 27 biogeographic regions which characterize the coastal zone of the United States, including that of Alaska, Hawaii, and the Caribbean and Pacific island commonwealths and territories. In addition, where biogeographic regions are especially large and ecologically diverse, the System will contain multiple site reserves.

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Background

The Chesapeake Bay is widely regarded as one of the largest and most productive estuaries in the world. In the classic sense of an estuary, the Chesapeake Bay is a drowned river valley with a saline gradient which ranges from tidal freshwater reaches at the fall line to near-oceanic conditions at the bay mouth. It is a dynamic system and, because of its immense size and complex geomorphology and hydrology, it contains a diverse array of coastal habitats and associated biotic communities.

The Chesapeake Bay forms a separate bigeographic region under the System's classification scheme (Clark, 1982). Because the Bay is an interstate body of water and because the estuarine system is so complex and diverse that it cannot be adequately represented by a single reserve site, the states of Virginia and Maryland are coordinating efforts to establish multiple-site estuarine reserve programs. It is hoped that not only will the state programs compliment each other in terms of site selection and management, but that collectively the reserve sites will characterize the entire Chesapeake Bay system.

The Commonwealth of Virginia is the first state in the nation to design and implement a site selection process for an estuarine reserve using the guidance contained in the 1985 Amendments. Under an award from the National Oceanic and Atmospheric Administration, the Virginia Institute of Marine Science (VIMS) initiated the process in June of 1985 and by January of 1987 had completed the first phase of the study which involved site identification and preliminary evaluation. The next steps will include site evaluation by a panel of regional coastal ecologists and final site review by affected state agencies, local government officials, landowners, and other interested parties.

The purpose of this paper is to report on the findings of the first phase of the site selection process for an estuarine research reserve system in Virginia. Work accomplished to date includes the following: (1) development of a comprehensive estuarine system classification scheme for the Chesapeake Bay in Virginia which could be used to identify the biogeographic zones and ecological features that should be represented in the System; (2) expansion the System's site selection guidelines to make them more useful for site evaluation; (3) field surveys of natural areas in the Chesapeake Bay to identify and verify the ecological nature of candidate sites; and (4) preliminary evaluation of each site. Preliminary evaluation was conducted to eliminate those sites inappropriate for further consideration because of adverse on site environmental conditions or current ownership which precluded their consideration (e.g., land already owned by the Federal government is ineligible for the reserve program). Sites already adequately protected by State or private organization as parks, wildlife refuges or natural areas may not be recommended by Virginia for dual-designation as reserves, but may serve as satellites to the reserve system, as will be explained in following sections.

Classification Scheme Development

Several attempts have been to classify physical and biological components of the Chesapeake Bay environment. EPA (1983) divided the Bay into physical segments based on similarities in salinity, hydrology, and turbidity. This scheme was modified by this study to delineate nine biogeographic subregions of the Bay: upper bay, middle bay, lower bay east, lower bay west, tidal freshwater tributary reaches, brackish water tributary reaches, lower estuarine tributary reaches, bay mouth, and embayments (Fig. 1). To account for ecosystem diversity within biogeographic subregions, a number of existing coastal classification schemes were combined to produce a hierarchial classification which includes coastal geomorphology (Clark, 1982); deepwater and wetlands habitats (Cowardin et al., 1979), non-vegetated wetlands (Theberge and Boesch, 1978), emergent tidal wetland communities (Silberhorn, 1978), shrub and forested wetland communities (McCormick and Somes, 1982), and deciduous forests of the Virginia Coastal Plain (Braun, 1950). The classifications were regionalized and served as a checklist for identifying site characteristics to be represented in the reserve system.

The Evaluation Criteria

The existing System regulations list the factor which must be taken into consideration when selecting and evaluating candidate sites. These factors include biogeographic and typological representation, ecologic value, representation of an entire ecological unit, degree of onsite disturbance, research importance, potential for education and interpretation, and various other management considerations. The regulations, however, do not provide guidance in application or evaluation of these factors (i.e., they do not constitute evaluation criteria). This necessitated the development of evaluation criteria as part of the site selection process. In consultation with the state of Maryland, VIMS developed the evaluation criteria described below:

> Biogeographic Representation -- The site is located within a subregion of the Chesapeake Bay which is as yet unrepresented in the multiple site reserve system for the Chesapeake Bay.

This criterion is used to evaluate the site's benefit to the reserve system (and to the national System) based upon its representation of a distinct biogeographical subregion within the Chesapeake Bay. It is used to ensure that all important biogeographic provinces are adequately represented and that there is not duplication within the Virginia and Maryland reserve systems.

> Ecologic Representation -- The site represents a significant component of the Chesapeake Bay ecosystem because of the

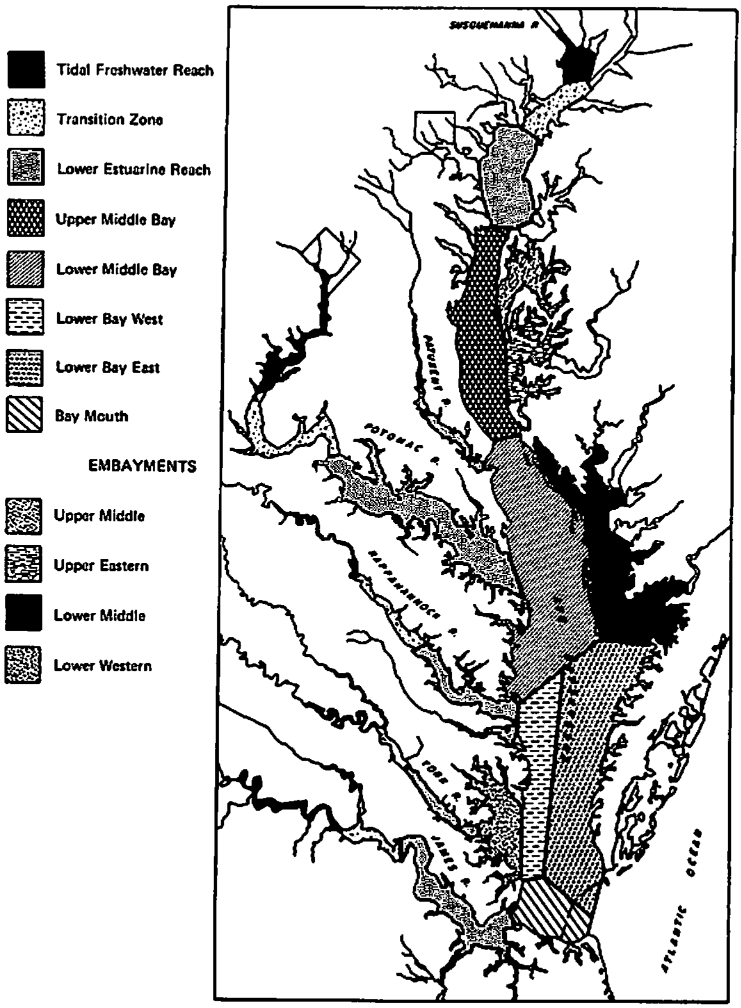

Figure 1. Chesapeake Bay Segmentation Scheme used for Estuarine Research System planning (Environmental Protection Agency, 1983).

types of geomorphological features and biotic communities which are found there.

Clark (1982) used the term 'typology' to refer to the structural and biotic characteristics of a given biogeographic subregion. These characteristics may vary within, as well as between, areas of the same biogeographical regional type in response to climatic or micro-environmental influences. In this study, the elements of the comprehensive estuarine classification scheme for the Chesapeake Bay which apply to coastal geomorphology and vegetative structure and composition, correspond to typology.

The coastal zone of Virginia is structurally and biotically complex. In addition to the main stem of the Bay, several types of basins are found throughout the coastal zone, including tidal rivers and creeks, bays, sounds, embayments, lagoons, and ponds. Shoreline physiography is characterized by such features as indented coasts, unindented coasts, peninsulas, spits, inlets, beaches, dunes, cliffs, barrier islands, bay islands, submerged bars, intertidal reefs and aquatic beds. The patterns, abundance and diversity of biota associated with these coastal features is influenced by hydrologic factors such as tidal range, duration of inundation, flushing, flooding, wave energy, circulation patterns and salinity, and by dynamic processes such as shoreline erosion and accretion, sedimentation, inlet migration, and island morphogenesis. The coastal zone and waters of the Chesapeake Bay provides habitat for a variety of animal species which are residents or concentrate in abundance during part of the year in the form of feeding, breeding and spawning, nursery, wintering, resting and sheltering areas.

<u>Ecologic Valuation</u> -- The site contributes substantially to maintaining or enhancing the ecological quality of the estuarine environment, as a whole, and the local environment, in particular, as evidenced by the vital functions it performs and the societal benefits it provides.

Under this criterion, sites are evaluated according to their importance to: food chain support; waterfowl and wildlife utilization; water quality control and maintenance; erosion and flood control; recreational, scenic and historical pursuits; fishing, hunting and other consumptive uses; and other support functions.

<u>Naturalness</u> -- The site approximates a natural ecological unit where ecosystem processes operate relatively undisturbed by human activities.

This criterion is used to evaluate two essential factors in reserve selection: (1) assurance that the site encompasses an adequate portion of key land and water areas to approximate an ecological unit; and (2) assurance that the site is in a natural state.

Natural ecological units are characterized and defined at the highest levels of the classification system, i.e., by combining aspects of basin type, shoreline physiography, vegetative structure and composition, and topography and drainage pattern. Ecological units can be delineated on maps using cartographic and photointerpretive standards and limits.

Natural state refers to a lack of disturbance from dredging, diking, draining, filling, bulkheading, wetland conversion to agriculture, mining, logging, transportation and utility corridors, marians, waste disposal, residential, municipal or industrial development and other forms of human activity that diminish the natural environmental quality of the ecologic unit.

Research Potential -- The site provides a natural field laboratory within which natural processes can be studied over a period of time to permit the accumulation of basic knowledge which is essential for understanding the statics and dynamics of the coastal region and for improving coastal management decisionmaking.

The objective is to select sites which will serve as natural laboratories for baseline studies related to ecosystem characterization and environmental assessment. The goal is to improve the scientific understanding of the coastal ecosystems and the ability to make informed management decisions. Factors taken into consideration in performing the evaluation include: historical use of the site as a research station; importance of onsite research to resolving important ecological issues (e.g., Chesapeake Bay water quality problem solving); interest in the site shown by researchers and managers; and site security and integrity (i.e., other uses of the site are not in conflict with, or at the expense of, research).

Education Potential -- The site provides excellent opportunities for educating the public about the Chesapeake Bay ecosystem.

The objective is to select sites which provide opportunities to enhance public understanding, appreciation and wise use of the Chesapeake Bay and its tributaries. Factors taken into consideration in evaluating a sites value to public education include the existence and scope of existing or proposed education programs; ability of the site to withstand low to moderate visitor traffic; accessibility for field trips, instructional 'hands on' programs, or self-guided tours; and compatibility of educational activities with research. In this study, the judgment is made that natural, fragile, or sensitive areas are not suitable for intensive public access or education programs and therefore the rule to be followed in site selection is not to recommend sites for both research purposes and public access unless the site is of adequate size and resilience to support both activities without major disturbance occurring.

Management Considerations -- The site can be acquired and managed by practicable means.

This refers to the practicality of designating and managing a site. The following factors are taken into consideration when making this decision: willingness of landowner to sell land; cost; public opinion; size and location of the site (i.e., not too big and not too remote); and ability of the State to manage the site with the limited financial resource available from the national System program and the State.

Site Identification

An initial list of 113 sites was developed from three principal sources: (1) an inventory of inland wetlands conducted for the Natural Landmarks program (Goodwin & Niering, 1971); (2) a survey of natural areas of the Atlantic Coastal Plain (Center for Natural Areas, 1974); and (3) a survey of natural areas of the Chesapeake Bay (Jenkins et al., 1974). Virginia's coastal county wetlands inventory reports (described by Silberhorn, 1978) and an atlas of environmentally sensitive coastal areas in Virginia (Rooney-Char et al., 1983) were used extensively in this study. Supplimentary information about potential sites was obtained through discussion with knowledgable people, review of scientific literature, and field surveys.

Site Surveys

Field surveys were conducted from June (1985) to December (1986) by canoe, kayak, power boat, and foot. An aerial reconnaissance survey was conducted in April 1986 to provide further documentation of selected sites.

Preliminary Evaluation Results

Of the 113 sites originally identified for consideration, 77 were eliminated for one or more of the following reasons: moderate to severe anthropogenic disturbance on the site; failure to encompass an ecological unit; current ownership by the Federal Government (e.g., National Wildlife Refuge or Military Reservation); current ownership by the Commonwealth of Virginia (e.g., State Park, Natural Area or Wildlife Management Ara); adequately protected under Virginia's Wetland Act; or adequately protected by private means (e.g., The Nature Conservancy and citizen's initiatives).

Fourteen (14) sites were found to be moderate in value, primarily because of minor to moderate disturbance onsite, but have not been completely eliminated because their importance in experimental, manipulative or restoration research. They will be forwarded to the panel of experts for final decision.

Twenty-two (22) sites were found to be of high value. These are sites which provide excellent representation of ideal biogeographic and ecological conditions; are in a relatively natural state (i.e., unimpacted by man's current or past activities), and encompass an entire ecological unit. For the most part, these are sites which are the least accessible to man (such as islands, extensive marshes, and water-logged swamps) and located in sparsely populated (rural) regions of the Chesapeake Bay drainage (such as in the York River basin and on the Eastern Shore of Virginia). The recommended sites are found in the following biogeographic subregions and drainage basins: tidal freshwater tributary segment of the Rappahannock, Piankatank, York, and Chickahominy Rivers; brackish water tributary segment of the Potomac and York Rivers; lower estuarine tributary segment of the Potomac, Rappahannock and York Rivers; lower bay, eastern shore; lower bay, western shore; and embayment of Mobjack Bay and Tangier Sound. The only province unrepresented is the bay mouth. The recommended sites represent a diversity of habitat types, including marshes, forested wetlands, marsh and hummock islands; bay islands, Delmarva (pocosin) bays; and bay bluffs.

Satellite Sites

During the course of this study, it was realized that many of the sites eliminated because of current ownership pattern were the best representatives of a particular biogeographic region, ecological habitat or community type, or would fulfill research or education needs because of facilities on site, ongoing programs and/or long-term institutional commitments to these purposes. Also, it was realized that many of the sites which are devalued because of onsite disturbance are valuable because of their potential for experimental, manipulative or restoration research and mitigation. To account for areas which do not meet the criteria for reserve selection because of ownership pattern or less-than-natural condition, but are nonetheless important in the overall Chesapeake Bay system, the concept of "satellite sites" to the reserve system was developed. A preliminary list of satellite sites has been developed. The management plan for the Chesapeake Bay reserve system in Virginia will propose a mechanism for coordinating management, research, and education activities between the reserve sites in the system and a network of satellite sites owned and operated by other entities.

Conclusions

The Chesapeake Bay region has a long history of intensive land and waterways use. The adverse environmental consequences of these land and water uses have surfaced in the past two decades in the form of declines in water quality and living resource quality and abundance. Major programs to protect and restore the Chesapeake Bay have been idanceted, and millions of dollars have been spent on a coordinated Bay-wide clean-up campaign. Except for a few initiatives related to controlling agricultural and urban nonpoint source pollution, however, the Bay program has devoted little attention to the role of natural coastal zone areas in the maintenance and enhancement of environmental quality and productivity. The National Estuarine Reserve Research System provides a unique opportunity to set aside representative natural areas for long-term studies on how these areas contribute to and are effected by the quality of the Chesapeake Bay system as a whole. It also provides the opportunity to educate the public on the values of the Chesapeake Bay system and to preserve the remaining relict of our coastal heritage.

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DEVELOPING SEDIMENT QUALITY VALUES FOR USE IN MANAGING CONTAMINATED SEDIMENTS IN PUGET SOUND

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Introduction

This paper describes the early stages of a joint effort by the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, and the Washington State Departments of Ecology and Natural Resources to develop sediment quality values for use in Puget Sound. The study was commissioned in response to a growing need on the part of federal, state, and local agencies to make decisions concerning the identification, regulation and management of contaminated marine sediments. Recent surveys of urban and industrial embayments in Puget Sound indicate that bottom sediments are the primary sink of chemical contaminants. Data also indicate that exposure to contaminated sediments may be linked to adverse biological impacts in marine biota, and that consumption of marine organisms exposed to contaminated sediments could pose risks to human health.

Approach

Ideally, the development of sediment quality values would be guided by definitive cause and effect information relating the individual and collective effects of specific contaminants to biological effects in a variety of aquatic species. To date, very little information of this type is available and it is unlikely that it will be available in the near future. In the interim, in the interest of protecting human health and environmental quality, the regulatory agencies with management responsibilities in Puget Sound must proceed with sediment management decisions based on the best information available. This information may be theoretically and/or empirically derived. It is on this premise that this sediment quality study was based.

The goals of the study were to evaluate options for sediment management and to identify numerical values for concentrations of chemicals in sediments that appear to be associated with adverse biological effects in Puget Sound. Specifically, the study objectives were to:

Compile chemical and biological data from Puget Sound appropriate for use in the development of sediment quality values.

Evaluate techniques that can be used to develop chemical specific values.

Evaluate the reasonableness of the values generated using different techniques (i.e., their ability to identify sites with known biological effects).

Evaluate the appropriateness of using the values in different regulatory applications.

Evaluation of approaches to establishing sediment quality values

Eight possible approaches to establishing numerical sediment quality values were evaluated based on (in order of decreasing importance):

The plausibility and scientific defensibility of their theoretical bases and critical assumptions.

The quantity of data required, and the current availability of data that could be used to generate sediment quality values during the project.

The range of chemicals for which the approach is appropriate.

The range of biological effects information that can be incorporated into the approach.

Of the eight approaches reviewed, three were selected as the most appropriate for evaluation in this study. Selected were the sediment-water equilibrium partitioning, apparent effects threshold (AET), and screening level concentration (SLC) approaches.

The equilibrium partitioning approach is based on a theoretical model used to describe the equilibrium partitioning of nonpolar, nonionic organic contaminants between sedimentary organic matter and interstitial water. A sediment quality value generated by this approach for a given contaminant equals the sediment concentration (normalized to organic carbon) that corresponds to an interstitial water concentration equivalent to the U.S. EPA water quality criterion for the contaminant. Field data are not required to generate sediment quality values using this approach, but are required to validate the sensitivity (i.e., predictive ability) of the values.

The AET approach estimates concentrations of sedimentary contaminants above which biological effects (e.g., amphipod mortality during bioassays, depressions in abundances of indigenous benthic infauna) are always expected to occur. An AET for a given chemical is derived from matched chemical/biological data as the concentration above which significant ($p<0.05$) biological effects (relative to reference conditions) are always observed. The approach was developed for use with any organic or inorganic contaminant, and does not require a priori assumptions concerning the specific mechanism for interactions between contaminants and organisms. AET can be developed for any biological effects indicator that can be statistically evaluated relative to reference conditions.

The SLC approach estimates the sediment concentration of a contaminant above which less than 95 percent of the total enumerated species of benthic infauna are present. This approach was originally developed and recommended for use with nonpolar organic compounds normalized to organic carbon content in sediments. However, like the AET approach, the SLC approach entails no a priori assumptions concerning the specific mechanism for interactions between contaminants and organisms, and can be used for organic and inorganic contaminants. SLC are empirically derived from matched field data for sediment chemistry and the abundance of individual species of benthic infauna. Project constraints permitted the testing of this approach for only three contaminants (napthalene, high molecular weight polycyclic aromatic hydrocarbons, and mercury), although application of the approach is not considered to be limited to these contaminants.

Generation of sediment quality values

In order to apply and evaluate the selected sediment quality value approaches, a large database of matched biological and chemical data was compiled. Eleven data sets were reviewed for data quality and comparability. Of the 11 Puget Sound data sets reviewed, paired data from 7 studies were included in the final database (Figure 1). These data included recent studies in Commencement Bay (Tetra Tech 1985), eight urban and non-urban embayments of Puget Sound (Battelle 1985), Everett Harbor (U.S. Department of the Navy 1985), and Duwamish River (Chan et al. 1985). Several data sets compiled by municipal dischargers were also included. Using the three selected approaches, sediment quality values were calculated for 73 individual or classes of U.S. EPA priority pollutants and other contaminants, and 3 conventional variables (e.g., total organic carbon).

Summary of Results and Conclusions

The goal of evaluating the sediment quality values generated using different approaches was to assess the potential use of the values for various aspects of sediment management. In order to achieve this

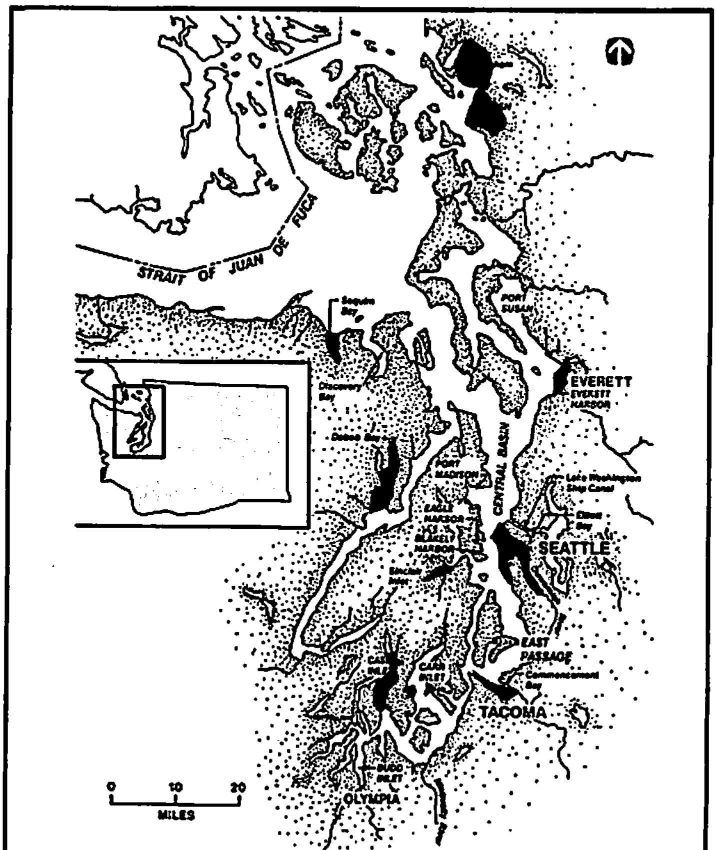

Figure 1. Location of chemical and biological samples included in Puget Sound database.

goal, an uncertainty analysis was conducted. The analysis included two components: accuracy and precision. Accuracy was defined as both sensitivity (i.e, the ability of values to correctly identify all stations in a large data set that are known to have adverse biological effects based on field and lab tests) and efficiency (i.e., the ability of values to identify only stations that actually have biological effects). These two definitions of accuracy are illustrated in Figure 2. Precision was defined as the expected variability of the sediment quality values given the particular constraints in the design and use of an approach.

Accuracy of the sediment quality values

In general, the magnitude of the sediment quality values (i.e., chemical concentrations expected to be associated with adverse biological effects) generated by the SLC approach were lower than the corresponding AET values, which were lower than the corresponding equilibrium partitioning values. The AET (normalized to sediment dry-weight, organic carbon content, and percent fine-grained material) and the equilibrium partitioning approaches were tested with respect to their sensitivity and efficiency, that is, the

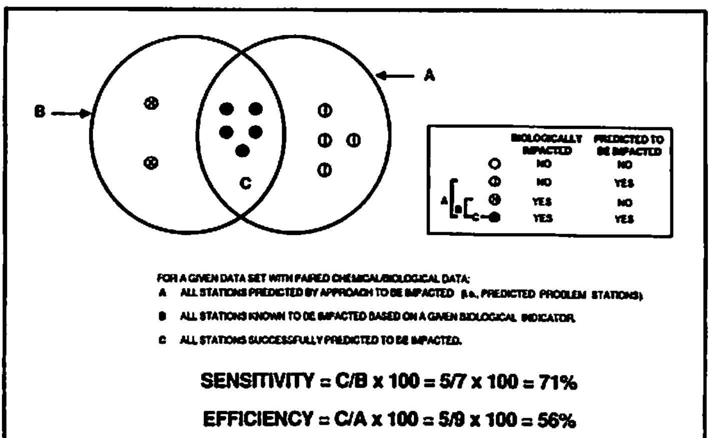

Figure 2. Sensitivity and efficiency as measures of accuracy.

frequencies at which they correctly identified impacted stations and misidentified nonimpacted stations. Stations were designated as impacted or nonimpacted by independent statistical comparisons of biological data to reference conditions. These impacted/nonimpacted designations were based on four biological indicators: amphipod mortality bioassays, oyster larvae abnormality bioassays, Microtox bioluminescence bioassays, and benthic infaunal analyses. A subset of impacted stations was designated as severely impacted based on somewhat arbitrary criteria: greater than 50 percent amphipod mortality or oyster larvae abnormality, or statistically significant depressions in the abundance of more than one major taxonomic group of benthic infauna (including Mollusca, Polychaeta, Crustacea). This subset of severely impacted stations was only used as part of the validation check on sediment quality values, and not to generate sediment quality values.

The 40 sediment quality values generated using the equilibrium partitioning approach correctly identified between 13 and 43 percent of the impacted stations, and between 0 and 46 percent of the severely impacted stations, depending upon the biological indicator used for validation. The equilibrium partitioning approach misidentified between 0 and 67 percent of the nonimpacted stations, depending upon the biological indicator used for validation. Hence, the equilibrium partitioning approach was not highly accurate nor efficient (see Figure 2) in identifying problem sediments.

The 64 sediment quality values generated using the AET approach (using dry-weight normalization) correctly identified between 54 and 94 percent of the impacted stations, and between 92 and 100 percent of the severely impacted stations, depending on the biological indicator used for validation. Corresponding AET values generated from chemical data normalized to total organic carbon content or to percent fine-grained material in sediments correctly identified between 37 and 88 percent of the impacted stations, and between 62 and 100 percent of the severely impacted stations, depending on the type of normalization, and the biological indicator used for validation. The AET approach misidentified between 0 and 69 percent of the nonimpacted stations, depending on the type of normalization used for chemical concentrations and biological indicator used for validation. Hence, the AET approach was highly accurate in identifying problem sediments, although the approach was not highly efficient in identifying only problem sediments (see Figure 2).

A detailed evaluation of the accuracy of the SCL values was beyond the scope of the study, because limitations in the database restricted generation of values to only three chemicals. It was assumed that such a small number of chemicals could not be expected to correctly identify all impacted stations. Hence, a preliminary evaluation was made only of the number of nonimpacted stations misidentified as being impacted using each of the three SLC values. The values misidentified between 15 and 70 percent of the nonimpacted stations, depending on the chemical, type of normalization of chemical concentrations, and biological indicator used for validation. The approach warrants further investigation.

Precision of the sediment quality values

The precision of the values generated using each approach was estimated for selected components of uncertainty that could be quantified. The uncertainty of the equilibrium partitioning approach was estimated to range from less than one to six orders of magnitude of the calculated values, primarily because of uncertainty in the estimation of theoretical constants and the applicability of water quality criteria used in the approach. For a given set of field data, the uncertainty of the AET approach was estimated to range from much less than one to two orders of magnitude of the values generated, primarily because of potential misclassification of nonimpacted stations that are used to define the AET. A statistical evaluation of the precision of the SLC values was beyond the scope of the study, but has been evaluated elsewhere (Battelle 1986).

Recommended uses of sediment quality values

The sediment quality value study involved identification of a range of chemical values that can be applied in sediment management, but did not identify the specific values which agencies should adopt for regulation or how these values should be used in different regulatory programs. Interagency technical and management workgroups are currently in the process of evaluating the ranges of sediment quality values identified during the study and identifying specific values for different regulatory uses in Puget Sound. The U.S. EPA, U.S. Army Corps of Engineers and the Washington State Department's of Ecology and Natural Resources are in the process of adopting sediment quality values (based on application of the AET approach) that can be used in combination with biological tests to regulate the open-water disposal of contaminated dredged material. In the coming year it is anticipated that sediment quality values will also be identified for use as a tool in classifying and prioritizing areas for source control and remedial action, and in establishing discharge limits for particulates in effluent that are protective of marine sediment quality.

Although sediment quality values are being identified for use in Puget Sound, the agencies involved consider the values to be interim. As additional laboratory information concerning chemical/biological cause and effect relationships is developed, and as supplemental field data becomes available, recommended sediment quality values and the approaches to establishing and using those values are expected to change.

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ESTUARINE WATER QUALITY PROGRAM EVALUATION: A QUASI-EXPERIMENTAL APPROACH

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Estuarine Water Pollution Control Programs

In cities bordering estuaries sewage collection is necessary to prevent disease. That solution to a public health problem becomes an environmental problem when raw sewage or improperly treated effluent is discharged into an estuary. A variety of treatment processes exist for sewage and by careful selection disease may be controlled. In addition the estuary may be enhanced for a variety of uses.

The sewage collection system commonly combines the wastewater from homes and industry with that from street drainage (EPA, 1980). At the sewage treatment plant the primary stage entails the settling and removal of solids from the waste stream. A secondary stage of treatment further purifies the water by removing organic material from the water by saturating it with air, and in most cases, adding biologically active sludge. Tertiary or advanced treatment techniques include extensions of biological treatment and physical-chemical separation techniques.

Selection of the technologies has depended upon a combination of factors. Prior to 1972 the ambient quality of the receiving water body was the determinant of the level of treatment required for the sewage. Individual municipalities could make progress under this system given favorable local political and economic conditions. However, in 1972 the Federal Water Pollution Control Act Amendments insisted on secondary treatment. To facilitate this upgrade Congress appropriated over $40 billion in 12 years (Bastian, 1986).

The 1972 amendments clearly stated that the goal was to reduce potentially harmful discharges from publicly owned treatment works (POTW's) through increasing the coverage and level of treatment. In addition the law mandated national pollution discharge elimination system (NPDES) permits to survey discharges and to impose specific requirements for different classes of industries. These two actions became the cornerstone of the national water pollution control strategy. Sewage treatment at the mandated secondary level should remove 85-90% of suspended solids and five day BOD, 10-30% of nitrogen and phosphorous, and 15-65% of the heavy metals from the wastewater (Mueller and Anderson, 1983). In addition, chlorination in advance of final discharge reduces the levels of certain pathogens. The NPDES program through effluent limitations for industry also mandates reductions in the levels of potentially harmful materials being discharged from other point sources.

Estuaries should be substantial beneficiaries of this national water pollution control program. Therefore an important remaining question concerns the environmental outcome of this governmental program.

Evaluation of Program Outcome

As defined by Wholey et al (1970), "Evaluation (1) assesses the effectiveness of an on-going program in achieving its objectives, (2) relies on the principles of research design to distinguish a program's effects from those of other forces working in a situation, and (3) aims at program improvement through a modification of current operations." Evaluation of the effectiveness of social programs began with consideration of Great Society programs (Wholey, 1970), and the methodologies for these analyses continue to evolve (Hoole 1978, GAO 1983, Rutman, 1984). Ultimately they rely on the identification of program goals, the instruments to achieve them, and some measurement of results. The analysis is structured to suit the specific question, and the results are tempered with statistical techniques to insure that appearances are indeed reflected in objective measurements.

The focus on program outcome is an important one to emphasize. Outcome emphasizes actual changes achieved to reach the goal desired as opposed to intermediary measures or outputs. In the terms of estuarine management a program output may be for example a regulation, the number of permits processed, or an allocation of funds. An outcome in an estuarine program is an improvement in water quality brought about by governmental action. Using the quasi-experimental methodology to discern the effectiveness of governmental actions is the subject of this discussion.

What Is A Quasi-experiment?

A quasi-experiment is one that does not include all the components of an ideal experiment. An ideal experiment in the natural sciences will have several elements (Caporaso, 1971). They include a dependent variable that we wish to explain and an independent variable that is assumed to be causally prior to it. Manipulation occurs when the experimenter intentionally alters the independent variable. Usually there are a number of confounding variables and rival explanations which one attempts to eliminate through a control. Then, if repeated manipulations of the independent variable produce changes in the dependent variable, one concludes the independent variable had an effect.

Social programs such as pollution control are quasi-experiments (Roos and Bohner, 1973). One variable is manipulated through the apparatus of government with the hope that the desired change will ensue. The evaluation of results is difficult because these experiments contain some but not all elements of of the ideal natural science experiment. As a result the task for the analyst is to design an approach that compensates for these weaknesses and hence leads to valid causal inferences. The challenge is to use the logic of experimentation in situations that do not meet all the requirements of an ideal experiment. Primary among the obstacles in a quasi-experiment is the fact that the random assignment of units and the control of treatments are beyond the grasp of the investigator. Information concerning events that have occurred must be extracted from records that were not necessarily kept to test the hypotheses of interest. The method emphasizes improvements in design over advanced data analysis as a means to infer cause.

For a reasonable chance of success the quasi-experiment must include several elements of logic that parallel those of an ideal laboratory experiment (Caparaso, 1973). First, the independent variable must shift enough through a known manipulation to produce a reasonable expectation of a change in the dependent variable. Second, the effect of the change of the independent variable on the dependent variable must go beyond that produced by chance alone. Third, plausible rival hypotheses must be examined and ruled out to support the case for a causal relationship.

Estuarine Pollution Control as A Quasi-Experiment

Governmental goals for water quality and expenditures for instruments, the sewage treatment plants, are the basis of the hypothesis that sewage treatment plants reduce estuarine water pollution. The independent variable is the initiation of plant functioning and the dependent variables are amounts of pollutants in the estuary. Testing the hypothesis requires the assembly of pertinent, accurate data on water quality in the estuary and possible influences on it including and beyond the cause hypothesized. The latter can be important because the strategy of a quasi-experiment is to identify correlation and to distinguish correlation from causation (Hoole, 1978). The approach requires the systematic testing of rival explanations before judgements about cause may be rendered. Ultimately the acceptance of the hypothesized cause is dependent upon careful analysis of the individual situation. The cause must precede the effect in time. Treatments must covary with effects. There must be no more attractive alternative explanations.

These alternatives or rival hypotheses provide difficulties in estuaries. A systematic consideration of how rival hypotheses might affect experiments has identified four categories of threats to validity (Cook and Campbell, 1976). Some are important in drawing conclusions about the specific case at hand while the others are important in generalizing across situations or developing theories. Internal validity, one of the first types of threats, concerns whether the relationship specified actually exists in the circumstances examined. In the case of the estuary no change in water pollution after the initiation of increased treatment would lead to questioning the hypothesis. Secondly, statistical conclusion validity requires examination to determine whether the presumed impact was a statistical artifact. In the estuary the pollution load must decrease with sufficient magnitude so that the change can be attributed to factors other than chance. The third type of threat, external validity, raises the question of whether the results would be the same in a different time or place. If for example flushing rates in estuaries vary as they do, these changes in rate may substantially affect the influence of the plant. Finally, construct validity issues focus on problems of generalizing from the operational measures to theoretical constructs.

A time series design is one of the many that are applicable to evaluation (Cook and Campbell 1976). Data concerning pollution in the estuary are collected before and after the initiation or enhancement of the treatment plant. With this series of before and after measurements the question then becomes did the event have an effect? Subject to the constraints described earlier one wants to know not only whether there was a change but whether it can be attributed to the proposed cause and whether it can be generalized to other circumstances.

Pollution has been referred to in a general manner. It will be helpful now to look at it as specific water quality parameters: dissolved oxygen, nutrients, metals, and bacteria. The technology of the plant as described earlier will influence the loading to the estuary associated with each one of these parameters. The fate of the material we wish to observe will be affected by physical, chemical, and biological processes within the estuary. Conservative properties, those whose values do not change during specified processes, are easier to draw conclusions from than nonconservative properties that can be substantially altered during a short period of time in the receiving waters. Metals are more conservative than the other three classes which are rapidly influenced by biological processes.

Assuming that a change of one of these dependent variables is appropriately correlated with an upgrade of plant activity, threats to internal validity must be considered. Was a decrease in metals in the estuary attributable to a decline in manufacturing in the watershed as opposed to greater efficiency in metal removal at the sewage treatment plant? Another data series, the type and value of manufacturing goods shipped, would be necessary to examine this. Other factors such as population change could have similar impacts.

Possible outcomes of the experiment give an indication of its utility in program evaluation. Representative observations of oxygen in estuarine bottom waters from years before and after the institution of secondary treatment are an example. If oxygen demanding wastes are primarily from industrial, combined sewer overflows, or non-point sources and one or more of those sources increases an accelerated decline in oxygen in the receiving waters might be noted even after enhanced sewage treatment. Alternatively, if the pollutants from sources other than the treatment plant remain the same but are dominant the treatment plant could have no effect and the decline would continue. Finally, if the plant is the appropriate response, oxygen depletion in bottom waters might level off or, with a lag in time, increase.

Reality is unlikely to neatly fit any one of the scenarios described and a trend between continuing decline at the same rate versus leveling off or increasing would provide an interesting challenge for interpretation. Here the use of non-equivalent dependent variables may be useful to identify alternate causes (Mark and Cook, 1984). Nitrates are minimally affected by secondary treatment. Some analyses (Freeman, 1978) indicate over three quarters of them come from non-point sources. A series of nitrate observations in the estuary, if not confounded by biological activity, might clarify matters. The nitrates are a dependent variable that should not decrease from the institution of secondary treatment. Their increase over time could indicate that non-point sources are the dominant factors affecting water quality in the estuary.

Conclusions

Future actions in estuarine management can benefit from an understanding of the effectiveness of past programs. Thus, program evaluation using historical data concerning the estuary in question is an important aspect of management. Previous program evaluations focused on the impacts of government actions in social programs have successfully used quasi-experimental analysis to understand similarly complex problems.

The approach focuses on experimental design in preference to statistical manipulations. It requires an abrupt event which is tied to the government program under consideration. A major strength of the approach is that it forces clear statements of program goals, program instruments, and expected program outcomes in the estuary. When these environmental outcomes are complex, careful consideration of experimental design may lead to useful evaluations. Quasi-experimental analysis is an intermediate ground between a detailed natural science explanation and evaluations based on intuition. It is applicable to a variety of situations, follows an experimental protocol, and, only after considering rival hypotheses, reaches conclusions about causes.

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PREPARING FOR EMERGENCIES

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SYNOPSIS OF IMPACTS FROM THE 1985 GULF OF MEXICO HURRICANES

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INTRODUCTION

In recent years, hurricanes have had a great impact on offshore oil development in addition to posing threats to residents of coastal regions and causing extensive economic damage. Hurricane Camille (1969) caused 262 deaths and record tidal surges of 22.9 ft. (6.9 m) in Mississippi. Three offshore platforms were affected; the first was completely destroyed, the second was severely damaged and removed from the offshore, and the third platform suffered damages but was repaired and reused in another area. The damage to these three platforms, plus 5,997 ft. (1,828 m) of pipelines, exceeded $40 million.

Other hurricanes which have caused destruction to offshore development are as follows: Hurricane Hilda (1964) destroyed six platforms; Hurricane Carmen (1974) caused four pipeline breaks; Hurricane Eloise (1975) caused one pipeline break; and Hurricane Bob (1979) caused one pipeline break (DeWald, 1982).

OVERVIEW OF 1985 HURRICANES

Tropical Storm Bob (July 1985) hit the Florida coast in the vicinity of Naples/Ft. Myers with 50 mph winds and heavy rains totaling 11 inches in a 24-hour period. No injuries were reported and only minor damage resulted to properties along the coast.

The southwest coast of Louisiana was hit by Hurricane Danny (August 1985) with gusts of winds reaching 100 mph. Flash floods, tornadoes, and power failures resulted which forced hundreds of people from low-lying homes. No deaths resulted from the storm.

The evacuation of more than 500,000 people from Louisiana to Florida was the result of Hurricane Elena (September 1985). Although she caused millions of dollars worth of property damage, no deaths or serious injuries resulted. Winds were recorded up to 125 mph, and at least 10 tornadoes were sighted.

Hurricane Juan (October/November 1985) intensified so quickly that the offshore oil and gas industry was unable to evacuate personnel on many rigs and platforms. As a result, massive rescue of more than 140 people was performed by the U.S. Coast Guard. When the legs collapsed on a Penrod 61 drilling rig, 43 people evacuated into escape capsules; however, one capsule swamped, which resulted in the death of one crewman. By October 31, Hurricane Juan had come within 60 miles of New Orleans. Seven lives were lost and 50,000 homes were flooded.

Hurricane Kate (November 1985) was the first November storm to hit the U.S. coast in 50 years. About 100,000 people left their homes before the storm hit the Florida panhandle. Sixteen people, including 10 in Cuba, lost their lives. Kate's winds were recorded at 75 mph and up to 8 inches of rain fell in some areas.

Natural Resource Losses in the Central Gulf Area

Hurricanes and winter storms are major contributors to the destruction of Louisiana's barrier islands. High wave energy and the associated storm surges erode the land areas, particularly the shorelines.

The 1985 hurricanes resulted in hurricane levee failure and North Shore beach erosion at Lake Pontchartrain; beach erosion of 25-75 ft., breaching, dune destruction, and backbarrier de-vegetation at Chandeleur Islands; beach erosion of 25-75 ft., breaching and backbarrier de-vegetation at Plaquemines barrier shoreline; beach erosion of 25-100 ft., breaching, dune destruction, seawall failure, partial hurricane levee destruction, and backbarrier de-vegetation at Bayou Lafourche barrier shoreline; beach erosion of 24-100 ft., breaching, dune destruction, and backbarrier de-vegetation at Isles Dernieres; beach erosion of 20-50 ft., breaching, and wildlife refuge damage at Teche Basin, and beach erosion of 20-60 ft., breaching, and wildlife refuge damage at Chenier Plain (Penland et al., 1986).

Impacts of Hurricane Danny on wildlife in the State of Louisiana were heavy. Alligator nests and eggs were destroyed throughout the marshes from Pecan Island to Pearl River, including north of Vermilion Bay, West Cote Blanche Bay, East Cote Blanche Bay, and Atchafalaya Bay. Deer on Marsh Island were severely impacted (50 percent loss) and an unknown number lost at other wildlife refuges. Thousands of nutria and muskrat carcasses along with raccoons, rabbits, and clapper rails were found in the Louisiana coastal areas. It was estimated that 60 to 70 percent of the nutria population was lost. Much of the vegetation, except wiregrass, was burned from high salinity water (Tarver, 1985a).

Hurricane Juan adversely affected the Louisiana shrimp industry. Considerable debris and detritus were deposited on the shrimping grounds, resulting in losses to fishing gear and a loss of fishing time. The storm dispersed the population of shrimp, caused premature immigration, resulted in some shrimp mortalities, and resulted in a decrease in shrimp landings (Chatry, 1986).

Ninety percent of the Alabama oyster resources were lost as a result of Hurricane Elena. All major reefs--Cedar Point, Buoy, and Kings Bayou--were impacted. The most productive reef, Cedar Point Reef (Mobile County), was virtually destroyed. Estimates were that restoration of 1,184 acres of reef area by planting adequate cultch material should result in replacement of the lost oyster resources within a period of 1.5-2.0 years, providing adequate spat set occurs (Tatum, 1985).

Damage estimates of the 1985 hurricanes off the Mississippi coast resulted in the death of approximately 10,000 marine birds (primarily eastern kingbirds, oven-birds, rails, herons, and egrets) and in a massive nutria kill (Thomas, 1986).

Natural Resource Losses in the Eastern Gulf Area

Hurricane Elena affected the beaches and shores of the Florida coast from Escambia County through Sarasota County, a shoreline distance of about 494 statute miles. Balsillie (1985) performed a Type I erosion value analysis relative to Hurricane Elena's effects on Florida beaches and shores. This was an average for sampled profiles where only erosion occurred. Through this analysis, it was determined that beach and coast erosion volumes for Pinellas, Franklin, Gulf, and Escambia Counties ranged from 8.3 to 15.6 cubic yards per shorefront foot of coast. The average erosion was 10 cubic yards per foot.

At the St. Vincent NWR, the 1985 Gulf of Mexico hurricanes resulted in the death of five deer; two loggerhead sea turtle nests and both eagle nests on the island were destroyed (Holloman 1986). A dolphin was temporarily stranded on the beach and there were massive fish kills in the freshwater lakes on the island. Many trees and understory vegetation were destroyed or damaged. At the St. Marks NWR, seven eagle nests were destroyed, fish were killed in an impoundment, and some trees were destroyed or damaged (White, 1986).

Economic Losses in the Central Gulf Area

Offshore losses to the oil and gas industries were extensive. Some of the losses follow: Bright (1985) reported that a Pennzoil 6 inch pipeline at South Pass Block 78 broke three times during the 1985 hurricanes, resulting in estimated repair costs of $800,000 from Hurricane Juan and $1,600,000 from Hurricane Elena. Wallis (1985) estimated $36,000 for replacement of three Southern Natural Gas meter station sheds and $5,000,000 to replace and put back in operation an 18-inch pipeline at South Pass Block 60. Linton (1985), with Chevron Pipeline Company, estimated that Hurricane Juan resulted in a $1,000,000 mudslide pipeline break at South Pass Block 78. Other Chevron Pipeline Company replacement/repair cost estimates for Louisiana onshore and offshore facilities as a result of Hurricane Juan included: $368,800 for an oil treatment terminal at Main Pass Block 69; $287,000 for a Fourchon oil treatment terminal; $220,000 for an oil storage facility at Bay Marchand; $4,000 for a business office/shop at Leeville; $38,000 for an oil storage facility at Empire; $83,000 for West Delta tank battery; and $81,000 for personnel evacuation. Production platforms were damaged in several offshore areas including South Timbalier, Ship Shoal, Eugene Island, Vermillion, Destin Dome, and Mobile. The Coast Guard (1986) reported vessel casualty damage at almost $9,000,000 and $1,000,000 as a result of Hurricanes Elena and Danny, respectively.

The seafood industry suffered total damages in excess of $54,000,000 as a result of the 1985 hurricanes (Dawley, 1986). In Louisiana, this included damages to 50 seafood plants, 9 vessels, 1 machine shop and the destruction of 1 plant and 4 vessels. This, including industry-related damage, resulted in losses of $3,143,000 (Simpson, 1986). In Mississippi, Hurricane Elena damaged 30 seafood plants and destroyed another, damaged 8 vessels, caused considerable plant and equipment damage to 3 local shipyards, and caused significant industry-related damage, which resulted in total damage estimates of $2,386,500. In addition, Tatum (1985) requested $1,492,088 in disaster funds to be used in replanting three very productive oyster reefs in the coastal area of Alabama. The economic loss from the 1985 hurricanes to the Alabama oyster industry was $48,000,000.

The Louisiana Department of Wildlife and Fisheries summarized hurricane impacts on Louisiana's wildlife refuges and management areas (WMA's) as follows: Hurricane Juan damaged the Pass-A-Loutre WMA headquarters and destroyed equipment there in the amount of $17,054; damaged the Salvador WMA headquarters, destroyed equipment, and damaged a levee and water control structure with a cost estimate of $73,000; and damaged the Pointe-Au-Chien WMA headquarters, destroyed equipment, and damaged levee and water control structures in the amount of $539,797. Damage cost estimates at the Marsh Island Refuge totaled $13,346,140 for equipment replacement, equipment repairs, levee and water control structure repairs, and for miscellaneous repairs including the replacement of boundary signs and lost lumber. Losses at the Atchafalaya Delta WMA for damage to the generator and storage sheds, equipment replacement, and loss of shell on a ring levee totaled $32,400. At the State Wildlife Refuge, the cost estimate was $918,840 for headquarters repairs, levee and water control structure repairs, and miscellaneous damage repair. Levee and water control structure repairs, along with some miscellaneous repairs, were estimated at $13,898,000 at Rockefeller Wildlife Refuge. At St. Tammany Refuge the cost estimate was $1,161,000 for levee and water control structure repairs. Restoration of the levee shoreline at the Manchac Management Area was estimated at $1,650,000 (Tarver, 1985b).

Estimated costs for highway repair and related damages by the Louisiana Department of Transportation and Development for Hurricanes Danny and Elena were $453,640 and for Hurricane Juan $1,957,139 (Creagon, 1985). Road/road-related repair costs in coastal Alabama for Hurricane Elena were $561,000 for Baldwin County and $156,500 for Mobile County (Poiroux, 1986.)

Hurricane Juan resulted in a $194,663,585 agricultural economic loss in Louisiana. This included $174,934,146 for crops, $11,951,664 for soybean quality loss, $5,686,500 for total immovables (farm buildings, mobile homes, service buildings, equipment and land damage), $450,250 for livestock, and $1,641,025 for aquaculture (Byrd, 1986).

The 1985 hurricanes resulted in impacts on schools, public offices, and other facilities/operations in Louisiana. The American Red Cross (1986) reported that it provided $8,000,000 in assistance to families in south Louisiana as a result of Hurricane Juan and $400,000 as a result of Hurricane Danny.

Hurricane Danny forced a major evacuation of the Mississippi coast. It cost property owners in Mississippi an estimated $51,000 in damages. Hurricane Elena was particularly devastating to the area, with damage estimates of more than $500,000,000. Approximately $500,000 to $700,000 in damages, due to flooding, were the results of Hurricane Juan (Sun Herald, 1986).

Total cost estimates reported for 1985 hurricane damages to the coastal counties of Alabama were: $336,969 for State agencies; $1,041,620 for Baldwin County, and $1,722,806 for Mobile County. These were estimates for eligible applicants under the Public Assistance Program (Bennett, 1986).

Economic Losses in the Eastern Gulf

Balsillie (1985) conducted Type II volumetric erosion values relative to Hurricane Elena. These values included all profiles regardless of gain or loss of beach/coast. From those values, it was suggested that the lower Gulf and panhandle coasts of Florida resulted in $12,400,000 to $22,900,000 of beach and coast erosion damages.

As a result of the damage to the Apalachicola oyster reefs from Hurricane Elena, $1,570,000 was requested for emergency funding under Chapter 4.B. of the Marine Fisheries Research and Development Act (PL 88-309) to reconstruct natural oyster reefs (Simpson, 1986). Estimated losses in potential oyster production in Apalachicola Bay's Cat Point Bar and East Hole Bar exceeded $30,000,000. Estimated losses in potential dock-side revenues from harvests exceeded $6,000,000 (Berrigan, 1986).

Hurricane Elena resulted in replacement/repair cost estimates of $128,500 for the St. Vincent NWR. At the St. Marks NWR, cost estimates to repair/replace items damaged by Hurricane Elena were estimated to be $49,000. Hurricane Kate resulted in $40,000 worth of damage to the refuge (White, 1986). Cost estimates for damages to the Gulf Islands National Seashore in Gulf Breeze, Florida, were in excess of $72,000. Uninsured damages on Florida's state parks as a result of Hurricane Elena were estimated at $702,664 (Barber, 1986). Hurricane Elena damages expected to be covered by insurance on Florida's state parks were estimated at $52,684 (Barber, 1986).

U.S. Highway 98 damage estimates were $750,000 for Hurricane Elena and $1,500,000 to $2,250,000 for hurricane Kate. The 1985 hurricanes resulted in $2,500,000 to $3,000,000 in damages to the St. George Island Causeway. Miscellaneous highway damages in Gulf County amounted to $50,000 (Spangenberg, 1986).

Conclusion

The 1985 Gulf of Mexico hurricanes were both environmentally and economically devastating. In the Central and Eastern Gulf of Mexico areas, coastal erosion and land loss were tremendous. Wildlife losses were fairly heavy in the Central Gulf area but appeared to be less in the Eastern Gulf area. Oyster resources were heavily impacted in the Central Gulf area (Mobile Bay) as well as in the Eastern Gulf area (Apalachicola Bay). The oil and gas industries suffered millions of dollars in losses in the Central Gulf. Wildlife facilities and parks suffered heavy economic losses in both areas. Likewise, highway damages in both areas were in the millions of dollars. Agricultural damages were heavy in the Central Gulf area. The 1985 hurricane season serves to underscore the continued importance of sound evacuation procedures and safety measures for the offshore industry, fishermen, wildlife managers and local residential communities.

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Abstract only

IMPROVED QUANTITATIVE ASSESSMENTS OF ENVIRONMENTAL HAZARDS

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One of the major problems facing decision-makers today relates to the lack of quantitative guidance that they receive from scientists and engineers. Measurements from various sources are frequently piecemeal and do not provide an overview of the environmental concerns. Sophisticated models are developed and then applied to only a small range of selected conditions. Conflicting hypotheses are often put forward based on these sparce data and interpretations of environmental interactions. This often leaves the decision-making process primarily dictated by bureaucratic considerations.

A statistical methodology for obtaining a better quantitative characterization of environmental hazards is used to obtain improved quantitative estimates of risk. This statistical technique is based on a convolution of spatial fields and can be used to obtain improved estimates of univariate and multivariate distributions of parameters. In turn, these distributions can be integrated to obtain risks of threshold exceedance, durations of exceedance conditions, and range of conditions leading up to the exceedance.

In overview of the FEMA-defined flood zones applied in southern Louisiana it was shown that the older methods used to define these levels appear to be quite over-conservative. Second, an analysis of the use of this technique to evaluate the hazards due to encountering spills (oil or toxic materials) has shown that these risks can be quantitatively evaluated in a fashion that can provide useful guidance to decision makers.

One of the major advantages of this new methodology lies in the increased ability to predict environmental extremes. In applications to offshore wave-related hazards in the Gulf of Mexico, it has been shown to provide approximately 10 times more information than a conventional site-by-site analysis. Another advantage is inherent in the ability of this technique to estimate nonlinear multivariate relationships among several environmental parameters. Standard multivariate statistical methods (such as multiple regression, canonical correlation analysis, principal component analysis, and factor analysis) are all based on linear algebra and are difficult to apply in situations where interrelations are highly nonlinear (such as the relationships between a direction quantity and a speed quantity).

LOUISIANA'S BATTLE WITH THE SEA; ITS CAUSES AND EFFECTS

Sue Hawes, Convenor

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Abstract only

LAND LOSS, ITS REGIONAL IMPACTS

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Two-thirds of the world's population and more than 40 of its largest cities are located in coastal areas. In the United States 75% of the population lives in close proximity to the sea. Human occupancy within 2 kilometers of the ocean shore is now increasing at more than three times the national growth rate.

These cultural elements and associated physical forces are the shoreline's worst enemy. Together, they are also responsible for the loss of a considerable portion of America's wetlands.

In the United States, between 1955 and 1975, estimates of wetland losses ranged as high as 220,000 hectares annually, most of which was attributed to human activities. Louisiana may be the best example of coastal problems in the United States because its coastline has changed most often. Parts of the state's coast are disappearing at more than 30 meters a year.

With 41% of the country's coastal marshes, the destruction of Louisiana's alluvial wetlands is serious. Accelerated by an estimated sea level rise of 1.2 mm/year and a subsidence rate that exceeds 40 mm/year at the Mississippi delta, Louisiana is losing some of its most valuable land. The state annually loses 103.5 km^2 of its coastal marshes - every 49 minutes another hectare becomes open water. For the first time in recent history, the region is changing from an area of net land gain to an area of net land loss. The land that is lost is not site specific, but includes the entire coast. No sections are spared.

The barrier islands are retreating, coastal highways are falling into the Gulf of Mexico, and, in general, the region's "first line of defense" against hurricanes is threatened. Further, saltwater intrusion is endangering the area's drinking water and aquatic habitats. The problem is acute. Numerous local, state, and federal agencies have initiated "solutions" that include everything from beach nourishment, to the possibility of redirecting the Mississippi in an attempt to try to correct the problem. Nevertheless, the future will present some interesting problems, since "high" land, already scarce, will be at a premium. The cumulative economic effect will be measured in the billions of dollars.

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RELATIVE SEA LEVEL RISE AND SUBSIDENCE MEASUREMENTS IN THE GULF OF MEXICO BASED ON NATIONAL OCEAN SURVEY TIDE GAUGE RECORDS

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Introduction

Coastal erosion in Louisiana

Louisiana is experiencing the most severe land loss and barrier island erosion problem in the United States (Fig. 1). Land loss rates in the Mississippi River delta plain exceed 102 km^2 per year (Gagliano et al. 1981). Louisiana experienced a decrease in total barrier island area of about 37 percent, from 92.4 km^2 to 57.8 km^2 between 1880 and 1979 (Penland and Boyd, 1981, 1982). Current predictions indicate the entire Plaquemines Parish delta plain will be converted into open water within 52 years, based on a land loss rate of 35.73 km^2 per year and that the entire Terrebonne delta plain will be converted into open water within 102 years, based on a land loss rate of 27.7 km^2 per year (Gagliano et al., 1981). Between 1887 and 1979, the Terrebonne Parish barrier islands decreased in area from 48.3 km^2 to 18.3 km^2. At a rate of 0.326 km^2 these islands will be converted to submerged sand shoals in 56 years (Penland and Boyd, 1981; Fig. 2). Rapid relative sea level rise induced by delta plain subsidence and combined with a deficit of terrigenous wetland sedimentation are the primary factors driving the rapid deterioration of the Louisiana coastal zone.

Previous sea level rise studies

Previous investigations have documented that the analysis of tide gauge records is a valid technique for measuring relative sea level rise and

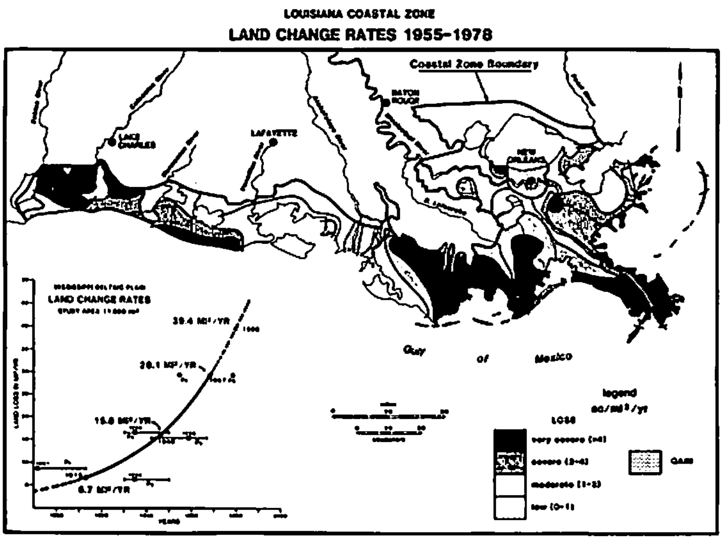

Figure 1. Louisiana is experiencing the highest rates of land loss in North America (Gagliano et al., 1981).

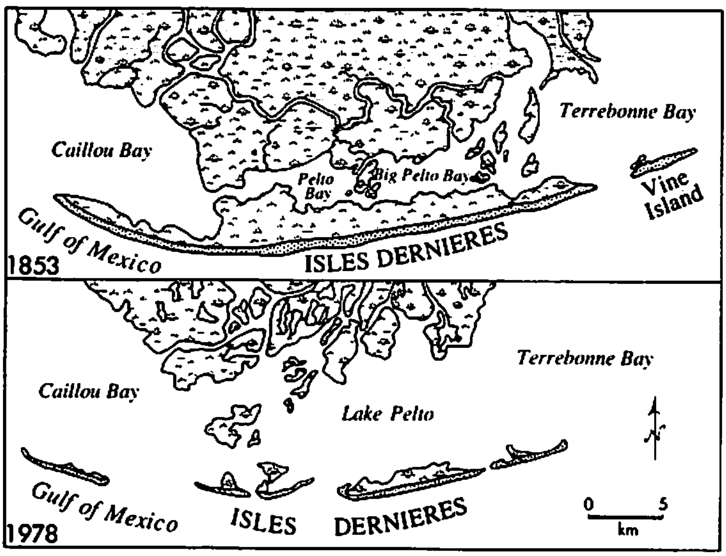

Figure 2. Historical map comparison of the Isles Dernieres barrier island arc in Terrebonne Parish, Louisiana. Note the rapid land loss and retreat of the coastal zone (Penland et al., 1981).

subsidence in Louisiana (Marmer, 1952, 1954; Gornitz et al., 1982; Hicks, 1978; Hicks et al., 1983; Pirazzoli, 1986; Penland et al., 1987a, 1987b). A comparison of early relative sea level rise rates for Louisiana indicates rates can be as high as 4.3 cm/yr (Swanson and Thurlow, 1973). This early study by Swanson and Thurlow (1973) utilized tide gauge records from the Mississippi River delta plain with a period of record from 1959 to 1970 for a total of 11 years. A comparison of the Swanson and Thurlow (1977) data set with other, more recent data sets (Byrne et al., 1976, 1977; Hicks and Crosby, 1978; Gornitz et al., 1982; Delaune et al., 1983; Penland et al., 1987a, 1987b; Pirazzoli, 1986) suggests that the 4.3 cm/yr relative sea level rise rate is anomalous because the period of record used (1959 to 1970) is too short and because it reflects a secular period of relative sea level rise. Typically, the longer the period of record for a tide gauge station, the lower the rate of relative sea level rise. This comparison indicates that the period of record must exceed more than 2 complete lunar epochs (18.5 yr) before the water-level time-series can truly begin to resolve relative sea level rise and subsidence. Our investigation represents the first systematic regional analysis of all National Ocean Survey (NOS) tide gauge stations in Louisiana and the Gulf of Mexico using only the long-term water level histories.

The National Ocean Survey (NOS) tide gauge network was analyzed in the Gulf of Mexico in order to determine the rates of relative sea level rise and subsidence impacting Louisiana and other Gulf Coast states. The oldest NOS tide gauge in the Gulf of Mexico was established at Key West in 1913 (Fig. 3). The oldest NOS tide gauge station in Louisiana is the Eugene Island station, established in 1939.

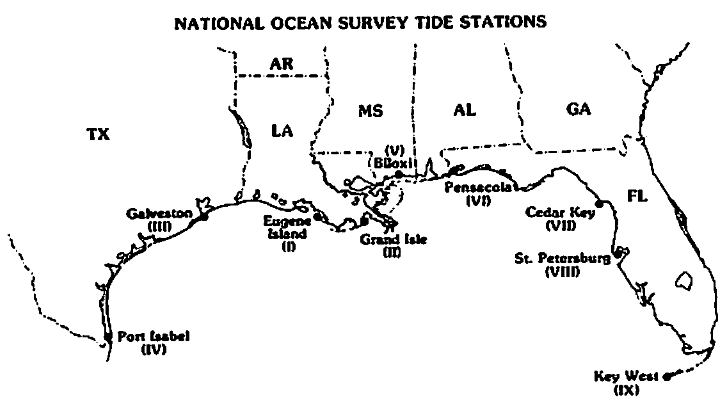

Figure 3. Location diagram of the National Ocean Survey (NOS) tide gauge stations used in this investigation.

Objectives

The first objective of this paper is to document the rate, distribution and character of relative sea level rise and subsidence in Louisiana based on the analysis of long-term tide gauge records. The second objective is to compare the results of the Louisiana analysis with the results of tide gauge analysis from Texas, Mississippi, Alabama, and Florida in order to determine the regional variability of relative sea level rise and subsidence in the Gulf of Mexico.

Tide Gauge Data and Analysis

Data base and analysis

The two NOS tide gauge stations located in Louisiana at Grand Isle (I) and Eugene Island (II) are considered to have the best resolution of all the stations in Louisiana. The tide gauges at these stations record water-level measurements every six and sixty minutes, 24 hours a day, at locations that have direct tidal exchange with the Gulf of Mexico. The Grand Isle station (I) at Bayou Rigaud has a 31-year period of record between 1947 and 1978. The period of record for the Eugene Island station (II) is 36 years between 1939 and 1974. The NOS provided summaries of daily mean, high and low water levels at each station (Hicks et al., 1983). This data base was averaged into summaries of mean monthly and annual water levels. For each station, a time-series plot of the annual water level history was constructed. A linear regression was performed on the complete data set in order to produce a best-fit straight line with a slope equal to the rate of relative sea level rise. A relative sea level rise rate based on the entire record was produced. Next, the tide gauge record was divided into two 18.5-year time intervals in order to balance the effects of the lunar epoch. The lunar epochs were defined as 1942-1962 and 1962-83 (Hicks, 1968). The same procedure was then followed again for each lunar epoch as performed for the entire record, which yielded a rate for relative sea level rise. This procedure was followed in order to detect either an acceleration or deceleration in sea level rise conditions between the lunar epochs and for the entire record. The maintenance history for each station was reviewed in order to remove any errors in the data due to re-positioning or damage to the station. This same procedure was then performed again for NOS tide gauge stations in Texas, Mississippi, Alabama and Florida. Tide gauge stations with sufficient record included Port Isabel (III) and Galveston (IV) in Texas, Biloxi (V) in Mississippi, and Pensacola (VI), Cedar Key (VII), St. Petersburg (VIII), and Key West (IX) in Florida.

NOS Tide Gauge Results - Gulf of Mexico

Louisiana

The Bayou Rigaud tide gauge station (I) at Grand Isle lies behind this barrier island on the Exxon Dock adjacent to Barataria Pass (Fig. 3). NOS established a new station at the U.S. Coast Guard Station, renaming it East Point after the Bayou Rigaud station was destroyed. It was releveled in 1978. Between 1947 and 1978, relative sea level rose steadily at a rate of 1.03 cm/yr. Analysis of the water level histories indicates that the rate of relative sea level has accelerated from 0.30 cm/yr to 1.92 cm/yr.

The Eugene Island station (II) is located on the Point Au Fer shell reef system 8.0 km south of the prograding Atchafalaya River delta (Fig. 3). In recent years this station is becoming more and more contaminated by the Atchafalaya River flooding such as the spring floods of 1972 and 1973. Analysis of the entire record indicates a relative sea level rise rate at Eugene Island of 1.19 cm/yr between 1939 and 1974 (Fig. 4). Analysis of the lunar epochs indicates relative sea level rise has accelerated from 0.95 cm/yr for the first epoch to 2.17 cm/yr for the second epoch. Table 1 lists the statistics for the Grand Isle (I) and Eugene Island (II) NOS tide gauge stations.

Texas

The Galveston tide gauge station (III) is located on the east end of Galveston Island on the north Texas coast (Fig. 3). This station is connected to the Gulf of Mexico by the Houston Ship Channel. The period of record is between 1908 and 1980 and the rate of relative sea level rise for the entire period of record is 0.62 cm/yr. The acceleration in relative sea level rise is from 0.32 cm/yr for the 1942-1962 lunar epoch to 1.17 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

To the south at the border of Texas and Mexico, the Port Isabel tide gauge station (IV) is located on the mainland shoreline of Laguana Madre at the south end of Padre Island (Fig. 3). For the period of record between 1944 and 1979 the rate of relative sea level rise was 0.33 cm/yr. The acceleration in relative sea level rise is from -0.03 cm/yr for the 1942-1962 lunar epoch to 0.86 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

Mississippi - Alabama

The Biloxi tide gauge station (V) is located on the mainland shoreline of Mississippi Sound, landward of Ship Island (Fig. 3). This tide gauge station is connected to the Gulf of Mexico by Dog Keys Pass. The period of record is from 1939 to 1983. A relative sea level rise rate of 0.15 cm was determined for the entire period of record. A slight acceleration in relative sea level rise was determined at -0.20 cm/yr for the 1942-1962 lunar epoch to 0.08 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

Florida

The Pensacola tide gauge station (VI) is located on the mainland shoreline of Escambia Bay near the west end of Santa Rosa Island (Fig. 3). This tide gauge station is connected to the Gulf of Mexico by Perdido Pass. Analysis of the entire period of record between 1923 and 1980 indicates that the relative sea level rise rate is 0.23 cm/yr. The relative sea level rise acceleration is from 0.05 cm/yr for the 1942-1962 lunar epoch to 0.46 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

The Cedar Key tide gauge station (VII) is located on an island between Suwannee Sound and Waccassau Bay in the Big Bend region of Florida (Fig. 3). A relative sea level rise rate of 0.17 cm/yr was determined for the entire period of record between 1914 and 1980. The relative sea level rise acceleration rate was 0.13 cm/yr for the 1942-1962 lunar epoch to 0.31 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

TABLE 1

RELATIVE SEA LEVEL RISE RATES
IN THE
NORTHERN GULF OF MEXICO:
NATIONAL OCEAN SURVEY TIDE GAUGE STATIONS

STATION NUMBER	STATION NAME	STATION LOCATION	RECORD PERIOD	FIRST EPOCH	SECOND EPOCH	ENTIRE RECORD	ACCELERATION
I	Eugene Island	Louisiana	1939-1974	0.95	2.17	1.19	1.22
II	Grand Isle	Louisiana	1947-1978	0.30	1.92	1.03	1.62
III	Galveston	Texas	1908-1980	0.32	1.17	0.62	0.85
IV	Port Isabel	Texas	1944-1979	-0.03	0.86	0.33	0.89
V	Biloxi	Mississippi	1939-1983	-0.20	0.08	0.15	0.28
VI	Pensacola	Florida	1923-1980	0.05	0.46	0.23	0.41
VII	Cedar Key	Florida	1914-1980	0.13	0.31	0.17	0.18
VIII	St. Petersburg	Florida	1947-1980	0.01	0.29	0.16	0.28
IX	Key West	Florida	1913-1980	0.10	0.40	0.22	0.30

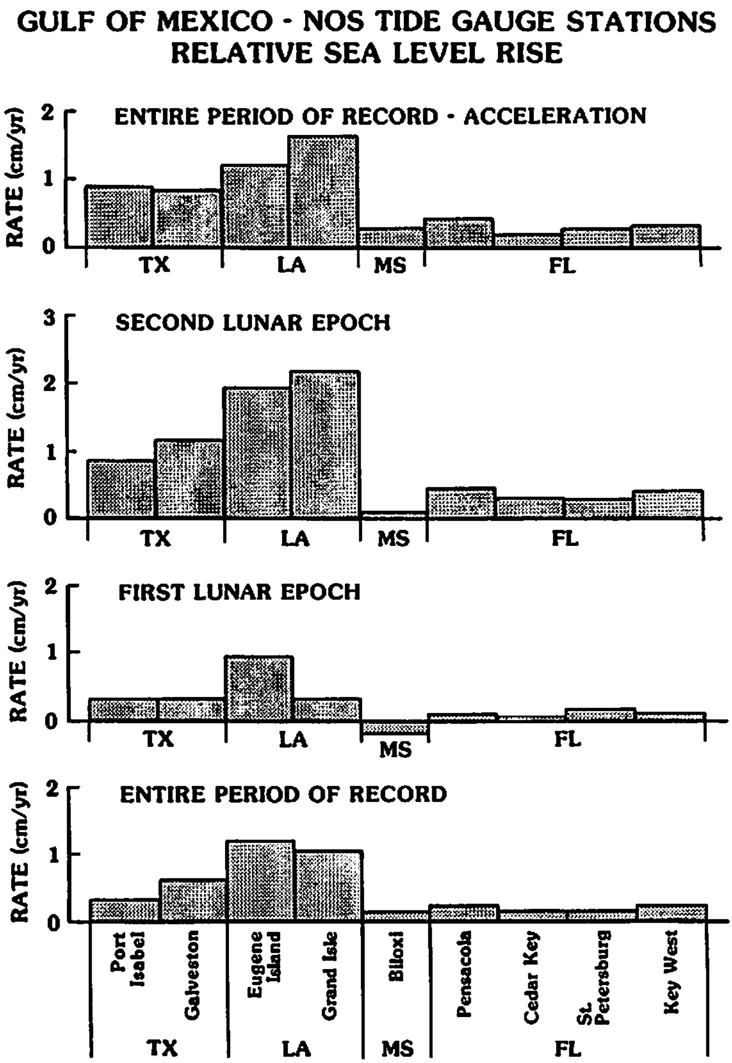

Figure 4. Relative sea level rise histogram for the NOS tide gauge stations in the Gulf of Mexico.

The St. Petersburg tide gauge station (VIII) is located on the northern shore of Tampa Bay. This tide gauge station is connected to the Gulf of Mexico by a series of tidal inlets along the Tampa Bay barrier shoreline (Fig. 3). The period of record is from 1947 to 1980 and the analysis indicated the relative sea level rise rate is 0.16 cm/yr. The acceleration in sea level rise was 0.01 cm/yr for the 1942-1962 lunar epoch to 0.29 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

The Key West tide gauge station (X) is located at the extreme western end of the Florida Keys in the southeastern Gulf of Mexico (Fig. 3). The relative sea level rise rate of the period of record between 1913 and 1980 is 0.22 cm/yr. The acceleration in relative sea level rise was from 0.10 cm/yr for the 1942-1962 lunar epoch to 0.40 cm/yr for the 1962-1982 lunar epoch (Fig. 4).

Regional Comparison

Gulf of Mexico - NOS tide gauge stations

In comparison with other U.S. Gulf Coast states, Louisiana is experiencing the highest rate of sea level rise in the Gulf of Mexico. The zones of highest sea level rise are associated with the Mississippi River delta plain. The rates of relative sea level rise decrease to rates comparable with the adjacent coastal states in the Chenier Plain to the west and the Pontchartrain Basin to the east (Fig. 4). The highest rate of relative sea level rise in Louisiana is at Eugene Island (II) where the average rate is 1.19 cm/yr with an acceleration from 0.95 cm/yr to 2.17 cm/yr between 1939 and 1974. The NOS Grand Isle tide gauge station (I) recorded a relative sea level rise rate of 1.03 cm/yr with an acceleration from 0.30 cm/yr to 1.92 cm/yr. For Louisiana, the total acceleration in relative sea level rise was between 1.22 cm/yr and 1.62 cm/yr.

In Texas, the rate of relative sea level rise ranges from 0.33 cm/yr in Port Isabel (III) to 0.62 cm/yr at Galveston (IV). The Galveston relative sea level rise rate is nearly identical to the Chenier Plain rate in west Louisiana. The total relative sea level rise acceleration rate ranges between 0.85 cm/yr for Port Isabel (III) to 0.89 cm/yr for Galveston (IV). From north to south, there appears to be a trend of decreasing relative sea level rise. However, the acceleration of relative sea level rise appears to be uniform on the Texas coast.

In the eastern Gulf of Mexico, the Mississippi, Alabama, and Florida tide gauges recorded the lowest rates of relative sea level rise. For Florida, the relative sea level rise rates ranged between 0.17 cm/yr for Cedar Key (VII) and 0.23 cm/yr for Pensacola (VI). For the period between 1942 and 1982, the total acceleration in relative sea level rise ranged from 0.18 cm/yr to 0.41 cm/yr. Biloxi (V) recorded the lowest relative sea level rise rates in the Gulf of Mexico with an average of 0.15 cm/yr for the entire period of record. The total acceleration in relative sea level rise was 0.17 cm/yr between 1939 and 1983.

Subsidence

Eustatic correction factor

The contribution of subsidence to relative sea level rise can be estimated from tide gauge water-level time series by subtracting out a correction factor for the eustatic sea level rise factor from a NOS relative sea level rise rate. The difference is considered the contribution of subsidence. The eustatic correction factor is based upon the analysis of tide gauge records from a stable coastline relative to the region and that the difference, termed subsidence, reflects the impact of compactional subsidence as well as any errors induced by station maintenance and any localized effect. This second component is assumed to be insignificant. Therefore, the eustatic-corrected water-level history is considered representative of subsidence.

Gornitz et al. (1982) analyzed more than 190 tide gauge stations worldwide. Through this investigation a global relative sea level rise rate of 0.12 cm/yr was determined. For the Gulf of Mexico, a relative sea level rise rate of 0.23 cm/yr was computed. This Gulf of Mexico rate is identical to the relative sea level rise rate determined for the Pensacola (VI), Florida NOS tide gauge station. This relationship indicates Pensacola is tectonically stable relative to the Gulf of Mexico basin. The difference of 0.11 cm/yr between the global and Gulf of Mexico relative sea level rise rate is attributed to the effects of a geosyncline downwarping, compaction of Tertiary and Pleistocene deposits, and regional tectonics.

Gulf of Mexico - NOS tide gauge results

Using the Grand Isle (II) and Eugene Island (I) NOS tide gauge stations and the 0.12 cm/yr eustatic and 0.23 cm/yr Gulf of Mexico corrective factors of Gornitz et al. (1982), the contribution of subsidence ranges between 0.80 cm/yr and 1.07 cm/yr in Louisiana (Fig. 5). The Grand Isle (II) and Eugene Island (I) corrected tide gauge data for the Gulf of Mexico indicate a contribution of 0.96 cm/yr and 0.80 cm/yr, respectively (Table 2). The Eugene Island (I) and Grand Isle (II) eustatic-corrected tide gauge data indicate a contribution of 0.91 cm/yr and 1.07 cm/yr respectively. As mentioned before, these tide gauge stations lie on the Mississippi River delta plain in Louisiana (Kolb and Van Lopik, 1958). These are the highest rates of subsidence in the Gulf of Mexico (Fig. 5).

In the eastern Gulf of Mexico, a comparison of the eustatic correction factors indicates that the coasts of Mississippi, Alabama, and Florida are not subject to subsidence as formed in Louisiana. The relative sea level rise rates range between 0.15 cm/yr and 0.23 cm/yr. These rates are equivalent to the 0.12 cm/yr global eustatic and 0.23 cm/yr Gulf of Mexico eustatic correction factors of Gornitz et al. (1982), indicating that compactional subsidence is not a major coastal process affecting the eastern Gulf of Mexico. Eustatic processes are driving relative sea level rise in Mississippi, Alabama, and Florida.

In Texas, the relative sea level rise rates from Port Isabel (III) and Galveston (IV) exceed the eustatic sea level rise rates, which indicate that this coast is experiencing the effects of subsidence. The rate of

TABLE 2

SUBSIDENCE RATES
IN THE
NORTHERN GULF OF MEXICO:
NATIONAL OCEAN SURVEY
EUSTATIC-CORRECTED TIDE GAUGE RESULTS

STATION NUMBER	STATION NAME	STATION LOCATION	EUSTATIC-CORRECTED: GULF OF MEXICO (0.23)	EUSTATIC-CORRECTED: GLOBAL (0.12)
I	Eugene Island	Louisiana	0.96	1.07
II	Grand Isle	Louisiana	0.80	0.91
III	Galveston	Texas	0.39	0.50
IV	Port Isabel	Texas	0.10	0.21
V	Biloxi	Mississippi	-0.08	0.03
VI	Pensacola	Florida	0.00	0.11
VII	Cedar Key	Florida	-0.06	0.05
VIII	St. Petersburg	Florida	-0.07	0.04
IX	Key West	Florida	-0.01	0.10

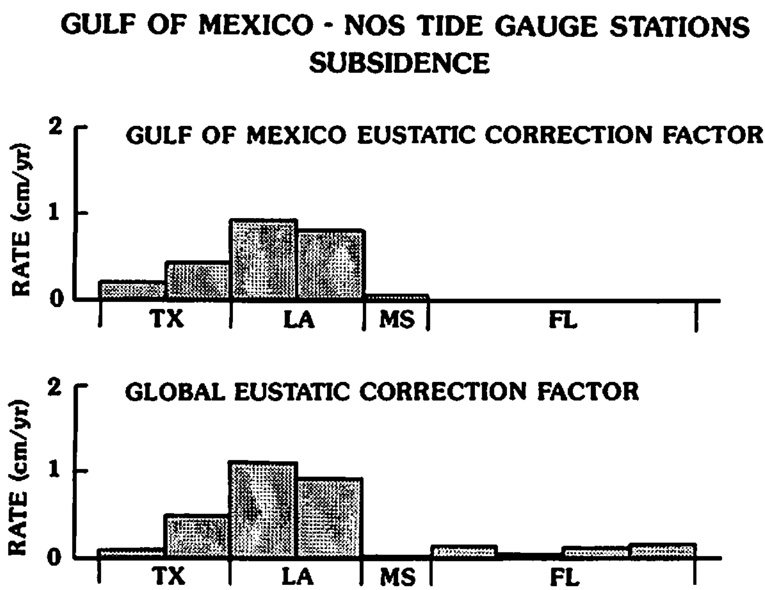

Figure 5. Subsidence histogram for the Gulf of Mexico based on NOS tide gauge results.

relative sea level rise is 0.33 cm/yr at Port Isabel (III) and 0.62 cm/yr at Galveston (IV). Using the Gornitz et al. (1982) eustatic-correction factors the contribution of subsidence ranges between 0.1 cm/yr and 0.5 cm/yr. In contrast with Louisiana, subsidence is not the major driving process of relative sea level rise, although it is an important component.

Conclusions

1. Analysis of National Ocean Survey tide gauge records from 9 stations along the U.S. Gulf Coast indicates that Louisiana is experiencing the highest rates of relative sea level rise in the Gulf of Mexico. Maximum relative sea level rise rates ranged between 1.03 cm/yr and 1.19 cm/yr. Texas ranked second with rates ranging between 0.33 cm/yr and 0.62 cm/yr followed by Florida with rates between 0.16 cm/yr and 0.22 cm/yr and then Mississippi-Alabama with a rate of 0.15 cm/yr. The NOS tide gauge stations detected an acceleration in relative sea level rise throughout the Gulf of Mexico, with the highest increase of 1.62 cm/yr found in Grand Isle, Louisiana. The amount of sea level rise acceleration appears to be proportional to the rate of relative sea level rise for the entire period. Acceleration amounts range between 0.18 cm/yr and 1.62 cm/yr for two lunar epochs.

2. Subsidence rates determined from the NOS tide gauge records using the eustatic-correction factors for the Gulf of Mexico and the globe indicated Louisiana is experiencing the highest subsidence rates along the U.S. Gulf Coast. The maximum subsidence rates in Louisiana ranged between 0.80 cm/yr and 1.07 cm/yr. Texas ranked second with subsidence between 0.10 cm/yr and 0.50 cm/yr. Subsidence rates in Mississippi, Alabama, and Florida suggest that these coastal zones are stable with respect to the Gulf of Mexico eustatic-correction factor. However, using the global eustatic-correction factor the subsidence rates range from 0.03 cm/yr to 0.11 cm/yr.

3. The maximum rates of subsidence apply only for the Mississippi River delta plain in Louisiana and indicate that contribution of subsidence to relative sea level rise ranges between 81 percent and 90 percent. In Texas the contribution for compactional subsidence is 30-81 percent and in Mississippi, Alabama, and Florida it is 0-48 percent, depending on the eustatic correction factor used.

4. The regional pattern of relative sea level rise and subsidence observed for Louisiana and the other U.S. Gulf Coast states is controlled by the thickness of the underlying Holocene sediment at each tide gauge station location. The highest rates of relative sea level rise and subsidence are associated with the Mississippi River delta plain where the Holocene section reaches a maximum thickness of about 200 m (Kolb and Van Lopik, 1958). East and west of the delta plain, the thickness of the Holocene section decreases to thicknesses of less than 20 m and in some cases pinches out completely, as in Florida. The rates of relative sea level rise and subsidence decrease concurrently east and west of Louisiana.

5. The rates of relative sea level rise are accelerating in Louisiana and the other U.S. Gulf Coast states. This acceleration is

proportional to the rate of relative sea level rise observed for the entire period of record at each station. These acceleration rates forecast that coastal Louisiana will experience a 1.5-2 m rise in sea level over the next century. These acceleration rates are consistent with the forecasts of the National Academy of Sciences and the U.S. Environmental Protection Agency of accelerated relative sea level rise due to the greenhouse effect (Hoffman et al., 1983).

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LAND LOSS IN LOUISIANA: IS RETREAT THE ANSWER?

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Statement of Problem

Louisiana is losing vast acreages of coastal habitat. At the current rate of loss, 55 square miles per year, an area the size of Rhode Island will be lost in 22 years (Breaux, 1986). Several parishes (counties) are slated to be eliminated in less than 100 years, Plaquemines in 47 years and Terrebonne in 98 years (Wicker, 1980). If the nation were to lose these lands to a foreign nation, an act of war would be declared. Yet, the Gulf of Mexico has engaged in a successful campaign which many believe goes unnoticed by most (Landry, 1985).

Louisiana's problems began with the taming of the Mississippi River at the turn of the century, and the take-off of the mineral extraction industries in the 30's. Controlled by guide levees, the Mississippi River now carries its life sustaining fresh water and sediment to the depths of the Gulf and the delicate balance between land and sea has been critically disrupted. Slowly, the interdistributary basins submerge below the surface of the sea, unable to be replenished with sediment. On another front, the salty waters of the Gulf intrude northward into aquatic habitat, along drilling slip access canals and pipeline corridors, stripping the area of vegetative cover before seccessions of species can take place (Davis, 1984). These remaining mud flats literally are washed away in months. Spoil banks thrown up along access canals impond water within the marsh causing many areas to drown, leaving vast areas of open water in a once unbroken marsh (Lafourche-Terrebonne Soil and Water Conservation District, 1986).

Accelerated by an estimated Gulf global sea level rise of .09 inches per year and a subsidence rate of .36 inches per year, Louisiana is losing its most valuable land (Penland, In Press). Every 49 minutes another hectare becomes open water (Davis, In Press). For the first time in recent history, the region is experiencing net degredation rather than net progradation. The land lost is not site specific but includes the entire coastal zone, which in certain areas, extends over 60 miles inland. The barrier islands are retreating an average of 50 feet per year and diminishing in size by .20 mi^2 per year (Penland, 1985). Coastal highways are falling into the Gulf of Mexico, once productive agricultural land and villages have sunk below the surface of the sea and, the regions first line of defense against hurricanes is threatened. Further, community drinking water surface intakes, situated 50 miles inland, have been contaminated by salt in concentrations in excess of 14,000 ppm (Edmonson, 1985).

Over the last 15 years years, these problems have been well documented by the academic community. More recently, state and local government and private industry have begun to engineer and construct wetland protection and restoration projects. However, the financial means to truly protect these vast acreages of valuable wetlands are beyond the capabilities of state and local government. Further, decades of oil and gas subsidies, which negated the tax payers burden to operate and maintain civic services and infrastructure, has resulted in an apathetic public attitude about civic responsibilities. These responsibilities concern the delivery of flood protection measures and community services, erosion and pollution control, and the intregal role each citizen plays in the envirornmental future of a coastal community. Presently, a large gap exists between the progress made by the research and engineering fields and the understanding, support, and funding of protection, conservation and enhancement measures by local, state and federal government. Ultimately, the protection of coastal resources and the communities whose economic base exists because of these resources is a civic responsibility.

With such an acute problem, government officials and coastal scientists are often asked several questions. Are these resources worth protecting? Why should the public pay for the protection of these resources? And, why do coastal Louisianians not just retreat from the coast? The remainder of this paper will address these questions.

<u>Retreat From the Coast</u>

Retreat? Yes indeed, we are retreating. Coastal Louisianians are undoubtedly the most experienced when faced with retreat from the advances of the sea. Since the early 1800's, residents of coastal Louisiana have been forced to vacate areas, such as Fort Beauregard, Last Island and Sea Breeze. Being fishing, farming and trapping folk historically, this retreat is often subtle as the inhabitants of the coastal zone cling to their lifestyles and economic base.

Today, as has been practiced historically in Louisiana, retreat takes the form of both vertical and horizontal movement. Horizontal retreat is the relocation of non-water dependent services to higher ground away from the encroaching Gulf waters or into flood protected fastlands. Vertical retreat is the elevation of structures and flood proofing of same. Retreat in coastal Louisiana is not a sudden occurrence, however. Both vertical and horizontal retreat occur most often and in the greatest frequency subsequent to a major storm event. For instance, the number of building permits issued which addressed the elevation of structures in January of 1985 (Pre-Hurricane Juan) was 67. The number issued in January of 1986 (post Hurricane Juan) was 367 (Foreman, 1986). It is at these times that the increase in vulnerability caused by the slowly eroding land base becomes most evident and drastic. For several months following these major storm event periods, it has been observed that many residents will relocate further north or towards higher ground by building new homes. Also, the number of existing or newly constructed structures elevated increases. In virtually all cases however, the retreat is minimal and generally contained within the coastal zone.

There are two primary reasons why a major retreat out of the coastal zone will not take place in South Louisiana. First is the location of the primary resource extraction industries within the coastal zone. The second reason is the nature of the existing infrastructure. The delta plain of the Mississippi River is rich in both renewable and nonrenewable resources. The extraction of these resources is a primary industry. The significant resources extracted within the coastal zone include fur and fish as renewable resources and oil and gas as nonrenewable resources. The fur and fish industries are wetland dependent and are also family oriented operations. The oil and gas extraction industries are very site specific and material source dependent.

Because the fishing industry is composed of thousands of independent family owned operations, as a means to reduce costs, the families live on the lower reaches of the natural levee ridges. They park their trawlers in front of their home on the bayous so that access to the marsh and gulf waters is easy and cost effective. In addition, the opportunities to "add-on" costs to pay for increase travel time, commuter services or infrastructure requirements is not presently as feasible, as in other areas of the country. This is because little value is added to the product locally whether it be in the fish and fur industry or the mineral extraction industry. For example, within the fishing industry, 60% of the shrimp catch is not processed at all. Of this amount, 89% is shipped out of state for processing (Weschler, 1986). Although not as drastic, this can also be seen within the mineral extraction industry. Resources are extracted within the wetlands and the outer continental shelf and moved via pipeline to the petro-chemical industries located to the north along the Mississippi River industrial corridor. Therefore, due to the primary nature of these extractive industries and the fact that little value is added on site, laborers of these industries and support services are located as close to the resource to be extracted as possible as a means of cost reduction.

The nature of the existing infrastructure also causes a problem with retreat. Even though Louisianians have been historically accustomed to retreat, they have in fact become more permanently fixed within the coastal zone. Beginning in the 40's and 50's, which some believe began with the influx of petroleum workers from Texas and Oklahoma, there has been a proliferation in the construction of ranch homes on concrete slabs. Prior to this period, the majority of construction was elevated on piers. Once a home is built on a slab, the structure becomes permanently fixed to the landscape and it is not feasible to raise the structure as a means to reduce flood damange. With entire subdivisions of homes built on slabs, it has become necessary to construct forced drainage systems, including protection levees, drainage canals and pump stations.

Residential development is not the only construction that has become fixed within the coastal zone. The extraction industries, by construction of ice houses, packing plants, pipe yard service supply companies, machine shops, fabrication yards and transportation support services have been located and established well within the coastal zone.

Retreat will be difficult for Louisianians. Although retreat is environmentally induced the call for retreat comes at the same time as the national importance of the resource base has increased.

Value of Resources

Are these resources worth protecting? Yes, these wetlands need to be protected because of their value, not only as an economic resource base, but also for the habitat and recreational values that they provide. In 1984, the value of Louisiana's reported seafood landings were as follows: Shrimp, $141,740,000.00; other species, which include crab, oysters, drum, trout, snapper, red fish, croaker, macherel, mullet, pompano and catfish was $38,945,000.00; and Menhaden was $196,623,000.00 (Weschler, 1986). Louisiana's fur industry annually yields between $2 and $24 million. The recreation industry annually is valued at $175 to $200 million and the oil and gas industry annually is valued at approximately $500 million (Davis, 1984). The total of these values is $1,069,308,000.00. It is obvious that oil and gas is a resource of national concern. The author contends that the fish and fur industries are of national concern also unless we continue to increase the import of these resources from foreign nations.

Cost of Protection

What will it cost to protect these resources? To manage the marsh, maintain the barrier islands and protect the inhabitants within the coastal zone that are responsible for extracting resources of national concern will cost $873 million. This is based on the following estimated costs for Terrebonne Parish, which is the largest parish by land area within Louisiana. Marsh management, $10 million; limited hurricane protection, $165 million; drainage, $44 million; and barrier islands, $50 million. This totals $291 million. Terrebonne's coastline is approximately one-third of the total coast of the Mississippi and Atchafalaya delta complexes. The extrapolation of Terrebonne's cost results in the aforementioned total for the deltas. As you can see, the cost of protection, although expensive, will rapidly be returned in the value of the resources of which will be protected. A great deal of thought and money has been spent locally which has led to these management decisions to stay within the coastal zone and protect its resources. Although the ultimate destruction of the delta plain may be envitable, it is felt that any delay which can result through proper management of these resources will be well worth the return economically.

As an example of efforts made by local government concerning this matter, one parish, Terrebonne, has conducted the following studies: Sand Resource Inventory, Marsh Value Study, Oyster Contamination Study, Subsidence Study, Soil Survey, Sea Level Rise Study, Habitat Characterization Study, Barrier Island Reconstruction Study, Use of Dredge Materials and a Drainage Study. In addition, the parish has developed an extensive education program, which utilizes billboards, hand-outs and phamplets, and the development of an eighth grade school curriculum concerning the parishes resource base and its erosion problems. The parish has also engaged and expended millions of dollars on marsh management facilities, drainage facilities and barrier island reconstruction projects.

Conclusion
South Louisianians are here to stay and the nation continues to be dependent on her resources. Therefore, I challenge government, educational institutions and citizens with the following recommendations:

Areawide wetland mangement
Coastal Zone Management in Louisiana is a permit processing program which is primarily site impact specific. Although the program is based on environmental management units within parish boundaries, these small units bound within these policial boundaries fail to address areawide wetland basin management. If Louisiana is to ever control land loss and implement enhancement measures, an areawide approach to the wetlands must be established. Drainage basins would be the most appropriate division of areawide wetland management.

Revised land use controls and enforcement
Many problems associated with flooding and flood control are caused directly by inadequate land use controls and/or the enforcement of same. Land use control measures must be revised to prohibit slab foundations, set first floor elevations, and flood proofing. In addition, regulations must address the appropriate delivery of utility services within the coastal zone.

Control oil and gas industry exploration techniques
Louisiana's wetlands can no longer withstand the uncontrolled dredging of access canals throughout the marsh. Even though state and local governments have been successful in reducing the length of new access canals, pressure must be brought to bear on the exploration companies. New drilling techniques such as multiple directional drilling from one access point must be strictly enforced.

Develop national resource extraction impact program
Since the nation is dependent on Louisiana's oil and gas resource and, the extraction of these resources has caused irreplacable damage to the wetlands, the federal government should establish a resource extraction reclamation program for oil and gas. Reclamation programs presently exist for coal, sulfur, copper and iron ore. It is time that reclamation of oil and gas extraction in wetlands also be addressed.

Expand fisheries resources
Louisiana has been luled to sleep with the "get rich quick" mentality of oil and gas. This is a non-renewable resource tightly controlled by outside influences. Louisiana must wake-up and explore avenues to expand its valuable renewable fisheries resource. Once the oil and gas is gone, if we haven't destroyed all the wetlands in the process, fisheries, if well managed, will always be here.

Values added and underutilized species
To increase the economic value of the fisheries industries, Louisiana must increase processing of these products within the state. Additionally, the states fishermen must learn how to catch, process and market many species of fish that for years have been considered trash.

Develop limited hurricane protection system
Even with the billions of dollars of resources extracted from coastal

Louisiana, society cannot afford to 100% protect these areas from hurricane impacts. We must instead design protection systems for regular storm events, elevate structures, flood proof, and evacuate for major storm events.

Introduce civics and coastal education programs
The general apathy of the public on government operations and the problems associated with living on a coast is caused primarily by the lack of education in these matters. Civics and coastal education programs must be reintroduced into the classrooms.

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RESOLVING CONFLICTS/ASSESSING RISKS

Sharron Stewart, Chair

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NOME, ALASKA PORT FACILITY DESIGN: COASTAL MANAGEMENT ISSUES

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Nome, A Remote Trade Center

Nome is located 500 air miles northwest of Alaska's major city, Anchorage. Because no roads connect Nome with the main road systems in the state, Nome is dependent on marine and air transportation. The population of Nome, approximately 3500, is small by lower 48 standards; however, it is a trade center for 15 villages with 5000 people in the Norton Sound-Bering Strait region within a 150-mile radius.

Existing Port and Lightering Costly

The existing port facility is located at the mouth of the Snake River. Built and maintained by the Corps of Engineers, the harbor consists of a 75-foot wide channel with revetment along 600 feet of each side. The channel requires annual dredging by the Corps to maintain an operating depth of approximately eight feet.

An improved facility has been needed for some time. The operating depth of eight feet in the existing port and shallow water in the near off-shore allows the docking of vessels with a draft of no greater than six feet. Nearly all line haul barges come from Seattle, across the Pacific, through the Aleutians, and across the Bering Sea, some 2400 miles to Nome. Their loaded draft normally exceeds 16 feet and is a maximum of 22 feet for dry cargo and 25 feet for liquid bulk cargo. Currently these barges from Seattle anchor about one-half mile offshore and transfer goods to shallow-draft barges that can navigate inside the mouth of the Snake River, a process which is called lightering. Twenty-five percent of the cost of shipping from the dock in Seattle to the dock in Nome is in lightering the last one-half mile. The cost of lightering is estimated at $69 per ton in 1982 dollars. The basic design solution to this problem is to build a rubblemound causeway extending to a point sufficiently offshore so lightering would be eliminated.

New Port: 3500 Foot Causeway

The ultimate port/causeway would extend 3500 feet from shore and have a short-term cargo storage in an "L" at the end of the causeway. Landward of the "L" are two piers to accommodate general traffic and potentially vessels associated with oil and gas development in the Outer Continental Shelf of Norton Sound. Extensions could be made to greater depths beyond the 3500 feet. The maximum draft of a fully loaded fuel barge is 25 feet. A minimum underkeel clearance of two feet is added to a three-foot allowance for tidal set down and waves at the dock face. A 30-foot depth for the deepest berth is provided for in the design.

Nearly completed in 1986 is a rubblemound causeway extending 2500 feet without an "L". Most barges can tie up to this facility. Fuel barges requiring the 30-foot depth can anchor south of the end of the causeway and pump fuel to the dock using a line stabilized with a bouy. When more funding is available the causeway can be extended.

The process of designing the Nome port facility illustrates several coastal management problems and effective solutions. Once this basic design concept was arrived at, engineering analyses were carried out to determine the structure that would withstand wave and ice forces. Height of the causeway and size of outer protective rock were the critical variables to be determined by the analyses.

Armor Rock Size[1]

The armor rock weight is determined by taking the average weight needed for the causeway structure head for non-breaking waves and the structure trunk for breaking waves. A uniform weight of 20 tons was used for preliminary design. Assuming the quarry rock has a specific weight of 165 pounds per cubic foot, cubic blocks would have 6.2 foot long sides. The east side of the structure will be well protected with respect to critical waves but may be subject to attack by moving ice fields. According to the physical model analysis, described in the section below on Ice Impacts, blocks of about 8 tons would not be substantially dislodged by ice overtopping. These blocks would be heavier than armor estimated for wave attack.

The armor rock weight needed to protect against wave forces is calculated by a formula which includes slope of the causeway armor, at 1/1.5, breaker height at 17.8 feet, and equivalent deep water wave length of 400 feet.

Waves at the causeway head and port structure would not be breaking, if it is assumed that the same wind that produced them will be conducive to a 13-ft. surge. It was assumed that the corners at the head structure would be rounded to avoid rock stability problems. Waves would break at a depth of 21 feet, which would correspond to a chart datum depth of 8 feet.

Structure Crest Elevation[2]

At structure head, run-up was estimated at 14.2 feet, which, added to a still water level of 13 feet, resulted in an estimated significant wave run-up elevation of 27.2 feet. The structure crest elevation was established at 28 feet mean sea level (MSL), to account for high astronomic tide. Since significant wave height is the mean of the highest one-third waves in the spectrum, it is expected that the maximum waves would produce overtopping. This was considered acceptable because of the low probability of occurrence of the design waves.

Run-up estimates made for portions of the causeway trunk showed that the crest elevation should be about 28 feet MSL up to the location of the breach. The roadway behind the crest of the west side armor may be located at elevation 16 feet MSL. The crest of the east side armor could also be located at elevation 16 feet MSL, to protect the roadway from ice overtopping. Wave run-up from the east side will be less critical to the stability of the structure.

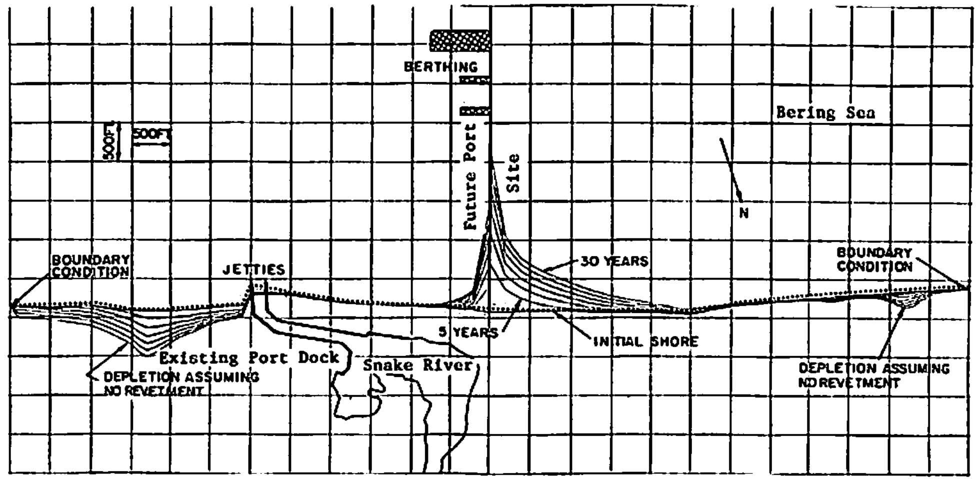
Littoral Drift: Accretion and Depletion[3]

Littoral drift is projected to cause accretion of sand on the west side of the causeway and depletion of shore sand on the east. The shoreline is projected to reach 500 to 600 feet from present shoreline in about five years. Depletion that is projected to occur on the east side of the causeway will tend to clean the present deposition at the mouth of the Snake River and might tend to starve the present beach to the west of the mouth of the Snake River. If this occurs, a 2000-foot long revetment may be required to protect the beach. Projected beach evolution is illustrated in Figure 1.

The probable maintenance dredging at the causeway breach is estimated from the five-year computed flux at about 8000 cubic yards per year. The resolution of the problem in the Corps of Engineers permit is to require monitoring annually of the accretion and depletion. The City, as owner, is required to restore the beach, probably by pumping sand from the accreted side to the depleted side.

A mathematical model was used to project the effects of littoral drift which incorporated the following data: sand flux conservation, beach sand storage, wave longshore energy at the beach, deep-water and breaker angles of the wave crests with the shoreline and deep-water wave height and period.

Littoral drift prevails at the site from the west. The jetties protecting the mouth of the Snake River have produced a marked accretion on the west side and depletion of the east side. A revetment along the east side has been built to arrest the erosion process which was threatening beach front properties. The beach configuration as of 1982 may be considered in equilibrium, after 63 years since the construction of the east jetty in 1920. The west jetty was built in 1923. In 1940 the jetties were rebuilt with steel and concrete.



TAMS

Figure 1

BEACH EVOLUTION AFTER CAUSEWAY CONSTRUCTION, BEACH DEPTH 20 FT.

Weather and Wave Analysis[4]

Certain critical historical weather and wave data was collected so that it could be incorporated in the analytic models used to project the effects of littoral drift and the size of armor rock needed.

The critical wave event was defined assuming a combination fetch and wind duration and speed which would probably be similar to that producing the estimated 100-year surge. The return period for the waves used for armor protection design was estimated at 100 years. Since the resulting still water level would be around 13 feet, the still water depth at the structure head would be 43 feet. The wind speed for the 100-year surge was established at 47 knots. A 50-knot speed sustained for 12 hours was assumed for wave forecast. Application of the shallow water wave forecast formulas resulted in a significant wave height of 16.7 feet and period of 8.9 seconds. The wave height is reduced to 16.5 feet due to shoaling and refraction. Due to the lack of available wave statistics at Nome, hindcast analyses were made to obtain synthetic wave records.

Storm surges are due to shallow depths in the Bering Sea. The November 1974 storm surge produced considerable flooding in Nome, with some parts of the City under 10 feet of water. Surges of 12 feet have also occurred in the past. A surge height of 13 feet, corresponding to a return period of 100 years, was used in the analysis.

Nome is exposed to rather limited fetches for wave generation. In addition, depths in Norton Sound are on the order of 60 feet or less, while depths south of Nome reach an average of about 95 feet from chart datum. Except for a window between St. Lawrence Island and the Delta of the Yukon River, fetches are limited by opposite shores at about 100 to 150 nautical miles (NM). The window is further limited by the presence of shoals and islets which, together with the effects of refraction and diffraction would effectively curtail waves coming from further south. Consequently, fetches of 100 NM toward the SE and 150 NM toward the S and SW were assumed for wave estimates.

Maximum recorded winds at Nome airport have reached speeds of more than 56 knots for very short durations. During the ice-free season the maximum recorded on-shore winds have reached speeds of 48-55 knots only occasionally. The maximum average 12-hour speed from the south, recorded on November 11, 1974, at the Pribilof Islands, was 46 knots and the maximum 3-hour speed was recorded at 52 knots. The same storm produced at Nome a maximum average 12-hour speed of 35 knots with a maximum of 36 knots for 3 hours.

Offshore winds may produce setdowns, which reduce depths available for operation. Using wind frequencies at Nome it was determined that a setdown of 2 feet will have a frequency of about 2 in 3 years.

Ice Impacts[5]

The Bering Sea in the vicinity of the port site has shore-fast ice normally from January through April. Moving ice sheets and ice ridges have the potential of dislodging armor rock and pushing up the sides and overriding the facility. Ice sheet thickness of about 1.0 foot is typical in early winter. A maximum ice sheet thickness of approximately 4.5 feet is predicted from computed freezing degree-day estimates of ice growth. Maximum ice sheet thicknesses of 2.5 feet to 3.0 feet are commonly reported in Norton Sound and the Bering Sea. Ice sheet velocities from zero to 2.5 feet per second with an average value of 0.70 fps are used in this analysis. The principal force propelling an extensive sheet of ice is wind drag. For a design wind speed of 60 to 70 mph, relationships for wind drag indicate that forces of the order of 20 kip/foot to 50 kip/foot can be generated through a 120-mile long fetch of ice.

One of the major conclusions of the ice analysis is that armor rock designed for stability against wave attack remains stable under ice override in the Nome environment. Ice override will probably be an infrequent occurrence. A clean unobstructed surface on the exterior of the facility will prevent damage from ice override and facilitate ice removal. Ice sheets 2.0 feet and thicker may ride-up the side-slopes of the causeway and overtop the causeway crest for both the 20 foot and the 30 foot crest elevations. Ice accumulations up to 30 feet high were observed to occur in the tests, and comparable ones are possible on the prototype causeway. The 8-ton, randomly placed, rounded armor boulders protecting the causeway side-slopes remain stable during ice ride-up on the causeway.

A causeway over-ride is marked by the layering of an initial cover of ice over the armor boulders as the advancing ice sheet first rides-up the side-slope. This layer of ice then acts to protect the underlying armor boulders as subsequent ice movement occurs over it. After the first few ride-ups of an ice sheet on the causeway, the ice sheet fails at different times at various locations along the causeway. A design ice load on the causeway side-slopes is sufficient to sustain the ductile crushing failure of a 4.5 foot thick ice sheet.

The model tests indicate that the most effective ice-defense strategy consists of a segmented barrier composed of closely spaced elements placed offshore of the portion of the port facility to be protected. Sufficient storage area must be available behind the ice barrier to allow ice rubble to accumulate.

Mathematical analysis was supplemented with analysis using a physical ice model. The modeled causeway section had a slope of 1:1.5 and was covered by scale-equivalent 8-ton boulders. The side-slope model was formed of five independent frames which were supported on hinges at their base. A load cell, placed behind each frame, was used to measure the horizontal force exerted by the ice on the side-slope frame. The model ice sheet was propelled by a pushblade, which was attached to a motorized carriage which can traverse the length of the ice tank. Load cells mounted behind the pushblade registered the load applied to the ice sheet.

Conflict Resolution: Interagency Coordination

The permitting process stretching over three years required extensive interagency coordination and resolution of conflict. The littoral drift issue was significant and is discussed above. The second major issue is that migrating salmon near shore would be forced into deeper, colder water by the 3000-foot causeway. Alaska State Department of Fish and Game viewed a fish passage near to shore as the solution. Maintaining salmon is important because subsistence fishing is a major element of millenia-old Eskimo Inupiaq culture. Salmon fry need shallow water for food, relatively warmer temperature and protection from predators.

The fish passage is located approximately 500 feet offshore in eight feet of water, the most acceptable depth to meet Alaska Department of Fish and Game requirements and also minimize maintenance dredging from littoral drift accumulation. The breach has a bridge that is 98 feet long at elevation + 16 feet. The slope of the rubblemound beneath the bridge results in a 50-foot opening at water level and 25-foot on the sea floor.

These issues were resolved through the interagency review of the application to the U. S. Army Corps of Engineers under Section 10 of the Rivers and Harbors Act of 1899.

Port Design Engineering Consultant

The City of Nome contracted TAMS Engineers (Tippetts-Abbett-McCarthy-Stratton) to produce the design that ultimately was used in the contract bid package. Ice modeling was done by Iowa Institute of Hydraulic Research at the University of Iowa. Preliminary design work was previously done for the City by Tetra Tech.

Footnotes

[1] Port of Nome, Alaska: Design Memorandum, TAMS 1982, Appendix A, pp. 24-25.

[2] Ibid. pp. 25-26.

[3] Ibid. pp. 11-20.

[4] Ibid. pp. 1-10.

[5] Port of Nome, Alaska: Design Memorandum, TAMS 1982, Appendix B, pp. 1-43.

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DEEP-OCEAN DUMPING: SHOULD WE USE THE OPEN OCEAN TO EASE PRESSURE ON THE COASTAL ZONE?

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Introduction

As inhabitants of the earth, we have four types of environment accessible to us: terrestrial, marine, atmospheric and celestial. When we are faced with the problem of what to do with the waste products of civilization, it becomes apparent that our choices are limited. Either we cut down on the manufacture of wastes, by restraint or recycling, or we dispose of them in one of those four environments. Outer space is accessible to us, but for the moment it is far too expensive to dispose of waste products there. That reduces our choice to land, air or water.

For the purpose of disposal, wastes can be grouped into five types: (1) ordinary solid wastes--what you find in garbage cans and landfills, such as household refuse and construction debris; (2) industrial and chemical wastes, such as pesticides, PCBs or paper mill refuse; (3) dredge spoils--solid materials removed from the bottom of water bodies, usually for the purpose of improving navigation; (4) sewage sludge--solid material left from the treatment of human or animal wastes; and (5) radioactive wastes--either "high-level" or "low-level"--such as what is left from the processing of irradiated fuel elements or nuclear reactor operations. What we call "hazardous wastes" may be found in any of these categories, although they are most often chemical or nuclear. This paper will use radioactive wastes ("radwastes") to illustrate the issues involved in ocean waste disposal.

Ocean Dumping

The term "dumping" applies to three methods of disposal: (1) actual physical dumping into the water column, such as what is done with dredge spoils or sewage sludge; (2) emplacement of waste containers in or on the seabed, such as what is proposed to be done with radwastes; and (3) incineration of wastes at sea, such as what has been done with certain hazardous chemicals.

In the United States today about 10 percent of all waste products find their way into the ocean. The types of materials thus disposed of range from dredge spoils, which represent about 80 percent of what we dump in the ocean, to radioactive wastes, of which there is currently no disposal in United States waters.

Between 1946 and 1970 some 90,000 drums of low-level radwastes were dumped into the ocean by U.S. vessels, not far from U.S. coasts. The entire quantity dumped in those 25 years is today exceeded every year by European nations that dump radwastes at a single site 550 miles off England. The U.S. virtually abandoned its dumping program in the early 1960s, and nothing whatever has been dumped since 1970. This cessation was more due to economic than safety reasons.

Ocean dumping was not regulated until 1972 when Congress passed the Marine Protection, Research and Sanctuaries Act (33 U.S.C. §§1401-1444) popularly called the Ocean Dumping Act. The Act prohibits marine disposal of "high-level" radwastes, but gives to the Environmental Protection Agency power to regulate the dumping of "low-level" radwastes. The Act was passed to implement the 1972 Ocean Dumping Convention, concluded in London in 1972 and to which the U.S. is a party. (2 U.S.T. 2403, T.I.A.S. No. 8165 [done Dec. 29, 1972; entered into force Aug. 30, 1975]). Both the Act and Article IV(1)(a) of the Convention prohibit dumping of "dangerous" wastes <u>into</u> the ocean and provide for licenses to dump other wastes. Neither, however, prohibits emplacement of wastes <u>beneath</u> the seabed.

The historical trend has been to dispose of wastes in ever more remote areas. In the future, as near-coastal areas are increasingly stressed by population growth and resulting decline in water quality, and as land disposal sites become less available and more expensive, pressure to dispose of wastes in the deep ocean will increase.

<u>Policy Analysis vs. Ethical Analysis</u>

If the foregoing is so, it becomes essential to examine more closely the policy and ethical issues involved. A vast body of literature deals with scientific or policy analysis of the issues of deep-ocean dumping. Virtually none exists that deals with <u>ethical</u> analysis. What is the difference? Policy analysis is different from, and ostensibly does not include, ethical analysis. Policy analysis is concerned with what is possible, expedient, politically attainable and cheap. Ethical analysis is concerned only with what is "right." It is rarely used in official determination of public policy--at least in environmental matters. Instead, it is an individualistic pursuit, usually the domain of persons and organizations that seek to express their opinions on the "morality" of government policy. Indeed, an unusual degree of concern with the "rightness" of a policy decision on the part of a policymaker is often viewed as naive. From the nature of their work, most public officials have come to believe that consensus on ethical choices is not possible in a pluralistic society like ours.

Many believe this is the way it should be: The government has no business meddling in people's ethical beliefs or upholding them. Ethical debate is thus discouraged in public meetings, probably because of the widespread but mistaken belief that ethical concerns are inextricably wound up with religion--a taboo in public discussion. Thus, when formal ethical analysis occurs at all in environmental issues, it is done by academics who publish articles in philosophy journals, by members of Greenpeace or similar conservation organizations at their informal meetings, or by scientists who debate ethical choices in the privacy of faculty lounges.

To put it simply, policy analysis is what goes on when decisionmakers meet. Ethical analysis is what goes on when those same decisionmakers lie awake at night in the privacy of their homes.

Policy Analysis of Ocean Dumping

It is now widely recognized that the ocean is not a single environment, but rather an interrelated web of biogeographical and physical units, such as estuaries, upwelling zones and midocean gyres, that are vulnerable to human abuse in widely varying degrees. Of all the earth's environments, the open ocean away from the productive continental shelves may be the least vulnerable to the influence of human activity, while coastal and estuarine areas are among the most vulnerable. For this reason, if for no other, resource managers will face increasing pressure to direct waste products and deflect environmental stress away from the coastline to the open ocean.

This will occur for two primary reasons: (1) land-based disposal options will become less available and more expensive; and (2) ocean preservationists like Greenpeace or the Oceanic Society or the Cousteau Society, while articulate and determined, are numerically weaker than advocates of any other type of environment on earth. No one lives in the open ocean, and hence it has no voting constituency.

In recent years some scientists and policy analysts have suggested that we are being overly protective of the ocean at the expense of our groundwaters and our coastal zone. (See, e.g., Charles Osterberg, "Rubbish on the High Seas," Newsweek, Oct. 7, 1985 at 18.) Some believe that the protectionist approach of the 1970s is about to backfire on us, by degrading our coastal resources and our groundwaters as a result. Opinions are strongly divided on the use of the deep ocean as waste space, and the division occurs along several lines of bifurcation.

Dispersion vs. concentration

Some favor concentration and isolation in the treatment of wastes, and others favor its opposite, dispersion or dilution to the point of insignificance. The appropriateness of each view will vary according to the type of waste product under discussion. There is widespread agreement, for example, that in the case of sewage sludge, dispersal is better than concentration. Manure is valuable when spread equably over the countryside, but noxious when gathered in a heap; and some oceanographers believe the same argument applies to the ocean. It is also widely agreed that the opposite is true in the case of radwastes.

Close-monitoring vs."final" disposal

Some advocate disposal of waste products by putting them in the remotest possible place, and others prefer to keep them nearby where we can watch them. Advocates of keeping a close watch on radwastes, for example, tend to favor land emplacement. We don't know enough about the deep marine environment to place any hazardous material there irrevocably, they say. Once we begin to dispose of radwastes thus, the process may not be easily reversible.

Advocates of remote disposal, on the other hand, want to see final and perhaps irrevocable disposal in the remotest possible place. Get it away from people and other life forms, they say. Although we may not know enough about the marine environment to say with absolute confidence that radwaste placed in the deep-seabed will not reach the biosphere, still we know enough about it to conclude that it's the best we can do, the furthest we can economically get from human activity. As one advocate puts it, "We know more about the plumbing of the oceans than we do about the plumbing of the land." (Edward Goldberg, "The Oceans as Waste Space: The Argument," Oceanus, Spring 1981 at 9.)

Important assumptions and costs are buried within each of these views. Deep-sea disposal encourages an "out-of-sight, out-of-mind" mode of thinking, and it reduces incentives to restraint and recycling by using what economists call a natural subsidy to internalize the costs of disposal. On the other hand, land-based monitored waste disposal also has hidden assumptions. It may overestimate the stability of governments and civilizations and their ability to sustain the kind of long-term commitment needed for effective monitoring. It externalizes on future generations costs that they may be unwilling to bear.

Advocates of each view need to answer the following questions before ethical and policy analysis of deep-sea dumping can proceed. To the advocates of deep-sea disposal: Are you confident enough in your belief that the deep-seabed is the best place to dispose of radwastes that you would put it where you can't retrieve it if you're wrong? And to the advocates of monitored land disposal: Do you really believe that any government in the world, now or in the future, after investing billions in storage facilities, would willingly abandon that investment if something went wrong, and spend an even greater amount to repair the damage?

Ethical Analysis of Ocean Dumping

Environmental ethics is that branch of philosophy which seeks to discover the scope of human duties toward the natural environment. It is a relatively new branch of inquiry, probably invented as a formal discipline in 1949 with the publication of Aldo Leopold's A Sand County Almanac. It takes as its starting point the following classic statement from Leopold's book: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." (Galaxy Book edn., 1970, at 224-25.) The field now has its own academic journal, in which are published contributions by philosophers, social scientists, lawyers and resource managers. (Environmental Ethics, Dept. of Philosophy, University of Georgia, Athens, GA 30602.)

Anthropocentrism vs. biocentrism

Among environmentalists there is a wide variety of ethical stances. We are all familiar with the division between conservationists who advocate "wise use" of resources and preservationists who would put much of what remains off limits to development. Much debate is also going on about whether environmental values should be "anthropocentric," i.e., human-centered, or "biocentric," life-centered. The biocentric approach to environmental ethics is that advocated by Leopold. It stresses values that preserve and enhance the health of the entire biosphere, even if necessary at the expense of human economic welfare. The anthropocentric approach places the collective desires of the human race above everything else. An anthropocentrist can often be identified by the cry of "Jobs!"; a biocentrist by the cry of "Quality of Life!" This distinction is now the chief source of division among those who seek protection of the environment. Resource managers will run into it more and more and should become familiar with the subtleties of each position if they seek to understand public attitudes about resource conservation.

From either the biocentric or anthropocentric view it is easy to argue for the protection of tropical forests, estuaries, coral reefs and other highly productive portions of the earth's surface. Their value to mankind and to the health of the planet is easily demonstrable. Less obvious are the benefits of protecting relatively unproductive parts of the earth's surface, such as arid deserts or polar icecaps. Yet if the number and content of international treaties and domestic laws now in effect are indicative, a consensus exists that even such unproductive "wastelands" should to some extent be protected for their scientific and esthetic values.

No comparable consensus exists that those parts of the open ocean that are marine "deserts"--remote from human interests, deficient in resources and esthetic value--should similarly be protected from the waste products of civilization. This lack of consensus is well illustrated by the vigorous debate on ocean incineration of hazardous chemicals and on the emplacement of radwastes in the deep-seabed.

On the issue of use of the oceans as waste space biocentrists and anthropocentrists tend to be in agreement. From either point of view, radwastes should be put in the deep-seabed, where they will be remotest from both human activities and life processes. For those who want the deep ocean protected from radwaste disposal, the fracture between opposing points of view runs along other lines.

Who Objects to Deep-Ocean Dumping?

Recently, pressure has been building to reopen the ocean dumping option for radwastes. In 1980 the Navy devised a plan to dispose of aging nuclear submarines at sea. Opposition was fierce, and in 1984 the Navy relented, choosing instead to bury its spent subs on government land. (N.Y. Times, June 5, 1984 at A7.)

The question naturally arises: What is there about the deep ocean that environmental groups arise to protest its use in this way? The mid-plate and mid-gyre ocean basins are the most environmentally stable regions on earth. They are geologically quiet and biologically unproductive. They are as remote as any earth environment can get from tectonic activity, erosional currents and human activity. They are as devoid of life as any place on earth except perhaps the polar icecaps. They are covered with thick layers of inert and absorptive clays that would probably act as an effective natural barrier to isolate hazardous wastes buried in them. Deep ocean basins are insulated from climatic change, and they are the least valuable property on earth. What kind of environmentalist would rather see a spent nuclear sub on land rather than in an ocean basin?

The answer to this question, as we have seen, cannot be found in the biocentric/anthropocentric split among environmentalists. From either point of view, the deep ocean is the best possible waste space on earth. The answer also does not come from the dispersion vs. concentration views of waste disposal, for placing radwaste on land sites or within the deep-seabed both necessitate concentration and isolation rather than dispersion.

Instead, the answer seems to come from three sources. One is the policy argument discussed above; it centers on the debate whether it is better to get rid of dangerous wastes by placing them forever beyond our easy reach, or by keeping them close where we can watch them. The other two objections are ethical arguments, and they have little to do with remoteness or nearness to human activities, food chains and life processes. These arguments would oppose deep-ocean disposal of wastes even if it could be shown that hazards could be effectively contained and no biological communities would be endangered thereby. The arguments fall under two labels: (1) wilderness preservation—the argument that we have a duty to guard against further human encroachment upon natural areas that are now relatively unspoiled by human activity--and (2) "rights" for natural objects--the argument that natural features of the earth have certain "rights" that need to be protected. Those who would raise either of these objections are as yet a distinct minority among environmentalists.

<u>Wilderness argument</u>

The first type of environmentalist who opposes deep-ocean dumping is what is ordinarily called a wilderness advocate. They would extend protection not only to productive areas like the Amazon Basin, but also to unproductive areas like the Antarctic icecap and the deep ocean basins. Wilderness advocates are well-known to resource managers and policymakers, and require no further discussion here.

<u>"Rights" argument</u>

The other type--those who would recognize moral rights in inanimate objects--are still relatively unfamiliar, and may require discussion. Environmentalists in this category presume the existence of an ethical hierarchy that is unfamiliar to most of us and incomprehensible to some. In the West, we are not used to taking seriously the idea that natural objects may have a moral claim on us. We tend to dismiss that notion as a superstition peculiar to Buddhism, Druidism or American Indian religions.

Everyone agrees that human beings have rights, both legal and moral, though the extent of those rights is of course open to discussion. Similarly, nearly everyone agrees that higher animals have some limited rights; the law does not allow pets or useful domestic animals to be cruelly mistreated, for example. Cruelty to higher animals is now seen as an offense to the animal rather than to its owner, and most of us grant domestic animals a place in our hierarchy of moral obligations.

For most people, however, this ethical hierarchy stops when we get below Flipper or Snoopy or Smokey the Bear. The consensus disappears when we consider higher animals, like wolves or sea lions, that may directly compete with our interests, or higher animals, such as monkeys or apes, that are useful as laboratory animals. But a solid minority among us believes that certain rights should be extended to predators, laboratory animals, lower animals and perhaps even plants. And a smaller but growing minority believes that we should recognize certain rights even in inanimate objects such as rocks or landforms, or in the earth itself—especially in esthetically pleasing or prototypical natural features that are now relatively unspoiled by human activity. If not legal rights, then at least moral obligations toward the environment that transcend economic motives. (See, e.g., Roderick Nash, "Do Rocks Have Rights?" The Center Magazine, Nov.-Dec. 1977 at 2.)

Who Favors Deep-Ocean Dumping?

The two positions outlined above are the ethical stances that can be counted on to oppose deep ocean dumping of any kind. Both oppose the enslavement of any part of the natural environment to human convenience or economic interests. In favor of deep-ocean dumping are those who think remote disposal of dangerous wastes is best both for humans and for the biosphere. Strict biocentrists would also favor the remote disposal option, except that those with a biocentric orientation tend also to be wilderness advocates, rights advocates or both.

Conclusion

In 1972 a respected law review published a seminal article by Christopher Stone on environmental law. The article, entitled "Should Trees Have Standing?," was widely circulated and discussed. (45 S. Cal. Law Rev. 450 [reprinted by William Kaufmann, Inc., Los Altos, CA].) ("Standing" is a legal term referring to whether a party will be recognized in court.) In 1976 it was followed by an article by Scott Reed that carried the pun further, entitled "Should Rivers Have Running?" (12 Idaho Law Rev. 153.) To be fully consistent, I should title this paper "Should Oceans Have Sounding?" except that in this preliminary exploration I am not able to answer the question posed by such a title. I shall be content to call it to your attention that there are those who hold the ethical viewpoint that natural features of the planet, such as the deep oceans, should be accorded rights in themselves, and that policymakers and resource managers will more and more have to deal with people who hold this view.

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Abstract only

HAZARDOUS WASTES, TURTLES, AND THE BEACH: THE FUTURE OF PADRE ISLAND NATIONAL SEASHORE

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This paper evaluates the risks to users from two external threats at Padre Island National Seashore, Texas: 1) Barrels washing ashore, some of which contain potentially hazardous wastes, and 2) The possibility of endangered Kemp's ridley sea turtles (Lepidochelys kempi) returning to Padre Island National Seashore to nest. By the mid 1970's barrels washing ashore at Padre Island were increasingly becoming a concern because of the suspect materials they contained. Also portions of Padre Island beaches may be closed during the months of highest visitation to protect Kemp's ridley sea turtles that may be nesting. Distribution of use data were obtained through a visitor survey during June, July, August, and September 1985. These data were used to predict aieas of greatest risk to visitors from contact with hazardous wastes, and to identify the effect of beach closure on visitation to Padre Island National Seashore. Results indicate that the risk to visitors from hazardous wastes is greatest in the upper six miles of the study area. Fishermen are exposed to greater levels of risk in the down-island areas than are beach users. If Kemp's ridley sea turtles return to Padre Island National Seashore to nest and the beach must be closed for this purpose, a higher percentage of fishermen will be displaced than will beach users. By determining the distribution of use in a particular area, managers are better able to quantify the effect of external threats. Risk assessments have traditionally addressed external threats affecting the health of a specific population, such as risks associated with hazardous wastes. Further, it is argued that risk assessments associated with impacts on recreation are also useful to managerial decision making.

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Abstract only

RISK MANAGEMENT OF PUBLIC OPEN-WATER RECREATIONAL BEACHES IN THE UNITED STATES

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In the United States the number one recreational activity is swimming and the second ranked activity is fishing. Combined with the fact that the majority of the population of the U.S.A. resides within 50 miles of the coast, it is estimated conservatively that annually there is a population-at-risk on the public open-water recreational beaches in excess of 250 million people.

These recreational beaches are very heavily impacted by man and there have been numerous coastal structures to maintain present beaches, retard erosion, and to trap additional sediment. However, there are problems associated with these shoreline structures and the geomorphic nearshore processes that have a significant effect on how the risks of these beaches are managed. The risk management of this beach user population has been studied in only the very minimal way; public safety education relating to the beach environment and processes encountered there has received only modest distribution; and the equipment and methodology for carrying out this management has, in the main, received only cursory attention from the city, county, state, and national administrative authorities responsible for the safety and health of the beach patrons.

Because there is a perception that people do not understand the processes endemic to the nearshore environment and that the nearshore contains numerous and constant hidden dangers in the form of rip currents, sand bars, and scour holes there have been numerous law suits brought to the courts when people have injured themselves while in the water, or diving into the water. The problem has become so acute in the United States that coastal communities have had their municipal liability insurance cancelled because of these law suits. In all these law suits, the "standard of care" and the methodology of risk management are called into question, examined in minute detail, and whenever possible found wanting by plantiff's counsel and associated expert witnesses.

RESTORING AND PROTECTING LIVING RESOURCES

Robert Stewart, Chair

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Abstract only

MAPPING THE UNMAPPABLE; USE OF GEOGRAPHIC INFORMATION SYSTEMS IN FISHERIES MANAGEMENT

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There is a growing need to precisely delineate offshore fish and shellfish habitat. Current fishery management practice is dependent upon delineation of key nursery spawning and feeding areas. Plans for offshore oil and gas development also require accurate habitat mapping. A geographic information system is designed to process large volumes of spatial data, presenting results in graphic form for interactive use by resource managers. While a large body of specialized hardware and software exists, use of geographic information systems in marine resource management is limited by the type and volume of data available and a lack of methods for variable selection and analysis. Using spatial data on the distribution of a relatively immobile species, the tilefish (Lopholatilus chamaeleonticeps), and a highly mobile shellfish species, the long fin squid (Loligo paelei), an experimental geographic information system was created. Statistical and cartographic manipulation of the data indicate that mapping of environmental variables that effect fish distribution, as opposed to the distribution of the species themselves, may prove to be more useful in marine resource management.

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THE USE OF MITIGATION IN ENVIRONMENTAL PLANNING FOR PORT DEVELOPMENT

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This study conducted under contract from USFWS consisted of four tasks: 1) Review and evaluate past mitigation projects in the Tampa Bay area; 2) prepare a list of feasibility options; 3) identify and rank potential mitigation sites; and 4) develop management and/or restoration reccommendations.

Auble et al. (1985), in a report on a workshop in which mitigation options to port development in Tampa Bay were suggested, discussed two classes of mitigation options: those designed to avoid, minimize, rectify, or reduce the adverse impacts of development, and those designed to compensate for unavoidable impacts. This document discusses the second class of mitigation options--those involving compensation for impacts where there is loss of habitat. However, implementation of management practices designed to reduce or avoid further impacts on Tampa Bay by port and other types of development are recommended before allowing development requiring compensation. These management practices are also an important part of any program developed to improve water quality and wetlands habitat within Tampa Bay.

Evaluation of Past Mitigation Projects

Ten sites where restoration was to have occurred were evaluated. These included filling of a subtidal area and plantings of black needlerush (*Juncus roemerianus*), mangroves (*Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*), and smooth cordgrass (*Spartina alterniflora*). Two of the sites were plantings on dredge-spoil islands. Specific goals were not stated for most of these projects. Our criteria for success must therefore be defined after the fact, and may not be the same as those envisioned by the contractor or regulatory agency. It is unlikely that a particular restoration project could meet all possible criteria for success, such as increasing productivity, providing habitat for particular species, controlling erosion, and improving water quality. Without studies of conditions existing before the projects and a knowledge of natural population variability, it is difficult to evaluate habitat replacement--which is the goal usually suggested or implied for restoration projects.

Success can be defined in terms of plant survival of the species planted and how this provides for in-kind replacement of the plant species lost. However, even these criteria pose difficulties in defining success unless: (1) the previously existing natural densities for the sites evaluated are known, (2) a desired density is defined, and (3) specific goals for that density are delineated. For the sites investigated, a variety of plants with different growth rates were planted. The lengths of time since planting and the environmental conditions where the plantings occurred varied and may not have been optimal for the species planted.

Spartina alterniflora was planted at six sites from 6 months to 6 years before this study. For five sites, data concerning survival at 1 year after planting are available (Table 2). Three sites (Archie Creek, Sunken Island, and Placido Bayou) had 70%+ survival, whereas two sites (Palm River and Feather Cove 1984) had survival rates of 25% or less. The portion of Feather Cove planted in 1983 had 90% survivorship. Shoreline erosion has destroyed a large portion of the S. alterniflora planted at Spoil Island 2-D. Four sites were older than 5 years at the time of the evaluation. Spartina alterniflora has been reported to coalesce in less than two years when planted at 0.3 m intervals (Kruczynski 1982). Density values averaged greater than 100 culms/m^2 at the 6 year old projects (Archie Creek and Sunken Island). However, variability in planting success after 1 year is shown by the successful portion of Feather Cove (approximately 150 culms/m^2) and Placido Bayou (an average of less than than 50 culms/m^2). Lewis and Lewis (1977) reported 741% (36 to 267 culms/m^2) increases in plant density values after 10 months on Fishhook Spoil in Tampa Bay. In Georgia, density values for S. alterniflora increased 977% (10 to 97.7 culms/m^2) after 5 months (Riemold 1980). This evaluation shows that excellent growth for S. alterniflora can be achieved in Tampa Bay given the proper conditions. Factors contributing to poor survival include: failure to restore the habitat to appropriate elevations; shoreline erosionpoor maintenance (i.e., removal of exotic vegetation, floating debris, etc.); competition by high marsh or upland plants; and poor planting technique.

Spartina alterniflora was established successfully in areas of low tidal and wave energy (Archie Creek, Sunken Island, a portion of Feather Cove, and Placido Bayou), but not in areas undergoing erosion (Spoil Island 2-D and Palm River). A contributing factor may be the lack of sufficient root mass to bind the sediments and retard erosion. Cammen (1976) found that the aboveground biomass of

Table 2. Summary of information on selected mitigation/restoration projects in Tampa Bay.

Project Name	Habitat type called for in restoration	Reasons for restoration	Time of resto-ration	Size of planted plot (ha)	Wetland habitat loss (ha)	Perma-nent loss (ha)	Survival after 1 yr %	Average density at time of study per m^2
Palm River	Mangrove and <u>Spartina</u>	Erosion mitigation	1979	0.012	Unknown	[f]	19	?
Archie Creek	<u>Spartina</u>	Mitigation	1978	1.82	1.5	0	75	230
Fantasy Island and Spoil Island 2-D	Mangrove and <u>Spartina</u>	Mitigation	1979 and 1981	2.12	2.1	[f]	73.3[a]	3 110
Sunken Island	<u>Spartina</u>	Habitat enhancement	1978	1.64	[e]	[e]	93.4	102
Apollo Beach	Mangrove	Enforced mitigation	1974	1.6	110+	[g]	minimal	10-17
Branches Hammock	<u>Juncus</u> marsh	Mitigation	1980	2.32	2.86	1.9	50[c]	-?
Feather Cove	<u>Spartina</u>	Enforced mitigation	1983 and 1984	0.6 2.5	4	[g]	90 0 or 10	163. 0
Harbor Island	Mangrove	Enforced mitigation	1974	10	10	0	[g]or minimal	0
Placido Bayou	<u>Spartina</u>	Mitigation	1983	1.0	1.0	0	[g] 70	31
Lassing Park	Subtidal fill	Safety	1983	3.9	n/a	n/a	n/a	n/a

[a] % survival for mangroves only
[b] natural recruitment occurring slowly
[c] % survival after 22 mo
[d] % survival for 1984 planting
[e] n/a is not applicable
[f] permanent losses occured but areas can not be determined with existing data
[g] cannot be determined with existing data

S. alterniflora established on dredged spoil equaled that of a natural marsh but the belowground biomass was less than half that in a natural marsh. Therefore, S. alterniflora may not be a good choice for controlling shoreline erosion; structural methods might be considered in conjunction with marsh grass plantings.

Succession of S. alterniflora to mangroves is occurring at three sites (Archie Creek, Sunken Island, and Placido Bayou). Spartina alterniflora serves as a pioneer species for invasion by mangroves (Lewis and Dunstan, 1975; Lewis, 1982) and may be expected to decline as the mangroves increase in density and size. Invasion appears to occur within 1 to 5 years for all species of mangrove. The species invading varies depending upon the available seed source. All three species of mangroves had been naturally recruited among the planted S. alterniflora at Sunken Island. The heights of the trees ranged from 0.3 to 2.0 m.

At four sites, mangroves were planted 5 to 10 years before this study. At the two oldest sites (planted 9 and 10 years previously), the planted species (Rhizophora mangle) failed to grow (Harbor Island) or was the least abundant species (Apollo Beach), although reaching a height of 0.5 to 2 m at the latter site. Natural recruitment by white mangrove (Laguncularia racemosa) and black mangrove (Avicennia germinans) resulted in these species occurring in higher densities than red mangrove (Rhizophora mangle) at the latter site. Heights of these two species ranged from 0.5 to 3 m. Densities at the 5 year old site (Fantasy Island) averaged 3/m^2. Some of the planted individuals are being lost to erosion; however, natural recruitment is occurring rapidly enough to counter these losses. The trees at this site ranged in height from 0.3 to 1.9 m at the time of planting. Heights 4 years later ranged from 0.1 to 1.2 m. The lack of apparent growth may have been caused by disproportionate death of the larger planted trees; stunting of growth by freeze damage; or low growth rates from low nutrient conditions because of high organic export. Alternatively, the small size of the mangroves may reflect recruitment of new seeds. Factors contributing to poor survival of mangroves include erosion and failure to restore the habitat to appropriate elevations.

Only one Juncus roemerianus site (Branches Hammock) was evaluated. Some habitat was permanently lost under the bridges and to the bridge structure. Recovery of J. roemerianus appears to be slower than that of S. alterniflora, and the conditions for survival of the former are more exacting. A mixed community consisting of J. roemerianus and other wetland species resulted when the proper substrate was not replaced by the bridge contractor. The regulatory agency decided not to require replanting of J. roemerianus because the existing community was deemed acceptable wetland habitat (FDER, pers. comm.).

For the subtidal site (Lassing Park), the goal of reducing water depth was achieved. It remains to be seen whether seagrasses invade this area naturally or survive if they are transplanted.

Two of the projects evaluated were conducted at dredge spoil islands. One was devised to compensate for destruction of vegetated intertidal habitat, whereas the other was a habitat enhancement project. The loss of bay bottom to these islands does not appear to have been considered in the overall balance of gains and losses. Given the extent of the seagrass losses in Tampa Bay, the creation of upland and vegetated intertidal habitat on the bay bottom may be inappropriate policy.

Permanent loss of wetland habitat has occurred in at least three projects. Changes in the kind of plant species, for part or all of the area lost, have occurred in seven of the nine projects (the subtidal fill, Lassing Park, is not included). Archie Creek and Apollo Beach are the two sites which appear to have species of plants similar to those occurring in the lost habitats. Recovery of a community similar in function to that which was lost was not determined in this study, and is difficult to assess without measurements made before the previous community was lost.

The seven projects designed to mitigate for habitat lost required a 1:1 habitat replacement. Few projects, if any, achieved this goal if we assume in-kind replacement was the objective. For the six small mitigation projects plus one for erosion control, 20.4 ha of vegetated habitat were to be replaced; 1.9 ha of this may be permanently lost; and at least 18.3 ha of wetlands were replaced by a different kind of habitat than that lost (in-kind loss). Mangrove habitat has been replaced out-of-kind because it has been recommended that S. alterniflora be planted initially with the expectation that mangroves eventually will colonize planted areas. The remaining out-of-kind replacement projects which failed resulted in the creation of approximately 10 ha of unvegetated, shallow, subtidal bottom. In the one large project, Apollo Beach, 110 ha of mangrove forest were destroyed. Natural recruitment has resulted in a dense mangrove forest 13 years after destruction, but from aerial photography the area appears less well developed than an adjacent undisturbed mangrove forest.

Recommendations

Human construction of wetland habitats is difficult and should be attempted only after all other avenues have been explored. It is better to avoid or minimize development impacts during the planning stage than to redress or compensate for them later. If impact avoidance is not possible, in-kind replacement of the habitat is recommended. Replacement by an alternate habitat should be considered only if the replacement habitat has been determined to be rare and endangered and the habitat lost is relatively common. Restoration for lost habitat should occur in upland areas, if possible, so that wetland area is maintained at a constant level. Enhancement of existing wetland is desirable to mitigate for impacts that degrade but do not destroy wetlands.

Additional compensation by replacing more area than that lost should be required if the probability of successful replacement of a habitat type is low, as with seagrasses, or if the length of time for recovery is longer than two growing seasons, as when *Spartina alterniflora* is planted to replace mangroves. Although this species is recommended for planting instead of mangroves, the succession to a mature mangrove forest requires many years. During the successional period, the many functions of mangrove forests, including provision of breeding habitats for wading birds and pelicans (Schreiber and Schreiber, 1978) would not be realized. Our site surveys were primarily vegetation surveys. Although we recorded observations of fish and wildlife, November is not a time when use by birds or fishes is very high. Quantitative observations during different seasons and knowledge of fish and wildlife usage of comparable natural habitats are necessary for a complete evaluation of the success of the restoration projects.

Monitoring to determine that restored habitat is functioning well for its stated goals and maintenance to control damage by floating debris and invasion by exotic plants should be included in the design of future projects. Documentation and publication of the results should be required so that this information is available for future projects. Future mitigation/restoration projects in wetlands may be more successful if specific goals for the area being restored are stated, compliance is more strictly enforced, and restoration techniques are refined to meet the goals. A detailed mitigation policy must be developed. Assurity bonds should be required prior to issuing permits. Detailed mitigation policy has yet to be developed by the State of Florida, though it is expected in the near future as the Warren S. Henderson Wetland Protection Act of 1984 is implemented. Monitoring and enforcement are increasing as agencies gain authority to protect these habitats.

Feasibility of Mitigation Options

Table 2 summarizes the feasibility of mitigation/restoration options for each habitat type discussed. Also included, where applicable, are recommended planting species, techniques, approaches, potential problems, and potential uses of dredged material.

The use of *Spartina alterniflora* to create salt marshes is recommended for newly created intertidal areas such as islands or shorelines constructed from dredged material. *Juncus roemerianus* has been planted in the high marsh areas but it is slow growing and sensitive to soil elevation. Both species can be planted relatively inexpensively as sprigs or plugs. *Spartina alterniflora* is a fast-growing grass that can quickly stabilize an intertidal shoreline. Fertilizers may be required if the soil is nutrient-poor and temporary or permanent breakwaters may be needed in high-energy environments. The importance of planting elevation for *S. alterniflora* is well documented, and this must be taken into account for a successful project. As mentioned above, in the Tampa Bay area, *S. alterniflora* appears to be a seral stage to mangrove forest development. After establishment, *S. alterniflora* tends to naturally collect floating mangrove seeds and protect the seedlings during development.

The feasibility of expanding and improving mangrove habitat containing the three species of mangroves found in Florida is good. The most cost-effective technique is to plant seeds or seedlings of the three species. Mangroves are known as shoreline stabilizers; potential problems during revegetation, however, result from the slow growth of the trees and spread of their root systems. When first planted, the mangroves are highly susceptible to erosion by waves and boat wakes. The most successful projects reviewed were mangrove plantings in regraded areas within existing mangrove forests, e.g., the Grassy Point and Windstar projects. The existing mangroves provide the needed protection and planting seeds or seedlings accelerates the natural revegetation process. Spartina alterniflora can provide the same protection and may be a means for preconditioning newly created intertidal areas (e.g., those created with dredged material) for planting or natural colonization of mangroves. However, a source of mangrove seeds needs to be available for natural colonization. Optimal planting elevation for mangroves appears to be at or slightly below the level of the surrounding marsh. Also existing mangrove wetlands can be improved by opening and improving connections between isolated wetland areas and the estuary. The described enhancement however, should not be used to mitigate for loss of habitat.

It is not likely that a seagrass planting program in Tampa Bay will be successful until water quality and clarity are improved (TBRPC, 1985). Before a large seagrass planting program is undertaken in Tampa Bay, an experimental planting program to identify the seagrass species, locations, and methods best suited for planting needs to be initiated. Data from the projects reviewed indicate that Halodule wrightii, because of its broad tolerance to environmental stress and pioneering features, may be the most successful species overall. Thalassia testudinum plantings have been successful, but the species is slow growing. The most successful planting methods for these species of seagrasses have been plugs, shoots, or seedlings. Because of the low survival rate of planted seagrasses and the consequent need for replanting, seagrass planting projects have proven to be expensive, e.g., Biscayne Bay and New Pass Channel.

Creation of the other intertidal and subtidal habitats (mud flats, artificial reefs, and oyster reefs) has not been traditionally considered as a means of estuarine mitigation, restoration, or enhancement. However, creation of these habitats should be considered as a means to attract particular species of fish and wildlife provided the habitat has been found to be limiting. Artificial and oyster reefs can be constructed to attract specific molluscs, crustaceans, and finfishes and an array of fouling organisms.

Water quality must be improved before seagrass, algal, and oyster reef communities can be expanded in Tampa Bay (TBRPC, 1985). Creation of wetlands, which are known to sequester nutrients and retard upland runoff, may help to reverse the historical decline in water quality in in Tampa Bay. Limitations exist as to the acceptance of creation of wetlands for water quality improvements. Many studies have linked the food webs of wetland habitats to ecologically and commercially important animal species. Analysis of historical trends of the populations of these species in wetland habitats in Tampa Bay is needed in order to prioritize the desired habitats for a large-scale restoration program and to give direction to the question of placement (location and size). The feasibility options recommended in this section, along with an understanding of historic habitat losses and desired needs, should form the basis for development of a bay-wide restoration and/or enhancement program for Tampa Bay.

Identification of Potential Mitigation Sites

Twelve potential mitigation sites were evaluated: six in Hillsborough Bay, five in Old Tampa Bay, and one in Lower Tampa Bay. The proposed mitigation plans for the Hillsborough Bay sites would involve filling 47 ha of old dredged borrow pits, filling 165.1 ha of subtidal sand flats for creation of mangrove or marsh habitat, and scraping down 52.2 ha of disturbed upland and transitional wetlands habitat for marsh creation. The proposed mitigation plans for the Old Tampa Bay sites would involve filling 132 ha of dredged borrow pits and scraping down 121 ha of disturbed upland. At the Lower Tampa Bay site, the plan calls for scraping down of 2.5 ha of disturbed upland for marsh creation. After evaluating the value of existing benthic habitats, filling subtidal areas may not be acceptable as mitigation. Additional projects for Manatee County are being developed by the FDNR (Evans, 1985).

At a majority of the sites evaluated or selected as suitable for habitat creation, submerged lands are owned by the TPA or other State or local public agencies (e.g., SWFWMD). Of the 12 sites proposed, 11 are located all or in part on submerged lands owned by the TPA or other governmental entities. Three sites encompass some privately owned land. Prioritization of the sites should be based on data concerning wetland habitat loss (i.e., Tampa Bay Trend Analysis Study) for each area of the bay and/or needs for particular habitats or species. The wetland trend study has not been completed and identification of needs for particular habitats or species has not as yet been attempted. Criteria that could be used to assign site priority in the absence of information on habitat loss and needs include: (1) land ownership (use of public owned lands will minimize costs); (2) needs for and feasibility of restoration in relation to future port-related projects; and (3) relationships to bay-wide restoration efforts and habitat needs. Site selection should also involve consideration of anticipated TPA needs in terms of expansion, improvement, or maintenance, and the types and amounts of unavoidable habitat losses projected. If the goal is to mitigate unavoidable losses due to future port development, a balance between habitat needs and anticipated unavoidable losses should be established.

Additional important factors to be considered in relation to site selection include pumping distances, suitability of dredged material for habitat creation, and the quantity of dredged material needed. Only sites within Hillsborough County may prove feasible from an engineering viewpoint; sites in Old Tampa Bay, excluding

MacDill, would probably exceed maximum allowable pumping distances. Projections of the volume of material to be dredged over the next 25 years are currently being compiled by the TPA. Of the total volume, most will be maintenance dredged material that may not be suitable for habitat creation. The potential use of maintenance dredged material for habitat creation should be evaluated further or disposal on upland or offshore sites may be necessary. The feasibility of alternate sand sources for some of the projects should be considered. Future TPA dredging and development activities may not generate enough good quality fill material required to complete the selected mitigation projects. Upland sand sources for some of the projects may need to be considered, especially those in upper Old Tampa Bay which are isolated from TPA projects.

Another problem to be concerned with is the scarcity of single large upland sites for habitat creation. Proposed projects at 9 of the 12 sites evaluated involve the scraping down of uplands. The size of the proposed sites ranges from 2 ha (Delaney pop-off canal) to 49 ha (Booth Point). Of the proposed areas for habitat creation involving the scraping down of uplands, 30% and 69% by area are located in Hillsborough Bay and Old Tampa Bay, respectively. In light of this scarcity of upland habitat for creation of new wetlands, restoration and enhancement of existing degraded wetland may need to be evaluated though this type of mitigation will not be acceptable for loss of wetland habitat. Mitigation needs for development may require that avoidance, reduction, and minimization of adverse effects be pursued as mitigation rather than destruction of wetland habitat.

Management and/or Restoration Recommendations

As the legal framework for environmental preservation and protection becomes more defined on all levels of government, the fact that we can no longer afford to lose wetland habitat to development should be made clear. To achieve this goal, mitigation that avoids, minimizes, and reduces the effects of development on wetlands should be recommended before replacement of habitat is even considered. There is a need for a local agency with an ecoregional perspective to oversee and coordinate the protection of natural resources in Tampa Bay. The initial steps in a coordinated effort to set regional goals for correction of the environmental problems in Tampa Bay have recently been undertaken by the Tampa Bay Management Study Commission (TBRPC, 1985). The Future of Tampa Bay (TBRPC, 1985) proposes solutions and funding sources for many of the environmental problems indentified in Tampa Bay.

When a project has been found to meet the requirements justifying unavoidable loss of habitat and all other alternatives have been explored, mitigation requiring compensation may be necessary. To provide guidance to developers and agencies for developing an acceptable compensation plan, the local agency should have defined regional restoration goals and determined the design criteria adequate to achieve these. The regional goals will determine whether in-kind or out-of-kind habitat replacement is to be recommended.

In this report it has been shown that marsh vegetation, i.e. mangroves and *Spartina alterniflora*, can be planted with relative ease and expected to grow well in Tampa Bay. As previously demonstrated, seagrass restoration, however, is still experimental and results are unpredictable. The value of benthic habitats and recommendations for their restoration has not been determined.

For compensation to be fair and consistent, standardized evaluation procedures (ways to determine the gains and losses from a development project and compensation plan) need to be used. The USFWS Habitat Evaluation Procedure (HEP) is useful, although it has not been used extensively in coastal environments. The reasons appear to be the limited availability of trained personnel, the uncertainty about its validity in habitats that are naturally variable, and the limited availability of models. However, the number of models for species in wetland habitats have recently increased. HEP also does not evaluate all wetland "functions." Adamus and Stockwell (1983) have proposed procedures reported to evaluate other "functions" but some of the assumptions used to develop the predictors are untested, disputable or wrong for some regions of the country. Before this or any procedure is recommended for use, it needs extensive field testing by qualified scientists in the types of wetlands for which it is recommended. These tests should be performed in wetlands for which there are at least 5 years of hydrological and ecological data and the procedures revised to reflect what is learned.

Once compensation has been accepted, compliance with the plan proposed must be ensured. This is best accomplished by including a consistent monitoring plan as part of the project cost. The information provided by monitoring can also assure that regional needs are being met, provide information for updating regional goals and more effective design criteria, and indicate where research is needed.

More research is needed on certain aspects of wetland restoration. Seagrass restoration is still experimental and results are not predictable. More research is needed on the animal use of mangrove and *Spartina alterniflora* restoration projects, comparing them with existing stands of the plants. Much of our knowledge on these systems is intuitive and, as Nixon (1980) indicates, many of the assertions may be generalizations. This research may lead to more effective design criteria for the planting and monitoring of restoration projects.

A major problem in implementing any type of mitigation policy for Tampa Bay is that the State has only begun to create the necessary legislative framework. The Wetlands Act of 1984 provides for mitigation of activities deemed unavoidable, i.e., compensation in the in the project. The procedures for administrating this policy, however, have not yet been defined and therefore guidance for the administration of these laws currently does not exist. Therefore, development of State, regional, and local mitigation policy needs to occur and be coordinated with the Federal policy to provide guidelines for wetland protection and development.

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SEAGRASS: A NEGLECTED COASTAL RESOURCE

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Summary Discussion

A comparison of the published seagrass literature with that on tidal marsh indicates that the latter has received far more attention over the past 20 years than seagrass. Presently an approximate ratio of 100:1 exists. Less than 500 references exist on the botanical and ecological aspects of seagrasses found in the northern Gulf of Mexico. The primary species found in this region are: *Thalassia testudinum, Syringodium filiforme, Halodule wrightii* and *Halophila engelmannii. Ruppia maritima* is estuarine in Louisiana, Mississippi and Alabama, here it does not grow intermixed with the three. In sharp contrast, *Ruppia maritima* occurs associated with true seagrass in Texas and South Florida. This paper addresses the three main causes that have resulted in a lack of research and, hence, information on seagrasses. Although seagrass meadows are well known within the scientific community, to be important as habitat for a multitude of marine animals, little is known about the plants themselves. The basic problems are: (1) *logistical*, (2) *difficult species to work with*, and (3) *lack of public awareness*. Most seagrass meadows lie or extend a considerable distance off the mainland shore. Proper study of these seagrass meadows requires the use of seaworthy boats which usually entails a costly logistical operation. Such costs have, correspondingly, caused many funding sources some reluctance in supporting seagrass research. Consequently little is known about the autecology of the various seagrass species of their physiology, adaptations, systematics or reproductive biology.

Secondly, transplanting and culture studies have clearly shown that seagrasses are extremely sensitive to disturbance. Transplanting and cultural studies are still extremely experimental. And nobody has successfully grown seagrasses for any significant length of time under controlled conditions in the laboratory or in glasshouses (greenhouses). Generally, many of the plants die in both transplantation and cultural studies which clearly indicate that seagrasses are difficult to work with. Consequently some scientists are reluctant to work with plant species or attack problems with which there is a very high degree of potential failure. Lack of coordinated field and cultural studies has resulted in an almost total absence of physiological information.

Thirdly, a lack of public awareness of seagrasses exists because they occupy a submerged habitat and are therefore not highly visible in comparison to tidal marshes. Furthermore, most seagrass meadows are off the mainland shore and the general public simply is not aware of them because of this distance factor. Most people are not aware that the sea bottom may be vegetated by plants that produce flowers at such considerable distances from the mainland shores. A lack of public awareness has resulted in a lack of public support for seagrass research and hence, their preservation. Efforts should be made to inform the general public of the presence of seagrasses and of their importance as a coastal and marine resource.

The literature clearly indicates that there is a world-wide decline of seagrass. The causes are unknown or poorly known and probably vary from place to place. Kemp (1983) presents an excellent general treatment of this subject. Locally, in the Mississippi, Louisiana, and Alabama coastal waters, hurricanes have been a major cause of seagrass destruction. In Mississippi Sound, freshwater released through The Bonnet Carré Spillway above New Orleans, Louisiana, travels through Lake Pontchartrain, Lake Bourne and enters Mississippi Sound, where it has kept water salinity at zero for three months or more. I surveyed the seagrass beds in Mississippi's coastal waters in 1968 and 1969 and prepared maps of their locations (Eleuterius, 1971). There were about 4,662 hectares (11,520 acres) of bottom covered by seagrass. Hurricane Camille occurred in 1969 and destroyed many seagrass beds. I resurveyed our coastal waters for seagrass beds in 1970 and each year until 1975 and found that about 1,970 hectares (4,866 acres) remained which is reported in Eleuterius and Miller, (1976). About 30% or 1,396 hectares (3,448 acres) of seagrass beds were lost due to Hurricane Camille, and a loss of about 28% or 1,296 hectares (3,202 acres) was attributed to prolonged low salinity. For a total loss of 58% over a six year period.

Numerous seagrass species are involved in the world-wide decline. Moreover, most evidence suggests that anthropogenic influences are involved. Increased inputs of nutrients, inorganic sediments, petroleum and industrial contaminants have been cited in relation to diminution of seagrass in the Dutch Waddenzee (Den Hartog and Polderman, 1975), the French Mediterranean (Peres and Picard, 1975), Cockburn Sound Australia (Cambridge, 1979), Chesapeake Bay (Bayley et al., 1978; Orth and Moore, 1981; Haramis and Carter, 1983) and Tampa Bay, Florida (Lewis et al., 1979).

Disease organisms, such as animal parasites, parasitic fungi and harmful bacteria or viruses have not been adequately investigated. Disease organisms are more apt to infect stressed plants, than those in a healthy environment. By what criteria does one determine a "healthy" environment for seagrass or healthy seagrass plants? Although a considerable amount of research examined the mysterious "wasting disease" which decimated populations of *Zostera marina* during the 1930's (Tutin, 1938), the etiology of the disease still remains unclear. However, the impact of the "wasting disease" of *Zostera marina* has caused significant direct and indirect effects on the marine environment and the associated seagrass fauna (Rasmussen, 1977).

Suggested Research Priorities

Enough research has been done on seagrass productivity, decomposition and associated animal communities to establish the importance of their ecological role. Physiological studies should receive top priority in research programs on seagrasses. However, these must involve cultural studies in the laboratory or "greenhouse" where living seagrass can be maintained over a period from two to four years or longer. It is often difficult or impossible to extrapolate ecological data taken on seagrass communities in Florida, Texas or North Carolina to those in Mississippi, Louisiana or the Alabama coasts because the geographical locations represent greatly different environments. Furthermore, there is no doubt that seagrasses growing in south Florida and Texas are different physiologically from those growing in Mississippi waters (Evans et al., 1986; Pulich, 1985; McMillan, 1978). These facts bring into focus the need for detailed systematic studies. There is considerable variation within a single species in certain localities and documentation of this variation is lacking (Eleuterius, 1974; Eleuterius, In press, Phillips and Lewis, 1983). The decline in seagrass populations begs the question: "What is the cause?" Although some reports indicate that pollution, increased turbidity caused by rapid run-off of rainwater and heated water from electrical generating plants, dredging operations, diversion of freshwater, and outboard motor "ruts" have all caused damage to seagrass beds, little attention has been given to disease organisms as agents causing large-scale decline in seagrass beds in tropical or subtropical waters. Hurricane and storm damage to seagrass beds is relatively well known, but continuous survey and inventory is necessary to assess damage, acreage and standing crops. However, the rate of seagrass recovery is not well known. Moreover, seagrass beds displace themselves in a westerly direction in Mississippi Sound (Eleuterius, 1974).

Much needs to be done to determine the ecological factors that affect the growth of seagrasses. Furthermore, the sediment and water chemistry of seagrass habitats need to be characterized at many widely separated geographical locations. Such data would be important for comparison elsewhere and provide a better understanding of the local conditions under which seagrasses grow. Light quality and intensity are important and water pressure needs to be looked into. These kinds of data are needed also in designing culture systems in the laboratory and greenhouse where physiological information can be obtained and bioassays, using seagrasses, can be conducted.

Although many scientists feel that transplanting seagrasses is not "worthwhile," I disagree. Much physiological and morphological information can be obtained from such studies, and they should be continued. A few "transplants" can make an ecological difference. Many transplantings have been successful (Thayer et al., 1982; McLaughlin et al., 1983; Eleuterius and McClellan, 1976; Eleuterius, 1975a; Eleuterius, 1975b; Eleuterius, 1981).

Furthermore, the reproductive biology of most seagrass species requires further clarification (McMillan, 1985a; Caye and Meinesz, 1985; Durako and Moffler, 1985). Flower production in Mississippi Sound occurs periodically and this year (1986), seeds were produced abundantly, but none have germinated. After extensive searching no seedlings were found. Are they sterile? Does something feed on the seed? Are the seeds swept out into the deep sea? McMillan (1985b) reported on a "seed reserve" in the sediments of seagrass habitats in the Laguna Madre off Texas. No such seed reserve occurs in Mississippi Sound (Eleuterius, unpublished data). Over a period of 18½ years of close observation I have seen few seeds, so the seagrass populations in Mississippi Sound are obviously maintained by vegetative growth. A precarious situation.

Research must solve so-called "pure science" problems in order to arrive at practical application. The following is based on this consideration. Detailed in situ studies which will define the major ecological factors influencing the growth of seagrasses are needed. Emphasis should be placed on light, substrate and water characteristics. I suggest that these follow an autecological approach with appropriate manipulations made in the field. Concurrent or subsequent laboratory culture studies should be designed to replicate environmental conditions as determined in the seagrass ecosystems. When successful culture of seagrasses in the laboratory or greenhouse conditions are obtained, critical controlled study and assessment of ecological and physiological factors will then be possible. The lack of vigorous adventitious growth and its total absence in most instances indicate that seagrass ecosystems are fragile. A fresh look at the morphology and growth patterns of the seagrasses, especially *Halodule wrightii*, needs to be carried out. Morphological work, based on statistical analysis, which would reveal the relationship of rhizomes and shoot production would be extremely important to a better understanding of vegetative growth and rates of rhizome growth. Can the growth rate of seagrass rhizomes be enhanced in such a manner that the plants will spread more quickly? Do certain genotypes within a species grow much faster than others? Bigley and Harrison (1986) offer some interesting possibilities.

Light penetration is probably one of the factors limiting seagrass distribution in turbid waters, such as that found along the mainland shore in Mississippi. Seagrasses in Mississippi Sound are not generally found growing in water greater than 3 meters in depth (MLW). Phillips (1960) and Taylor (1928) indicates that in Cuban waters the greatest depth was about 24 meters (80 feet). However, even in these clear waters, maximum growth occurred in shallow waters of 7–16 meters (23–52 feet). Buesa (1975) also indicates that blue light may favor the growth of *Syringodium filiforme* and red light for *Thalassia testudinum*. It is interesting to note that *T. testudinum* is very abundant on the southeastern Cuban shelf, whereas in Mississippi Sound, *Halodule wrightii* is the most abundant species. A combination of water depth, wave energy and an array of related ecological factors affect seagrass distribution productivity and reproduction at different locations.

Concluding Remarks

It is extremely important that techniques of culturing seagrasses, including tissue culture, be developed as soon as possible in view of declining and disappearing populations, well adapted to geographical areas. Such a situation exists in Mississippi Sound today, where *Thalassia testudinum*, *Syringodium filiforme* and *Halodule engelmannii* have practically disappeared, primarily because of Hurricane Elena and several other storms and hurricanes that occurred here in 1985. Restocking from an innovative seagrass nearby nursery may save these especially adopted ecotypes and genotypes from extinction. Hopefully, it is not too late.

Acknowledgments

I wish to thank my associate and friend, Mr. John Caldwell of the Botany Section, GCRL, for his help in various ways during the preparation of this manuscript. Thanks are also due Mr. Michael Chambers for his assistance and interest in seagrasses. Mrs. Cindy Dickens and Mrs. Mereau Tacon prepared the manuscript and final camera-ready copy, respectively.

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EVOLVING RATIONALES FOR FEDERAL HABITAT PROGRAMS

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Preface

This paper is the opinion of the author. It may not represent the views of other agencies or staff. Nonetheless, it does explain some of the pressures affecting habitat conservation programs during an era of decreasing federal budgets and growing coastal development pressures.

Introduction

Federal habitat programs in the Northeast, and perhaps elsewhere, are entering a new era in their efforts to restore and protect living marine resources and their habitat. These new challenges to existing programs threaten to change program emphasis, affect the breadth of coastal resource planning, and limit the tools of federal habitat managers. This trend is most obvious at the budget and management decision levels where pressures from development and commercial industries and politics are most severe; fortunately, many staff biologists and planners still operate with the full agency mandates in mind, unperturbed by the neglect accorded to their work by decision-makers. Regardless the inefficiencies and frustrations of this situation will probably continue. Hopefully, habitat conservation programs and employee morale will endure.

What Does This Mean to Resource Managers?

The implications of this growing shift are significant. In NOAA's National Marine Fisheries Service, habitat conservation has always been a broad concept related to commercial, recreational, forage, and protected species. Specific mandates provided NMFS with an entree into habitats for existing anadromous and marine species and for historical habitats vital to species under restoration such as Atlantic salmon and striped bass. However, with the narrowed emphasis on habitats related to species with commerical value and with political pressures to support major development projects, NMFS has been forced to apply its dwindling budgets and resources to only a small portion of its mandated responsibilities. In the Northeast, NMFS habitat programs find increasingly less time for forage stocks despite their importance to commercial fisheries, less effort committed to habitat supporting species under restoration in their former ranges, and little interest in species of low fisheries management concern despite their importance to recreational fishermen or marine ecosystems. Protected species may fare even worse.

Concerning the NMFS mandates in wetlands, commercial fisheries, anadromous fish, and the Clean Water Act, these artificial constraints are very frustrating. NMFS opportunities to influence Army Corps of Engineers' decisions in their Section 10 and 404 permit reviews have been reduced by policies in both agencies, and Northeast Region participation in other project planning like hydropower projects has suffered from the budget ax. Despite these concerns that various habitat components and mandates may be neglected, this shift does reflect budget realities and current administration philosophies. This shift should not be interpreted as an intentional abrogation of legislative mandates by the individual habitat offices that are trying to balance budget impacts and resource threats.

This trend is not limited to any particular issue or species in the Northeast, and perhaps not even to just the Northeast. One major limiting factor is the emphasis on species covered by fisheries management plans prepared under the Magnuson Fishery Conservation and Management Act. In the Northeast, with the preponderance of offshore rather than estuarine-dependent fisheries, this means more emphasis on lobster, scallops, cod, and haddock than would be seen in the Southeast where the major commercial fisheries are shrimp and menhaden, both estuarine-dependent species. This trend toward emphasis on commercial fisheries is accentuated by the NMFS and fishery council philosophy that stocks in state waters should be managed by interstate commissions rather than federal intervention. Another example is in the art/science of mitigation. Uncertainties associated with efforts to recoup productivity losses impose a definite drain on coastal and estuarine resources. In essence, mitigation imposes a forced loss of fishery production for at least the months or years between project development and completion of mitigation plans.

Conclusions

Despite these trends in the philosophies and budgets of habitat programs, NMFS and presumably other federal agencies still continue to emphasize fishery habitat conservation. And continued pressure to support coastal development can be expected in an era of expanding human populations and growing desire to live within sight of breaking waves.

But what are the implications to the living resources and habitats, and the programs that have evolved in response to federal and state habitat mandates? First, the recent shift in management emphasis is now affecting federal research programs. Emphases on commercial fisheries and major development projects has probably slowed NMFS efforts to reprogram part of its management efforts toward estuarine issues and growing problems like environmental contamination, excess nutrients, and coastal habitat alteration. Second, NOAA's role as the nation's conscience for marine science has been compromised by our limited participation in certain estuarine and coastal issues. Third, total NOAA/NMFS strength as perceived by other federal agencies may be declining, as evidence by Department of Interior proposals to increase their role in anadromous fish programs and the Environmental Protection Agency's creation of an Office of Wetland Protection; both changes could represent the beginning of a challenge to NOAA/NMFS responsibilities in estuarine and marine resources management. Fourth, NMFS may actually be neglecting legal mandates by limiting its habitat and resource management programs. For example, NMFS rarely defends the economic value of fisheries and their habitat through the full extent of the interagency elevation process in their Memorandum of Agreement with the Corps of Engineers under Section 404(q) of the Clean Water Act. That agreement enables NMFS to challenge Corps permit decisions, but NOAA/NMFS rarely exercises its full, formal challenge. Fifth, several of the duties now neglected by NMFS may actually hurt development plans. One classic example is hydropower applications in the Northeast where NMFS is required to provide written comments to applicants for a Federal Energy Regulatory Commission license to generate hydroelectric power. Budget cutbacks have forced NMFS not to provide a written comment in response to each permit application received. The result is that applicants encounter an administrative hurdle that delays their programs, and NMFS loses the opportunity to work with developers to install fish ladders to help re-establish valuable anadromous species to their historic ranges. It's a classic case of both sides losing. Unfortunately, I think this entire issue of decreased programmatic support for habitat management and research is a missed opportunity for all marine resource users.

MANAGING LOUISIANA'S COASTAL RESOURCES

James Edmonson, Convenor

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Abstract only

THE ATCHAFALAYA RIVER AS A RESOURCE

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The overlapping delta cycles that formed and maintained Louisiana's coastal plain became a process of the past with the controls placed on the Mississippi River and its main distributary, the Atchafalaya River. The resultant wetland losses, compounded by subsidence, sea level rise, and further modification of the area's hydrologic processes make it increasingly necessary to rely on engineering works for the protection of coastal development and the maintenance of wetland resource base. The extent to which both these objectives can be met will depend on the ability to integrate ecological considerations and engineering. Present needs for improvement of the Atchafalaya Floodway system provide a significant opportunity to develop this approach as a partial answer to Louisiana's coastwide problems.

The characteristics and problems of the domain of the Lower Atchafalaya River are almost prototypical for coastal Louisiana. The area combines the often conflicting needs for use of the river as a sediment and freshwater resource, maintenance of navigation access and flood control, flood protection of coastal communities, and the reduction of water stresses in remaining bottomland hardwoods. Continuing subsidence and sea level rise will ultimately require that flood protection of the developed area be accomplished through levee construction and forced drainage. These costs can be reduced, however, by maintaining a wetland buffer between the Gulf of Mexico and the leveed area. Wetland restoration and maintenance would simultaneously serve the partial renewal of the state's most important long-term resource. The utilization of the Atchafalaya River for that purpose is therefore in the public interest for at least two major reasons. The opportunity to do so is provided in principle by the congressional mandate to develop a multi-purpose plan for the management of the land and water-related resources of the Atchafalaya Basin, and the urgency for the state of Louisiana to undertake the long-term protection and management of its remaining coastal resources.

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BENEFICIAL USES OF DREDGED MATERIAL IN NEW ORLEANS DISTRICT

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Introduction. Louisiana is losing wetlands at a rapid rate. Recent figures (Wicker, 1980) indicate a loss of 50 square miles per year - and the rate may well be increasing. There are numerous reasons for this loss. Natural forces such as subsidence, compaction, and sea level rise are part of the cause. Man's activities also play a part. In order to make southeastern Louisiana habitable, it has been necessary to levee the Mississippi River to prevent destructive flooding. The presence of the levees prevents the periodic nourishment of the marshes with sediment and nutrients. Petroleum exploration has turned many areas of coastal marsh into a maze of canals. These canals can prevent sheet flow and marsh nourishment, and impound water on the marsh. Navigation channels have allowed saltwater intrusion which has destroyed marsh.

Freshwater Diversion. The trend of land loss is real. It can probably never be reversed, but some measures can be taken to slow it. One method of reducing it would be to divert fresh water from the Mississippi River into the marshes. Some sediment would be carried by this fresh water - enough to build a 2,500 acres in Davis Pond and 700 acres in Big Mar (U.S. Army Corps of Engineers, 1984). But upstream dams have halved the volume of sediment being carried by the river, so less is available to create land. The river nutrients would nourish the marsh and the fresh water would prevent future marsh loss: 83,000 acres at Davis Pond, 16,000 acres at Caernarvon, and 4,000 acres at Bonnet Carre.

Value of Marsh. Most measures we take to reverse the trend of marsh loss will fill shallow open water. Thus, we need to compare the values of shallow bays and marshes. Bays are inhabited by various benthic assemblages; juvenile fish and shellfish utilize them as nursury areas. Large numbers of wintering waterfowl rest and feed in bays. On the other hand, marsh contains a more complex benthic community because the lower portions of marsh plants provide additional "living area." Marsh is more valuable as a nursery because the plants provide cover that allows juvenile fish and shellfish to hide from predators (Minello and Zimmerman, 1983). The detritus from the decaying marsh plants and the nutrients provided by the diatom communities also play a vital role in the estuarine food web (Odum and Zieman, 1972). Turner (1979) has shown that commercial yields of shrimp are directly related to the amount of intertidal marsh, not the amount of open water. Furbearers are common in Louisiana marshes and thousands of waterfowl and wading birds depend on the wetlands for their food. Recent research (Minello, pers. comm.) indicates that use of man-made marshes by juvenile fish and shellfish is less than their use of "natural" marsh. However, creation of marsh with only some of the functions of natural marsh is preferable to continued marsh loss.

<u>Delta Splays</u>. A slow but sure way to create marsh is to mimic the natural formation of mini-deltas. The Mississippi River forms a birdsfoot delta below Venice, Louisiana. Each distributary is generally enclosed by natural levees. Where these levees have broken, a small delta splay begins to form (See Figure 1). We measured the cross-sectional area and angle of the most efficient. We will mimic these parameters in making seven artificial breaks in Main Pass in order to allow the creation of 300 acres of marsh (U.S. Army Corps of Engineers, 1985). It will be necessary to make seven breaks in the levee because, along Main Pass, there splays seem to reach a maximum of

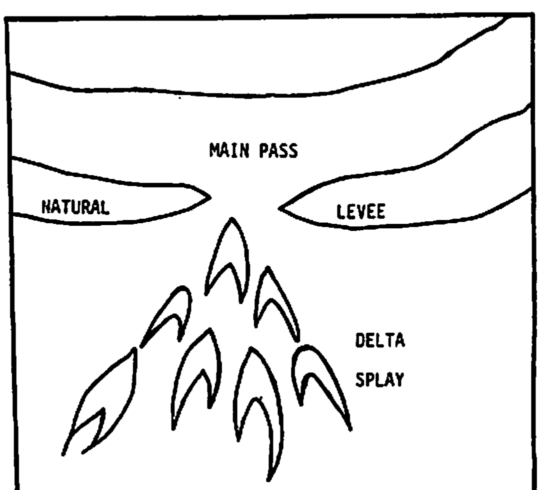

FIGURE 1 DELTA SPLAY

only 45 acres before erosion overcomes delta building. This action is mitigation for marsh loss caused by construction of a hurricane protection levee system.

Innovative Uses of Dredged Material. We remove about 30 million cubic yards of dredged material every year in order to keep New Orleans District navigation channels passible. There are many ways to use this material to help stop land loss. The Gulf Intercoastal Waterway runs along the southern boundary of the Laccasine National Wildlife Refuge. A Refuge levee protected a large area of vegetated pond and marsh from erosion and salinity intrusion. The levee was in poor shape, so during a maintenance dredging in 1982, we placed dredged material north of the old levee. The Refuge used some of the material to make a new levee and the remainder served to protect the new levee. Along the Barataria Bay Waterway, we have used dredged material to build up the bank of a pond to prevent salinity intrusion which could endanger the trees where bald eagles nest. Further west along the GIWW, Grand Lake was threatening to break through its northern shoreline. If this had happened, the marsh north of the GIWW would have been threatened by erosion due to a longer wave fetch. We placed dredged material in the thinnest spots to rebuild the shoreline.

Marsh nourishment is a technique that we use where there is an upland bank between the waterway and eroding marsh. We place the end of the dredge pipe at the edge of the bank (See Figure 2) and start pumping.

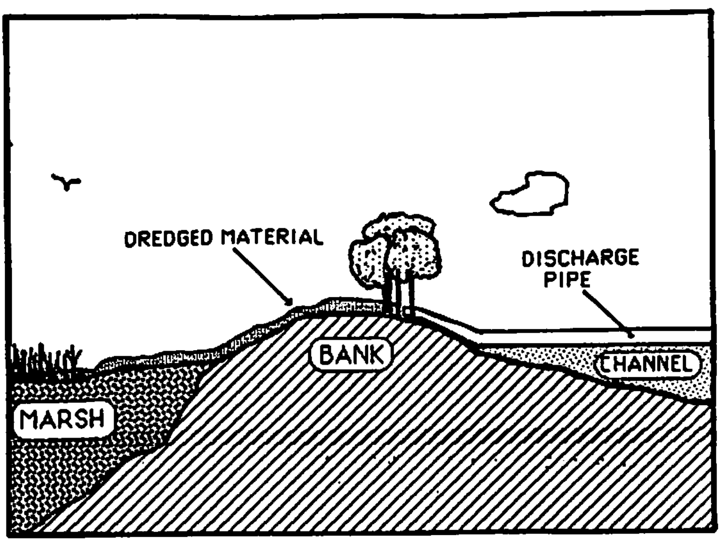

FIGURE 2 - MARSH NOURISHMENT

The heavy material falls out among the trees and only the fine material is left to flow out over the marsh. This sediment builds the marsh and fills eroding ponds. Vegetation grows up through the sediments.

Previous Marsh Creation. A major beneficial use of the dredged material is to actually create marsh. However, we have many constraints. The authorization for old navigation projects does not include marsh creation as a project purpose. Thus, we cannot spend extra money to create marsh. We have a limited budget with which we must keep navigation channels open and any marsh creation must be done at no extra cost. It is possible that the new Omnibus Water Resources Bill will provide additional money for such efforts.

Water quality. We are also concerned about the quality of the soil with which we would create marsh, since our rivers receive both industrial and agricultural chemicals. Near the mouth of the Mississippi, we had a contractor, MEL Inc., do extensive sediment testing. They found that these were heavy metals (cadmium), pesticides (chlordane), and PCB's in the sediments (U.S. Army Corps of Engineers, 1983). If the sediments were placed within the intertidal zone, the pollutants would remain in a reduced environment and be rapidly diluted by river marsh waters. If they were put above the influence of the tide, they would be in an oxygenatel area and more available to the ecosystem.

Bioasssay data showed mortality of less than 10% with both reference site and disposal site sediments, thus contaminants in the dredged sediment should not have any short-term toxic effects.

Results of bioaccumulation studies indicated that concentrations of contaminants in organisms living in disposal site sediments were generally not significantly different from concentrations in fauna living in reference site sediments.

Impacts of marsh creation. Creating marsh with dredged material destroys the benthos in the pond or bay where the material is placed and creates temporary high turbidities in adjacent areas. Most fish and mobile shellfish are able to escape. Recolonization of the benthos in fine grained sediments occurs within two weeks to six months (McCauley et al., 1976 and Stickney, 1972). Around the edges of the mound, some benthos can burrow upward through 20 cm of material (Oliver and Slattery, 1976). Adult migration and larval recruitment also occur. Insuring that the material is in the intertidal zone has three advantages. It dilutes any pollutants and keep them in a reduced state. It allows colonization by marsh plants. Third, it allows better access for juvenile fish and shellfish. In Louisiana, marsh vegetation succeeds naturally if the "final" elevation of the material is correct.

Interagency coordination. Prior to any maintenance dredging, we hold an interagency-plan-in-hand inspection. We invite state and Federal agencies to join us in an examination of the proposed disposal sites and we entertain their suggestions for judicious use of the dredge material.

Southwest Pass. We first started creating marsh with dredged material along Southwest Pass of the Mississippi River. There we discovered that if we kept the initial height of the material below six feet, it would generally compact and settle into the intertidal zone and marsh grasses would colonize it. Moving the dredge pipe more often would probably create more marsh. However, with our limited maintenance budget, this is not possible. We have chosen an enclosed area on the South side of the pass and applied for money under Section 150 of the Water Resources and Development Act of 1976. We would use the money to keep the initial height at five feet and monitor this to see if more marsh is created. We are presently dealing with the leasors of the land to attempt to work out institutional problems.

Marsh Creation. Table 1 indicates the acres of marsh we have created by

TABLE 1
ACRES OF MARSH CREATED

Location	Land Ownership	Marsh	Mud Flats 1/
MR-GO jetties	State	30	140
MR-GO inland	Private	20	
Tiger Pass	State	230	
Avoca Lake	Private	600	
Sweet Lake	State	90	
Sabine NWR	Federal refuge	200	
Atachafalaya Delta	State mgmt area	60	300

1/ These will probably become marsh once we place dredged material on them again.

carefully choosing disposal sites and moving the dredge pipe as often as practical. As can be seen, we have tried to build marsh on public lands as often as possible and have built it in state water bottoms in other cases. Occasionally we have no choice but to place the material in 4- to 6-foot deep open water. It takes more than one dredging cycle to create marsh in such areas and much material is lost. The ideal area for marsh creation consists of nearly totally enclosed ponds that are 1-3 feet deep. The utilization of sediment is more efficient in such areas. In order to estimate the initial height of the dredged material, it is necessary to take into account such variables as consolidation, subsidence, erosion, accretion, water depth, and sediment type. As we become more experienced we become more accurate in our estimates. In 1981, we created 600 acres of marsh in Avoca Lake by diking the area and limiting initial height to 3.0 MLG feet. Now over half of this marsh is gone. In our maintenance dredging this year, we will increase initial height of the material.

Future Marsh Creation. We are now authorized to dredge the Mississippi River to -55 NGVD. When we do so, we will move 57 million cubic yards of material during construction and 30 million cubic yards each year. We have calculated that we could create 55 square miles of marsh if all this material is used. In this project, we have included funds to control initial height and to monitor and refine our marsh creation efforts. We have also completed the environmental documentation to create 500 acres of marsh on Barataria Bay Waterway.

Conclusion

In summary, marsh is more valuable than shallow open water. When we use dredged sediments to build marsh, some toxicants may enter the ecosystem, but concentrations should not be much above background levels. And since we are losing 50 sq. mi. per year (and have lost one acre in the 16 minutes you have taken to read this paper) the benefits outweigh the losses.

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Abstract only

RESOURCE MANAGEMENT ISSUES IN THE LAKE PONTCHARTRAIN BASIN, LOUISIANA

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The Lake Pontchartrain Basin contains all of the classic elements for land-use conflicts in a coastal setting. Productive wetlands border much of the lake with concentrations in the western portion in the Lake Maurepas area. The south shore of the lake is occupied by the expanding New Orleans metropolitan area and the north shore is facing rapid residential and recreational development. The lake has a productive sports and commercial fishery and is the site of shell dredging and petroleum production. Urban expansion, storm runoff, sewage discharge, resource development, and shoreline and wetland loss are all impacting the quality of Lake Pontchartrain waters and the viability of fringing wetland habitats at a rapidly increasing rate.

The Governor of Louisiana created a task force to investigate the feasibility of establishing a special management area in the basin under the state's Coastal Zone Management Program to deal with conflicting land and water use activities. This approach would utilize special guidelines, developed by the task force and administered through the state program, to define permit conditions for competing uses. Concern over restrictions that would limit landowner rights and over measures that could restrict resource development has created some strong differences of opinion among task force members who represent local governments, state agencies, industrial interests, environmental organizations and federal agencies. The results of efforts to create a special management area in the Pontchartrain Basin will be significant not only in terms of future management of that area, but in testing the ability of diverse interest groups to devise and accept a comprehensive land-use management system that goes considerably beyond the generally limited systems currently in place in Louisiana.

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Abstract only

NEARSHORE SAND RESOURCES FOR BEACH NOURISHMENT IN LOUISIANA

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Louisiana has the most critical coastal erosion and land loss problem in the United States. Land loss in coastal wetlands has been estimated at over 100 km^2 annually, while shoreline erosion rates exceed 6m per year under normal conditions and approach 50m following hurricane impact. In response to this problem, the Louisiana Geological Survey developed the Coastal Protection Master Plan under the mandate of Act 41 of the 1981 Legislature. Phase II of the Master Plan calls for beach nourishment of Louisiana's barrier islands using sand dredged from offshore sources. To locate the necessary borrow material, the Louisiana Geological Survey is conducting a statewide nearshore sand resource inventory on the Louisiana continental shelf.

Data collection occurs in two phases. High resolution seismic reflection profiles are gathered in prearranged, closely spaced grids. The nature of the return of the seismic signal is in part dependent upon lithology and can be utilized to map potential sand bodies. Maps of acoustic targets are compared to modern and historical shoreline geomorphology to choose core locations. Cores are needed to confirm seismic interpretations and provide samples for textural analysis to determine suitability as borrow material.

Current results indicate that significant quantities of sand are present on the continental shelf. Sands occur in buried fluvial, tidal, and distributary channels, submerged beach ridges, barrier islands, and tidal deltas, and large shoals. Utilization of these deposits for beach nourishment depends upon the economics of dredging and the creation of leasing guidelines to permit use of sands from Federal waters.

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BARRIER ISLAND RECONSTRUCTION: BRIDGING THE GAP BETWEEN ACADEMIC RESEARCH AND ENGINEERING PRACTICES

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Introduction

Terrebonne Parish is losing vast areas of wetlands and barrier islands. Over a 23 year period of time, from 1955 to 1978, Terrebonne Parish lost 42% of its barrier islands (Wicker, 1980). In 1985, during Hurricane Juan, Terrebonne's Eastern Isle Derniers lost 10 - 20% of its land area (Penland, 1986). These islands are considered to be a key element in the short term survival of Terrebonne's wetlands. If the islands are lost, it is estimated that Terrebonne's land loss would accelerate geometrically. Shoreline erosion rates for these islands typically average 34 feet per year (Meyer-Arendt, 1982). Terrebonne's islands suffer much of their damange during severe winter storms or hurricanes. Normal tidal and wave action is mild and works to restore the islands (Mossa, 1985). This restoration is hindered by lack of sand lost in breaches and overwashes which occur during the winter storms and hurricanes.

With the disapperance of its islands and its severe land loss problems, Terrebonne began to seek ways to stabilize its coastline. If not stabilize, then at least extend the life of its islands and wetlands. Immediately a debate broke out in Terrebonne Parish, which mirrors the national debate of soft (natural) defense versus hard (structural) defenses. In 1982 a report prepared by consultants hired by the Parish concluded: "Shoreline erosion can be retarded by nourishing the beaches with introduced course sediments, and the loss of sand can be reduced by sealing off breaches and washovers and installing sand-trapping jetties in locations where longshore migrating sand enters major sink areas (Wicker, 1980). Debate in Terrebonne raged on. Two searches were initiated at this time; one for funds and the other for information.

By 1983 it was determined that: a) a preponderance of information available suggested that soft or natural coastal defenses were more cost effective in providing protection than hardened structures, and b) that funding for coastal protection in Terrebonne was not going to be available from any source other than Parish coffers. Although the State of Louisiana had by this time established the Coastal Protection Trust Fund with an appropriation of approximately $35 million, no procedure for disbursement had been established. In fact, as of this writing, no state Trust Fund monies have been spent on Terrebonne's barrier islands.

With this information and not receiving any action by the state, Terrebonne's lawmakers decided that: a) they wanted to begin the restoration of the island chain themselves; b) they wanted to settle the natural versus structural argument by implementing a natural approach to determine how it works; and c) they appropriated one million dollars to the project.

The one million dollar budget affected many of the decisions made througout the course of this project. The first project developed was to use Cat Island Pass dredge material for the restoration of a section of Eastern Isle Dernieres. This pass is located five miles away from the project site across open water.

Project Design

Over the last 18 years, the U.S. Army Corps of Engineers has contracted for eleven dredging projects of the Houma Navigational Canal at Cat Island Pass. In each of these projects, disposal of the dredged material has occurred in a designated subaqueous spoil area immediately adjacent to the Canal. Cat Island Pass was scheduled for dredging in the summer of 1984. Therefore, in the Spring of 1984, the Parish proposed to the Corps the use of this dredge material for barrier island restoration at Eastern Isles Dernieres, approximately 5 miles to the west of the Houma Navigation Canal. Several meetings were held with Parish and Corps officials which resulted in the Corps' willingness to allow the Parish the use of the material if the Parish handled and paid for the transport of the material (Edmonson, 1985).

Project design began by the Parish personnel immediately. The use of Cat Island Pass dredge materials for island restoration work dictated several design constraints for the project. The Corps' dredging project impacted the parish's project schedule, the type of material to be used in the project, and the geographical location of the parish's island restoration project.

The material to be obtained from the Cat Island Pass project contained between 5% and 70% fine material. The sand had an average Ø value of 3.02. With these material characteristics, it was decided that a settling pond had to be designed to maximize the retention of solids at the fill site. Ultra fine sand would require some form of protection. Work began on the design of retaining dikes and beach front to ring forty acres for use as a settling pond.

During preliminary design, the Staff began to locate a fill site. A large active overwash area was located at the eastern end of Isle Dernieres. This was as close a site as could be found near the Corp's Cat Island Pass Project. It was felt that the sand lens contained in the overwash area of the parish site would provide the needed foundation for the containment pond dikes and dredge material placement.

This site also satisfied several other objectives of the project. It provided a good source of material for construction of the dikes. Construction of the front dike with sand deposited on the washover fan resulted in a larger grain of sand for the beach foredune. This would serve to armor the fill material. Construction on the washover area also minimized the destruction of exisitng marsh habitat. Most importantly, cconstruction on an active washover prevented a major breach from occurring at this site in the future.

After selection of the disposal site was completed, a topographic survey was made of the work site. The site survey was extended 200 feet into the Gulf of Mexico. This bathametric information was used to determine the proper slope of the foredune to be established by placement of the front containment pond dike. Dikes eight feet in height with slopes of 7 1/2 to 1 were designed with borrow material to come from the washover fan contained within the ringed area. The front, dike paralleling the beach, would have a 22 to 1 shoreface slope.

Final designs called for 3,200 linear feet of barrier island to be reconstructed utilizing a fill site containing approximately 38 acres. This project was let for bids on August 16, 1984. Midway through the bidding phase of this project it became apparent that dredging contractors had serious misgivings about bidding the project. Various dredging contractors were consulted to determine problems associated with the project. Most comments concerned the excessive exposure of the dredge pipe to the open waters of the Gulf. Distance of transport was also sited as a major concern. Due to these concerns, the contractors estimated the cost of the transport pipe alone to be $1 million. Therefore, an addenda with an alternate for a dredge site 3,700 feet behind the island was prepared and issued.

At the close of the bid acceptance period one bid was received for constructing containment pond dikes. The bid for this alternate was $450,125.00. The bid was rejected because there were no bids received for the delivery of material and the cost for dike construction was considered to be too high.

Dredging companies were again interviewed to determine their problems with the project and its contract documents. The problem of risk and the potential for large losses was a common theme in their replies.

Therefore, a new set of contract documents were prepared based upon the alternate dredge site located adjacent to a tidal inlet. Sand quantity bid items were changed mainly in their method of measurement. The material from the alternate dredge site was of a much higher quality than from the Cat Island Pass Project with as much as 85% sand anticipated. Net section cut replaced net section fill as the pay unit for obtaining dredged material from the alternate dredge site. Measurement for payment for the dike placement could be demanded by the contractor after <u>200</u> feet of material placement. The changes in method of measurement shifted much of the project risk from the Contractor to the Owner. The project was again bid with three alternates on October 24, 1984. Bids were accepted on November 29, 1984.

Project Implementation

The bid of T.L. James for $841,980.00 to construct the dikes and to place fill material was determined to be the most economical bid for effecting the project. This bid allowed for construction of the project within budget. The contract for the project was executed on January 16, 1985. Work on the preliminary topographic survey began immediately to check levee alignments and overall design. It was found that in a three month period between surveys, the washover changed significantly enough to cause adjustments in levee alignment.

Work on the project began on March 2, 1985. The dikes were constructed by drag line excavation and placement. Shaping of the dike was accomplished by bulldozer. The front dike was partially placed by bulldozer. T.L. James issued a subcontract to LaBouve Dragline for this work. Work was accomplished in 2 1/2 weeks for the containment dikes and foredune. This was approximately 60% of the scheduled thirty day dike construction time.

T.L. James began erecting equipment for the dredge activities on March 14, 1985. The project was completed and the dredge was demobilized by March 31. Total elapsed time for the project was twenty-nine days. This was approximately one-half the time T.L. James had originally scheduled for the project. Construction was done in a professional manner.

There was one major storm during the project. This occurred while dike construction activities were in progress. Although the island was overwashed, no significant damage was done to the dikes that were already constructed.

The summer following construction, a vegetation and sand fence program was initiated as a summer employment program for area youths. Sprigs were planted, fences erected and a plot was planted with dune grass seeds. Notably, the grass seed did rather well. This shows promise for reducing revegitation cost on future projects. Also, the dunes erected with washover fan material were starting to be revegetated from material contained within the sand.

This project has withstood three hurricane surges. These surges were caused by Hurricanes Danny, Elana and Juan. Damages caused by Hurricanes Danny and Elana was minimal. The sand fence, a nylon open weave fabric, was knocked down and had to be re-erected after these two storms. Hurricane Juan caused more substantial damage. Part of the foredune was lost during this storm. As of this writing, bid documents have been prepared to replace the section of foredune lost and 60% of the project site has a vegetative cover established.

<u>Conclusions</u>

1) This project demonstrated that soft (natural) defenses could be effective in protecting Louisiana's coastline. This project is the model for the Louisiana Department of Natural Resources Phase I Coastal Protection Strategy.

2) In an era when local match funding is required for State and Federal spending, economy will have to be a key part of any coastal protection project. Lower levels of protection at an affordable cost might be constructed by a society rather than optimum protection at unaffordable costs.

3) Optimable material (Ø size) might not be affordable or necessary for

successful implementation of such a coastal protection project. Creative engineering can help overcome the disadvantages of less than optimable material.

4) Successful project implementation requires that as much attention needs to be paid to design details and contract writing as is paid to the technology involved in the project.

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CHANGING PATTERNS OF HUMAN ACTIVITY IN THE WESTERN BASIN OF LAKE PONTCHARTRAIN

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At one time, a great baldcypress (Taxodium distichum) and tupelo gum (Nyssa biflora) forest blanketed the lowlands which begin south of Ponchatoula, Louisiana, and rings all of Lake Maurepas and the western shore of Lake Pontchartrain. (Fig. 1). Now, most of the trees are gone, either the victim of the sawman's work, or the slow death caused by changes in the ecosystem. The region resembles nothing less than a battlefield, one in which the major combatants were man and nature, and one in which there were no winners. It is difficult to imagine that this forbidding landscape once bustled with economic activity and that hundreds of people made their permanent homes in villages located in the heart of the swamp.

More than seventy years ago, September 28, 1915, to be precise, it appeared that man had gained the upper-hand in his struggle to survive and prosper in the cypress forest, for human activity then far exceeded present-day levels.

Some of those working in the swamp were employees of the Illinois Central Railroad which cuts a forty-five mile swath through the western edge of the basin. Maintenance crews manned section stations established every five or six miles along the right-of-way and lived in quarters at the sites.

In addition to the railroad section stations, there were several villages adjacent to the line: Frenier, Ruddock, Manchac (Akers Post Office) and Strader. Some of these people also worked for the Illinois Central, some farmed, and others were employed in some aspect of the lumber industry. Many of the latter could be found toiling deep in the swamps sawing cypress and tupelo gum, primarily the former. By 1915, the lumber industry reigned as the economic mainstay of the region and the increasing efficiency of logging operations

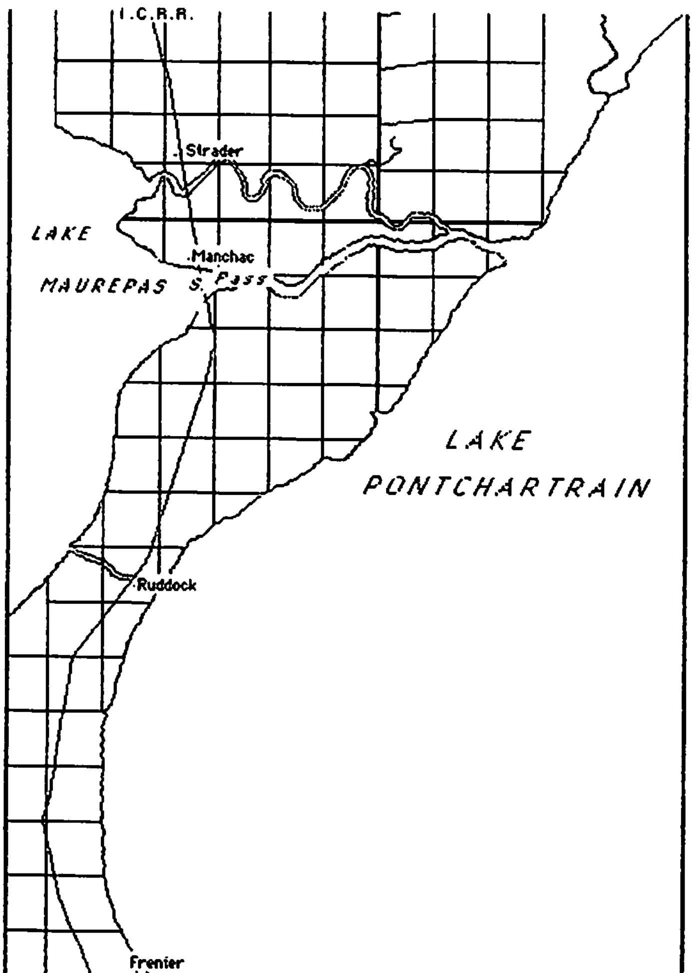
I.C.R.R.
Strader
LAKE
MAUREPAS
Manchac
S. Pass
LAKE
PONTCHARTRAIN
Ruddock
Frenier

Fig. 1

pointed to the day when all the trees would be cut and the cypress forest would become a thing of memories.

The demise of the logging industry, however, was still a half century in the future that September day in 1915. For the truck farming industry, the villages of Frenier and Ruddock, and scores of people living in the swamp, the future would hit early the next day,

September 29, 1915. For at that moment, one of the most powerful storms ever to strike the Gulf Coast of the United States was roaring across the Gulf on a northerly course, its eye locked in on southern Louisiana (New Orleans Times Picayune, 2-4 October 1915).

As the hurricane tracked west of New Orleans, it literally followed the right-of-way of the Illinois Central, destroying almost everything in its path. The low-lying cypress swamp was especially hard hit; both Frenier and Ruddock were blown into the swamp and would never recover. While the storm's force might be considered unique, the vulnerability of the area to hurricanes was not, for storms paid periodic visits to the region, one as recently as 1909 (Barbier, 1984)

The West Indian Hurricane of 1915 illustrated the difficulty of establishing either commerce or permanent community life in the Western Basin of Lake Pontchartrain. Although Pierre Le Moyne Sieur de Iberville first discovered that the waters of the two lakes and Pass Manchac could be used for navigation purposes, it was not until the early 19th century that commercial schooner traffic developed between small ports on the rivers draining into Lake Maurepas and New Orleans. By 1837 this trade provided the reason for the operation of the first lighthouse on a site where Pass Manchac empties into Lake Pontchartrain (Cipra, 1976).

The lighthouse stood for the next 17 years as the only man-made intrusion in the dense cypress forest of the region. It lost this distinction in 1854 when enterprising railroad men completed construction of the forty-five mile long swamp segment of the New Orleans, Jackson and Great Northern Railroad, a line which by the time of the Civil War linked the largest port city on the Gulf with cities on the Ohio River (Stover, 1955). Following the war, the railroad through the swamp became part of the Illinois Central Railroad, a system that extended from the Great Lakes to the Gulf.

The railroad's construction marked the beginning of the end of the cypress forest. Not only did the line cut down trees for the right-of-way, it used the timber to construct bridges, trestles and crossties. It also provided lumbermen, beginning in the 1890's, access to population centers north and south to market the wood.

There was never any question that cypress wood was an ideal construction material, for the wood was extremely durable and easy to work. All the lumbermen lacked, until 1883, was the technology to harvest trees in the swamp. That year, the invention of the steam powered skidder made possible two methods of hauling cypress logs from the swamp: pullboat logging and dunnage railroad logging (Bryant, 1923).

When the Strader Cypress Company began cutting trees on seven thousand acres north of Pass Manchac, in 1892, it used the pullboat system. Despite its limitations--pullboat logging was confined to natural waterways until lumbermen dredged canals--the Strader Cypress Company managed to cut enough cypress and tupelo gum to operate a sawmill at Strader, located on Owl Bayou one mile north of Pass Manchac (CRT 12:437; 17:82).

More lumber companies launched operations in the region and accelerated the depletion of the cypress and tupelo gum trees. The lumbermen used both the pullboat system and dunnage railroads to systematically reduce the size of the forest and clear-cut the land.

As logging increased in intensity, one company, the Ruddock Cypress Company, Ltd., constructed one of the largest and most modern sawmills in the southern region of the United States. The plant, located at the milltown of Ruddock on the Illinois Central operated until June of 1902 when a fire totally destroyed the mill. The fire raged out of control until firefighters arrived from New Orleans on the train (Picayune, 5 June 1902).

The cutting down of the trees continued on a major scale until the onset of the Great Depression of the 1930's when the market for cypress, or any other wood, plummeted. It was not until the reorganized Louisiana Cypress Lumber Company renewed production in 1936 that logging activity approached pre-1929 levels. From 1936 until 1956, when the company's mill at Ponchatoula sawed its last cypress log, Louisiana Cypress Lumber Company produced an average of 14.3 million board feet of lumber per year (LCLC Monthly Statements, July 1936-February 1956).

The closing of the mill at Ponchatoula brought to an end the sixty-four year history of the cypress industry in the Western Basin of Lake Pontchartrain. However, the legacy of those years lives on.

Aerial infra-red photographs show clearly the ruthless efficiency of the loggers. The entire region is scarred, either with the circular patterns gouged by pullboat logging or the parallel lines cut by dunnage railroads.

Pullboat logging required "swampers" to snake cut logs from deep in the swamp, as much as three thousand feet, to the boat. As the logs were being winched in, they cut narrow canals in the vulnerable surface of the swamp. By the time the loggers finished cutting a section, these "cuts," as they were called, were often as deep as five to six feet (Bourgeois, 1983).

The damage done by the dunnage railroads, while different, was equally as destructive. The dunnage railroad bed, made of sawdust and wood shavings, disrupted the natural flow of water through the swamp. Also, this method used an overhead skidder to winch in the logs from the swamp. The overhead skidder could transport above the ground as many as five or six large logs to the railroad cars. Unfortunately, the moving logs bowled over or maimed trees left standing, but in the path of the logs.

The wounding of the environment is an on-going process. Perhaps the most harmful result of logging is the increase in the flow of brackish water from Lake Pontchartrain into areas of the swamp where fresh water once dominated. The problem has been made more acute by the subsidence of the land, a result of the loss of the soil-holding root systems of the trees (Saucier, 1963).

The demise of the lumber industry meant more than a change in the land. It signaled the reduction of man's presence in the swamp. Gone was an industry that employed hundreds of workers toiling in the mills or cutting trees in the swamp. Gone, too, was a unique system of labor, one which utilized highly specialized tools and equipment and one-of-a-kind workers. "Swampers," were men with rare skills and an affinity to live and work in an environment that held little appeal to other men.

Most of the lumber workers had specific duties. On the pullboats, crews consisted of deckmen, firemen, wood passers, and engineers. Out in the swamp were the plug setters, sliders, "saws" (two-man crews using six-foot crosscut saws) and whistle blowers (Bourgeois, 1983).

Whistle blowers were important to every crew, because they were the only means of communication between the men working in the swamp and the workers operating the winches. For this reason, no two whistle blowers had the same signal system. Most of them used varying patterns of long and short "toots", but the man who whistled for Fernwood Industries employed a "talking whistle," a sound impossible to capture on paper (Ramsey, 1985).

When the cypress industry ended, the workers not only lost the opportunity to employ their specialized skills, many of them had to change their lifestyles. A number of the "swampers" lived with their families in the small communities of the basin such as Ruddock, Frenier, Strader and Manchac. They supplemented family income, when not working for the lumber companies, with other means such as fishing, shrimping, trapping, hunting, boat building and moss gathering. Most of these activities, the exceptions being fishing and shrimping, declined when the trees were removed. Moss gathering was an early casualty.

Although the growing popularity of synthetics would have doomed the moss industry eventually, it suffered a premature end because of the reduction of the forest. While no one earned great wealth, moss gatherers could get as much as six cents a pound for moss at the gin where it was processed and pressed into bales. The finished product provided padding for furniture and automobile upholstery (Kraemer, 1984). It goes without saying that since Spanish moss grew on trees, the removal of the trees meant the end of Spanish moss.

However, while it lasted, the moss industry did provide a source of needed revenue for families living in the swamp. The United States Census of 1900 listed it as one of the major occupations of persons living in Ruddock and Frenier (U. S., Department of Commerce, Bureau of the Census, 1900).

Another occupation to suffer from the cutting down of the trees was boat building. In some cases swampers carved their own pirogues (a dugout canoe found everywhere in southern Louisiana) out of solid cypress logs (Heath, 1984). There were also professional boat builders in the region who constructed boats of varying size, from the pirogue up to houseboats with four or five rooms. The larger craft required the use of "tank grade" cypress planks at least three inches thick. This aspect of the industry had added importance because many of the swampers lived on houseboats which could be moved to accommodate the needs of the workers in the lumber industry (Kraemer, 1984).

The industry has not totally disappeared, because boats--the Manchac skiff--are still being made in Manchac, but fiberglass has taken the place of cypress as the primary building material.

The decline in cypress trees has also changed the maintenance program of the Illinois Central. When trees were abundant, the railroad had section crews housed at intervals along the track. When ties needed replacement, the crew or an independent contractor cut down trees and carved the eight foot by eight inch ties out of the logs with an adz (Reno, 1983).

Although it is obvious that the clear-cutting of the cypress forest resulted in the end of several petty enterprises dependent on a supply of trees, it is more difficult to state with certainty how or why the despoliation of the forest contributed to declines in the trapping of fur-bearing animals and the hunting of both waterfowl and game animals such as deer, rabbit and squirrel.

At this time, scientific data detailing the population losses of waterfowl, deer, squirrel, mink and rabbit are not available. One can only rely on the testimony of persons who lived in the area more than fifty years ago. They recall that game abounded in the swamps. One of these witnesses remembers that in the 1920's he could see herds of deer, "like cattle," along the shore of Lake Pontchartrain (Dagruy, 1984). Swampers desiring a venison roast only had to select a deer from a herd of twenty or more and shoot it (Ibid).

It is true that extensive logging operations produced physical changes in the basin's vegetation. But other factors have helped alter the animal population. The introduction of the South American rodent, the nutria, has injured the muskrat population all over southern Louisiana. Furthermore, increased hunting and greater accessibility (interstate highways and boat launches) have, understandably, contributed to the decline of game animals.

Yet, the increased accessibility is, in part, a direct result of logging practices. The many man-made canals allow sportsmen to reach areas of the swamp by boat that would have been difficult to enter on foot. Furthermore, the removal of the trees and the changes in vegetation, such as the decline in the number of palmetto palm, have reduced the cover for game animals, making them easy prey for hunters.

Not all the physical changes were caused by the loggers. At one time, in the late 19th and early 20th centuries, the communities of Ruddock and particularly Frenier served as the centers of a successful winter and spring truck farming enterprise, which required removal of trees and drainage of the land.

These small communities, both settled by German immigrants in the mid to late 19th century, became famous for the size and quality of lettuce and cabbage grown in the rich, black "coffee ground" earth. Martin Schloesser, the region's first settler, started a wood stave business but soon became interested in the growing potential of the soil. He sent back to his native land for cabbage and lettuce seed which he planted and got more than satisfactory results (Bank of St. John, 1974).

The truck farming industry built by Schloesser and the other immigrants is in some ways a classic example of people taking advantage of and trying to improve upon their environment. On the positive side, the soil, rainfall and temperature in the winter and early spring were ideal for raising cabbage and lettuce. On the negative side, the low-lying lands between the two lakes were flood prone and highly vulnerable to hurricanes which periodically raked the area.

As a result, the residents constructed entire communities and sidewalks on pilings. Most houses stood at least eight feet above the soupy ground (Reserve (La.) L'Observateur, 20 January 1972). To prevent flooding of the farms, the residents built a system of levees around each farm. These levees also served as foot paths linking all the farms in the community (Ibid.).

By the early 20th century, the hard-working German farmers made the cabbage and lettuce grown in the swamp well-known throughout the nation and were shipping, by rail, their produce to Chicago. As the fame of their product grew, so did the communities of Ruddock and Frenier. By 1910 Ruddock counted over seven hundred residents (Fortier, 1914) and Frenier had close to two hundred (U. S., Department of Commerce, Bureau of the Census, 1910).

The citizens of Frenier were especially proud of their community. In 1894, Monsignor Leander Roth of Kenner, Louisiana, contributed $150 towards the construction of the Holy Cross Church. It became a focal point of village life, and the parishioners used the church for baptisms and marriages. Funerals, however, were held five miles north of Frenier on an Indian shell mound--the only "high" ground for miles (Vicknair, 1971).

Frenier made another giant stride in 1914 when the community opened the doors of its first school. Unfortunately, the school had a brief history, because it, and the village of Frenier, were blown away by the 1915 West Indian Hurricane (Ibid.).

Survivors of this disaster, who are still alive, can still recall the horror of the tempest which hit the area with awesome force on September 29, 1915. By the time the storm roared out of Louisiana heading to the northeast, it left in its wake over 350 dead and property damage in the millions of dollars (Picayune, 2-4 October 1915).

For the communities of Frenier and Ruddock, there would be little rebuilding. What was left of both communities was strewn across a wide section of the swamp. Fatalities were high in both places, twenty-five dead at Frenier (Ibid.), and at Ruddock rescue workers spent days searching for survivors and burying the dead (Baton Rouge Morning Advocate, 17 August 1979).

Survivors of the storm and others--trappers and hunters--did return to the area in small numbers in the years immediately following the hurricane. At Ruddock they established camps in railroad boxcars blown into the swamp during the storm (Bank of St. John, 1974). And, at Frenier, there was some hope as late as 1922 that the community could once again become "one of the important towns of this (St. John the Baptist) parish." (Laurent, 1922). It did not. Today there is not a trace of either Frenier or Ruddock, save for some old pilings at Frenier Beach on the shore of Lake Pontchartrain.

The writer who, in 1922, predicted that Frenier would once again become a thriving community pinned his expectations on the area's natural beauty and potential as a tourist center. While he missed the mark on the Frenier area, the Manchac region to the north did develop, in part, as a vacation or week-end retreat community.

The recreational use of Pass Manchac dates from 1907, when the millionaire brewer and businessman from New Orleans, Edward Schlieder, acquired a 5,500 acre tract of cut-over cypress land from the Salmen Brick and lumber Company (Schlieder served on the board of directors). On this site, now known as Turtle Cove, located on the southern shore of Pass Manchac about a mile from Lake Pontchartrain, Schlieder constructed the most elaborate dwelling in the swamp. In addition to the two-and-a-half story main building, Schlieder added a large boathouse, a caretaker's home and a dock long enough to accommodate his seventy foot motor-driven yacht. All the construction material and equipment, including a steam-powered dredge, had to be barged to Pass Manchac from New Orleans (Succow, 1984).

Schlieder spared no expense, nor did he deny himself any luxury. The camp had electric lights and a walk-in refrigerator powered by a gas generator. The refrigerator often contained sides of beef, fresh vegetables, fruit and, at times, carcasses of deer slain on the property. Mrs. Josephine Heath, who lived on the property as a young girl fondly recalls that the "place was like a piece of jewelry." (Heath, 1984).

Few could afford to build camps as luxurious as Schlieder's, but prior to World War I, several more vacation camps, primarily for hunters and fishermen, appeared in the Pass Manchac area (Succow, 1984).

The construction of camps and week-end retreats has accelerated since the closing of the cypress logging industry in 1956. Improvements in transportation systems have made the region more accessible. The first road (unpaved) linking communities north of the Pass with New Orleans opened for traffic in 1926 (Jones, 1984). That first road brought about a profound change to the swamp. It reduced the necessity of people to establish permanent homes in the area and do without the basic attractions of community life, schools, churches and commercial outlets. Eventually the road was surfaced with blacktop and in 1965 a new and wider highway was completed, U.S. 51, which, unfortunately, closed to traffic that same year when Hurricane Betsy damaged a portion of the highway (Morning Advocate, 11 September 1965).

The difficulty of building and maintaining highways on the marshy surface of the swamp led federal and state highway planners to construct I-55 above the swamp on pre-formed concrete sections. This project was completed in 1979, and there is now an elevated highway that extends from just south of Ponchatoula to metropolitan New Orleans (Picayune, 26 May, 1979). This highway has only two exits between Ponchatoula and LaPlace; Manchac and Ruddock. Both sites contain public boat launches which have contributed to an increase in recreational activity in the waters of Pass Manchac and the many man-made canals dredged by the lumber companies and highway construction crews.

Not all the people using the waters of the area are visiting sportsmen, for the village of Manchac has survived. Most of its residents earn their living in one or more aspects of the seafood industry. It would be safe to say that if the catfish, crabs, and shrimp disappeared, there would be little reason for Manchac to exist.

Therefore, it is important to the professional fishermen of Manchac and visiting sportsmen, that the water quality of the Pass Manchac area be maintained. Unfortunately, this does not appear to be the case. Recently, in 1984, the Department of Biological Sciences at Southeastern Louisiana University completed a year-long study of the water quality of Lake Maurepas and Pass Manchac. They concluded that "in regard to water quality as measured by coliform densities, the lake does not meet federal and state regulations for its current uses, i.e. recreational and commercial activities." (Childers, 1985).

If the rate of pollution of the waters of the Western Basin of Lake Pontchartrain is not reversed, the presence of man in the region could revert back to what it was in 1699 when Iberville made his historic voyage. If this were to happen, however, only the absence of man would be the same, for the scenes witnessed by Iberville, verdant cypress and tupelo gum forests teeming with wildlife will be replaced with a landscape ravaged by man. The few trees remaining, but slowly dying, will provide less cover for declining species of game. And, the waters which flow through the region will be as devoid of life as the mutilated swamp.

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THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

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Abstract only

THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM: PAST ACTIVITIES AND FUTURE DIRECTIONS

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The National Estuarine Research Reserve System (formerly National Estuarine Sanctuary Program) was established in 1986 with legislation that reauthorized the Coastal Zone Management Act of 1972 (CZMA). The mission of the System is the establishment and management, through an equally-shared Federal-State cooperative effort, of a national system of estuarine research reserves representative of biogeographical regions and estuarine types in the United States. National estuarine research reserves are established to provide opportunities for long-term research, education and interpretation. Scientific and educational programs are particularly focused on the development of information for improved coastal management decisionmaking.

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SITE DIVERSITY AND MANAGEMENT APPROACHES

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Fourteen states and the Republic of Puerto Rico currently participate in the National Estuarine Research Reserve System. System components can be found in nine of the fourteen Atlantic Coast states, two of the five Gulf Coast states, three of the four west coast states, a Great Lakes state, and Hawaii. Important similarities and differences exist between component sites in terms of both physical/biological characteristics and the surrounding environment. Several sites are located in natural areas; others in areas that have undergone agricultural, industrial or urban development. Because of these differences, various management approaches are employed at the different sites.

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RESEARCH OPPORTUNITIES

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The first National Estuarine Reserve Research System (NERRS) site was established in 1974. Program efforts between 1974 and 1982 were focused on selection and acquisition of additional sites. In 1982, some funds were provided for research projects involving baseline studies and monitoring activities. Generally, these projects were related to local/regional management issues. As the need for acquisition decreased and program emphasis shifted to accomplishments, funding for research increased from a few thousand dollars to $500,000 in FY 1986. The number of projects increased concurrently from a few in 1982 to 44 projects in 1985. With the reauthorization legislation (CZMA) of 1986, the research emphasis of the National Estuarine Research Reserve System was shifted. Emphasis is now directed to projects of national rather than local significance. The increased opportunities for research created by this new emphasis is the topic of this paper.

In examining the increased opportunities for research, advantages to researchers in using the NERRS sites will be discussed first. Then, program changes within NERRS to encourage research will be considered. Next, national estuarine research priorities will be described. Finally, national estuarine management issues will be presented.

Advantages to Researchers in Using NERRS Sites

NERRS consists of a network of protected estuarine land and water areas easily accessible to scientists. Every component of the system has a manager who can assist a research team. Many sites have on-site facilities ranging from research laboratories and boats to housing for investigators. Within a few years, most sites will have computers available to augment the storage and retrieval of information from earlier conducted research.

In the protected sanctuaries, scientists can collect long-term data. A long-established research or monitoring site is invaluable in the development of new research aimed at solving specific ecological problems. Long-term data sets will provide information on status, trends and episodic events that enhance the ability of scientists to understand basic estuarine processes.

Reserve sites can also play a role in comparative studies. Standardized data collection will facilitate comparative analysis and information exchange within and between biogeographic provinces.

Most estuarine scientists are interested in making a contribution to their field of science, and also in seeing their data used to solve major coastal problems. NERRS can assure estuarine scientists that their research at sanctuary sites may be used to address coastal management problems.

For estuarine data to be useful, it must be transmitted quickly to agency managers, other scientists, and the general public. Because of the research and coastal management role of NOAA, NERRS can rapidly transfer research data critical to coastal management issues.

NERRS provides a unique opportunity to address national research questions and estuarine management issues. To fully utilize this opportunity, the program has strongly expressed a willingness to work with the scientific community to publicize the availability of NERRS sites, their unique/unusual resources, their facilities and amenities, and the results from research conducted on the sites.

Program Modifications and Activities

With the shift in focus from local to national research questions and management issues, NERRS has initiated efforts to make their program more attractive and responsive to the estuarine research community. Several steps initiated, or undertaken, are described below. These steps, coupled with moving the NERRS office to the newly established Estuarine Program Office in NOAA should greatly enhance the research productivity of the reserve system.

NERRS is now in the process of revising their announcement of research opportunities to provide a document that will be more useful to estuarine scientists. Special attention is being given to describing the national research priorities of the program as well as the proposal review procedures and criteria. The announcememt of research opportunities will be published in the Federal Register. In addition, the announcement will be distributed to universities, federal and state agencies, and to estuarine scientists and administrators of coastal/marine laboratories.

A number of reserve sites are located reasonably near major research institutions. These institutions often have programs in estuarine-related sciences and graduate students entering these programs. Therefore, NERRS is considering the establishment of a graduate fellowship program to attract students to their sites.

A NERRS site catalog will be prepared to provide interested parties with specific information about the reserve system sites. The catalog will contain detailed information about individual sites and general information about NERRS. Site specific descriptions will include information on site location, size and biological assemblages. Also included will be a list of publications resulting from research conducted on the site and a list of research currently being undertaken. More importantly, the site descriptions will present information on any unique/unusual characteristics the site may possess. The general information about the national program will list the various sites, their location, their unique/unusual characteristics, and the source for additional information about the site.

Often agencies that support research can only partially fund even the most meritorious proposals. Therefore, NERRS will identify projects that are only partially funded and will consider providing complementary funding if the investigators agree to undertake the research on a NERRS site.

All states having a NERRS site also have a Sea Grant College Program. The National Sea Grant College Program was established to accelerate the development, use and conservation of the nation's marine and coastal resources. To achieve this objective, Sea Grant combines the research skills of university scientists from all disciplines with a strong commitment to make research findings available to the public through a network of advisory and education specialists. Technical and public information reports, conferences, workshops and personal contacts by Sea Grant marine agents and researchers ensure that information relevant to the wise use and development of marine resources reaches those who need it. NERRS is considering the establishment of closer linkages with the Sea Grant College Program to better utilize the Sea Grant mechanisms for information transfer. NERRS sites in several states already have joint projects with Sea Grant universities.

Estuarine research is either undertaken or supported by several federal agencies: NOAA (which includes the National Sea Grant College Program, the National Marine Fisheries Service, and the National Ocean Service), National Science Foundation, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service. Support is also provided by various units of state government, foundations and private industries. Much of the estuarine research supported by these agencies is appropriate for reserve sites. NERRS will make every effort to encourage estuarine researchers being supported by the other agencies to use their sites.

NOAA is actively developing a national estuarine research plan upon which to focus its various components of research, management and monitoring. We strongly urge the incorporation of the National Estuarine Reserve Research System into the Estuarine Program Office so that proper emphasis can be achieved. Use of those national resources illustrated by the reserves can play a prominent role in the overall estuarine research program led by NOAA. It is very important to emphasize that research activities be driven by research issues rather than by management issues.

National Research Priorities

Although large data sets exist for many fundamental processes of estuaries, there are several serious deficiencies in the information needed to understand the complexities of how most estuaries function. In 1984, some of the nation's most capable estuarine researchers gathered in Raleigh N.C., for the first in a series of national estuarine symposiums. Based on the latest scientific information and protocols, the researchers recommended research directions for better understanding estuarine functions. This assessment resulted in five categories of problem-oriented estuarine research. All five categories of research can be conducted on NERRS sites. Moreover, the National Estuarine Reserve Research Office is likely to place emphasis on these categories in program development. The categories are:

1. Water management and estuarine productivity

One of the most important problems currently facing our nation is the allocation of freshwater resources. As municipal, commercial, industrial, agricultural and recreational demands for water increase, availability of water to estuaries decreases. Changing land use near the estuaries and upstream tributaries affects the quantity, quality and timing of freshwater inflows. Since estuaries, by definition, involve the inflow and mixing of fresh and salt water, these variances may impose significant changes on estuarine productivity. The relationship between freshwater inflow and productivity in the estuaries poses an exceedingly important research question. We need to know the quantitative relationship between freshwater inflows and fisheries production in estuaries. In addition, we need to determine how much fresh water is too much or too little on a seasonal and annual basis.

2. Sediment management and estuarine productivity

Sediment quantity and quality can affect estuarine productivity. Man's activities in the watershed can affect sediment processes such as the rate of accumulation and contaminant absorption. To better understand sediment management, researchers need to examine the rates of accumulation and the changes in sediment composition between points of entry and accumulation. Scientists also need to categorize the processes controlling the movement, absorption and desorption of contaminants and develop the capability to predict the relationship between sediment accumulation and habitat type for a range of environmental conditions.

3. Nutrients and other contaminants and estuarine productivity

There are increasing nutrient problems in estuaries. More people are living near our nation's coast. The resulting increased use of inorganic fertilizers and conversion of wetlands to urban and agricultural use overloads the estuary's ability to act as a nutrient and sediment sink and increases estuarine nutrient levels. We do not yet understand the relationships between nutrient inputs, recycling and production. Researchers need to test how an estuarine ecosystem responds to combinations of nutrient inputs and recycling. And scientists should examine the fate of synthetic chemicals and metals in estuaries.

4. Coupling of primary and secondary productivity

Estuarine ecosystems are characterized by high levels of primary and secondary productivity. The relationship between primary and secondary production is uncertain. Thus, the importance and ecological efficiencies of food chain pathways remain unresolved. Food chains in estuarine ecosystems are connected quantitatively and qualitatively. We must understand the relationship between quantity of biomass at one producer level and the quantity and quality of biomass at the next level. The concept of the trophic structure in an estuarine ecosystem is more of a food web than a food chain. Moreover, the food web trophic structure found in the estuary if generally abbreviated compared to the longer food chain found in the ocean and the open water of the Great Lakes. The problem of understanding the fundamental aspects of this issue is difficult because of the likelihood that a change in one trophic level impacts other portions of the ecosystem by altering the directions or size of energy flow from one component to another.

5. Habitat requirements for fisheries production

Estuaries act as nurseries for important commercial and recreational fish and shellfish. But some estuaries produce more fish than others. Understanding the role of estuarine habitat and quantitative differences in fisheries production will provide the key to more effective fisheries management. To find out what makes one estuary more productive than another, scientists need to address questions about habitat selection, species migration, species residence time, food quality and the effects of environmental variations on survival, growth and movement of fish and shellfish.

National Estuarine Management Issues

Recently efforts have been made to identify the most relevant coastal management issues facing the United States. These efforts have included researchers, managers and public interest groups through various public meetings, management conferences and symposia throughout the country. These efforts have culminated in the second national estuarine symposium held in Baton Rouge, Louisiana during November 1985. At this symposium, prominent U.S. estuarine experts concluded that a better understanding of the following seven issues represented our most critical national estuarine management needs:

1. The relationships between physical and chemical variables and the productivity of estuarine ecoystems;

2. The effects of foreign substances, especially pathogenic materials and toxic chemicals, on the chemical and biochemical processes in the estuarine environment;

3. The impact of man's activities on the fundamental functioning of estuarine ecosystems;

4. The appropriate measures for ameliorating undesirable effects and reclaiming damaged estuarine ecosystems;

5. The means to increase harvest of fisheries products;

6. Methodologies to improve the economic return of land around the estuaries by resolving the conflict between land use changes and estuarine productivity; and

7. The optimum stream flows into the estuaries that will maintain native populations and ecosystem functions.

All seven issues are of interest to the National Estuarine Reserve Research System. In all likelihood, NERRS will encourage investigators to conduct scientific studies on its sites that are related to these seven issues.

Summary

The National Estuarine Reserve Research System has shifted its focus from local to national research questions and management issues. As a result of this shift, NERRS has undertaken or initiated a number of steps to make the reserve system more responsive to the needs of the estuarine research community. The effectiveness of this important estuarine program could be enhanced even further if NOAA would shift the reserve program to the newly created Estuarine Program Office.

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ESTUARINE MANAGEMENT AT THE ROOKERY BAY NATIONAL ESTUARINE RESEARCH RESERVE

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Rookery Bay is one of 17 National Estuarine Research Reserves located in the United States. The Reserve is a joint Federal and State program involving NOAA's Division of Marine and Estuarine Management and the State of Florida, Department of Natural Resources. The purpose of the National Estuarine Research Reserve Program is to preserve and protect estuarine areas so that they may be used as sites for research and education.

The Rookery Bay site is located in southwest Florida along the Gulf of Mexico coast between Naples and Marco Island. The 8,400 acre site is dominated by extensive mangrove forests and a reticulated system of bays and tidal creeks.

Management programs are designed to emphasize protection of the resource. This is in response to the potential for habitat degredation resulting from urbanization and agricultural development of Reserve's watershed. A major concern is the effects of changing quantity, quality and timing of freshwater entering the Rookery Bay estuary.

The management programs of Rookery Bay have been designed to address these concerns. The areas of program management include resource protection, research and education. The resource protection program is divided into four components: managing the resource's vulnerability to development threats; controlling public access; restoring disturbed habitats and developing individual management plans for each major vegetative community in the Reserve.

The research program is designed to increase scientific knowledge about Rookery Bay and apply this information to the management of the area. A high priority is being placed on conducting systems studies and a long term environmental monitoring program.

The education program is intended to increase resource protection and management into two ways. First is to create a more informed public by traditional environmental education programs. Second is to provide educational opportunities for professionals involved in education, regulation and policy development of the coastal zone. To achieve this goal the Reserve will sponsor workshops and serve as a regional environmental clearing house on coastal zone issues.

By providing a highly protected resource, maintaining its natural features, conducting research and developing environmental education programs, the Reserve hopes to significantly contribute to our knowledge and understanding of the coastal zone.

MANAGING LIVING RESOURCES

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RESOURCE INVENTORY OF THE FLORIDA BIG BEND REGION

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Introduction

The curve of Florida's west coast between Ochlockonee Bay and Tarpon Springs defines the Florida Big Bend, an area considered valuable by both environmental and commercial fishing interests. The Florida Big Bend area was nominated as a Marine Sanctuary under the National Marine Sanctuary Site Evaluation of 7 June 1983 (Chelsea International Corporation, 1983) and placed on the Site Evaluation list for further study and consideration (48 Federal Register 35568-1983).

Extensive seagrass beds occur in the region (Phillips, 1960; Moore, 1963; Earle, 1972; McNulty et al., 1972; Enos and Perkins, 1977; Iverson and Bittaker, in press). Species reported include *Thalassia testudinum* and *Syringodium filiforme*, which develop dense stands in the nearshore zone; and *Halodule wrightii*, *Halophila decipiens*, and *H. engelmanni*, which are fringing or pioneer species seen around the edges of the major beds. Macroalgal species of *Caulerpa*, *Udotea*, *Penicillus*, and *Sargassum* are also common in these seagrass beds (Iverson and Bittaker, in press).

Seagrasses and macroalgae are important primary producers in marine habitats (Mann, 1973; McRoy and McMillan, 1977). They also provide nursery grounds for sport and commercial fish species and habitat for many larval and adult invertebrates critical to nearshore food chains (Zimmerman and Livingston, 1976; Phillips, 1978; Dawes et al., 1979).

Recent interest in offshore oil and gas exploration in the Big Bend area produced concerns about possible environmental impacts to seagrasses and associated biota. In response, the Minerals Management Service (MMS), as the Federal agency responsible for prediction and management of oil- and gas-related environmental impacts, initiated the Florida Big Bend Seagrass Habitat Study. Study results are being used in buffer zone discussions associated with upcoming eastern Gulf of Mexico lease sales and in formulation of lease sale biological stipulations.

Earlier studies had summarized published reports on seagrass distributional patterns, and qualitatively estimated the acreage of seagrass beds and live-bottom areas in the eastern Gulf of Mexico (Phillips, 1960; Moore, 1963; Earle, 1972; Parker et al., 1983). Between 1974 and 1980, Iverson and Bittaker (in press) used teams of scuba divers to map the major nearshore seagrass beds (water depths <10 m) in the Florida Big Bend area, and several seagrass mapping studies using combinations of aerial imagery interpretation and direct observation had been performed at specific sites along Florida's northwest coast (Withlacoochee Regional Planning Council, 1982; Continental Shelf Associates, Inc., 1983, 1984, 1985). However, prior to this study, overall seagrass distribution patterns within the Florida Big Bend area were poorly known. Very little study had been devoted to the seagrass/algal beds known or presumed to extend offshore beyond the 10 m contour.

The Florida Big Bend Seagrass Habitat Study was designed to map seagrass distribution patterns in both nearshore (<10 m) and offshore (10 to 20 m) portions of the Florida Big Bend area. The study encompassed approximately 1.5 million ha (3.7 million acres or 5,830 mi^2) of seafloor. Study objectives were as follows:

1) To map and inventory seagrass beds in the Big Bend area using a combination of aerial photography (remote sensing) and shipboard "ground truth" surveys.
2) To determine the seaward extent of the major seagrass beds.
3) To classify and delineate major benthic habitat types in the area.

Materials and Methods

This study consisted of three phases:

1) A pre-overflight ground-truth cruise (Cruise 1);
2) Remote sensing overflights of the study area; and
3) A post-overflight ground-truth cruise (Cruise 2) to verify interpretation of remote sensing data.

During Cruise 1 (24 October to 1 November 1984), 1,232 km (144 mi) of seafloor between the 10- and 20-m depth contours were surveyed using underwater television. Loran-C navigational fixes and designations of bottom type were recorded at 5-min intervals during television tows. Fifty representative "Signature Control Stations" were established to aid aerial photographic interpretation by providing locations of known seagrass density to check against signatures seen on the imagery. At each station, large, floating targets were deployed and divers took quantitative photographs of the seafloor to determine seagrass density and species composition.

Between 30 October and 15 November 1984, aerial photographs were taken along 26 north-south flight lines encompassing 2.1 million ha (5 million acres or 8,200 mi^2) of seafloor. Standard Kodak 23 cm x 23 cm (9 in. x 9 in.) color print film was used. Scale on all photographs was 1:40,000. During Cruise 2 (19 to 27 February 1985), nine additional transects [174 km (108 mi)] were surveyed using towed divers and underwater television, and 11 of the 50 Signature Control Stations established during Cruise 1 were resampled.

Aerial photographs were analyzed stereoscopically, and seagrass beds were categorized by density (dense, sparse, or patchy) as determined by interpreting "photo-signature characteristics" such as tone, color, texture, and size. Signatures of submerged seagrass beds ranged from dark blue-green offshore to light-medium brown in nearshore areas influenced by tidal fluctuations. Areas of nonvegetated sand bottom (white signature) and nonvegetated mud bottom (brown signature) were also recognized in the photographs. Live-bottom habitats characterized by hard corals, gorgonians, sponges, and other epibiota associated with low-relief rock outcrops or rock covered by a thin sand veneer could not be differentiated from surrounding seagrass beds at the 1:40,000 scale of the aerial photographs.

Six hundred photographs were interpreted and distributions of the major habitat types were outlined on clear acetate. These interpretations formed the basis for a 1:40,000 scale map of the study area. A reduced Composite Map (scale 1:250,000), which can be superimposed directly on the 1:250,000 scale MMS protraction diagrams, was produced.

Results

A total of 1.5 million ha (3.7 million acres) was mapped from the aerial imagery during the study (Figure 1). Mapping delineated 232,893 ha (575,479 acres) of dense seagrass beds, 498,034 ha (1,230,643 acres) of sparse seagrass beds, and 279,722 ha (691,195 acres) of patchy seagrass beds.

Study results indicate two major groupings or species associations of seagrasses in the Florida Big Bend area. An inner (nearshore) association of *Thalassia testudinum*, *Syringodium filiforme*, and *Halodule wrightii* occurs in water depths of less than 9 m. *Thalassia testudinum* grass and *S. filiforme* form dense beds that are easily detected in aerial photographs, and only at the southern end of the study area do the dense beds extend into Federal waters (Figure 1). Seaward of these dense seagrass beds is a zone where five seagrass species may be seen: *T. testudinum*, *S. filiforme*, *H. wrightii*, and two additional species: *Halophila decipiens* and *Halophila engelmanni*. Farther offshore, large areas of continental shelf between approximately the 10- and 20-m depth contours support a mixed macroalgal/seagrass assemblage in which the two *Halophila* species are the only vascular plants. This assemblage extends beyond the 20-m depth limit of this study and is abundant to at least the 23-m depth contour.

Thalassia testudinum and *S. filiforme* are the largest seagrass species in the Big Bend area, and their blades trap sediment from the

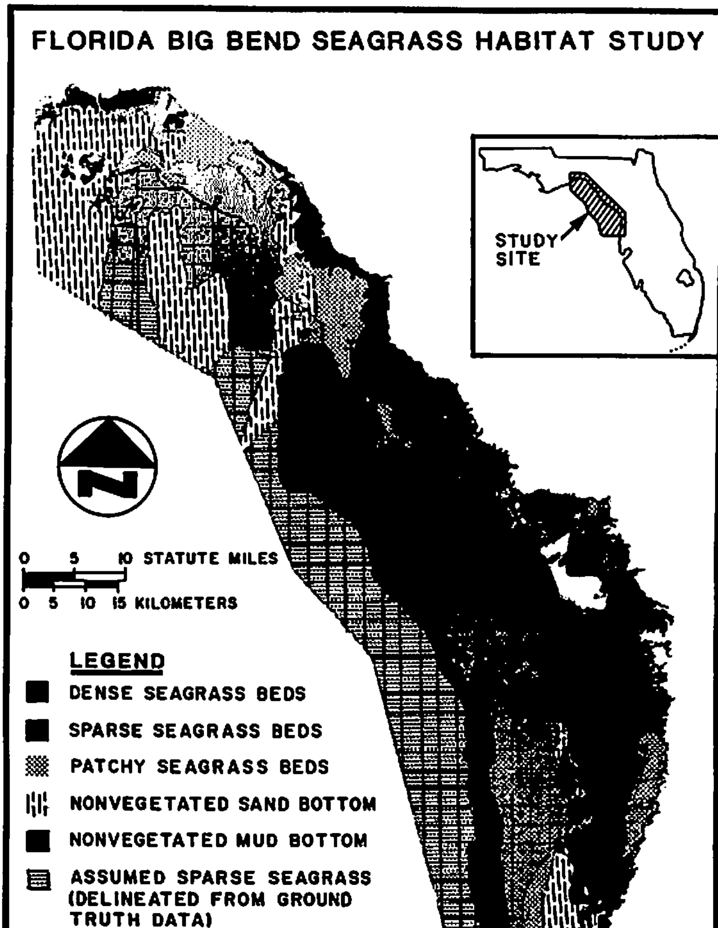

FIGURE 1. FLORIDA BIG BEND SEAGRASS DISTRIBUTION-BASED ON AERIAL AND GROUND DATA.

water column, thereby helping to build seagrass beds. Halodule wrightii and the two species of Halophila are much smaller and generally are considered to be fringing or pioneer species that inhabit the margins of major seagrass beds and tolerate environmental conditions not suitable for the larger species.

The unique aspect of seagrass communities in the Florida Big Bend area is the extended nature of the deeper, fringing zone dominated by H. decipiens, H. engelmanni, and various macroalgal species. Ground-truth data indicate that macroalgae account for an average of 21% of total blade density seen here. Ground-truth data also indicate that approximately 44% of the area mapped as sparse seagrass beds on the basis of aerial photographs, was live-bottom habitat that could not be differentiated from seagrass beds in the aerial imagery.

In addition to the spatial zonation patterns of seagrasses noted in this study, seasonal variability in seagrass bed density and species composition was evident, especially in the sparse offshore beds. At most offshore Signature Control Stations sampled during Cruise 2 (February), blade densities were 50% to 90% lower than those noted during Cruise 1 (October to November), and H. decipiens had disappeared. Halophila engelmanni persisted, but many instances of wave stress and uprooting were evident during Cruise 2. Temperature, light, and wave action are likely to be important variables influencing both spatial and seasonal abundance patterns in these deep seagrass beds.

The ecology of deepwater seagrass/algal beds in the Florida Big Bend area has not been studied, but these habitats could play important roles in this productive environment. Future studies should focus on primary productivity, influential environmental variables, and associated flora and fauna of Big Bend area seagrass beds.

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Abstract only

BUFFER ZONES IN WETLAND MANAGEMENT PRACTICE

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The coastal zone features a diversity of wetland types of varying size, type and importance; from large forested fresh water wetlands to narrow strips of salt marsh. Development can adversely affect adjacent wetlands through increased runoff, sedimentation and the introduction of chemical and thermal pollutants. Buffer zones are strips of vegetated land, composed in many cases of natural ecotonal and upland plant communities which separate development from environmentally sensitive areas and lessen these adverse impacts of human disturbance. In addition, buffer zones provide erosion control and flood protection for residential areas.

The definition of buffer widths appropriate to provide adequate protection to wetlands under different development situations has long been a point of contention. On-site soil characteristics, vegetation cover, topography, climate, and land use patterns, and human/wildlife/plant population densities all determine the extent of development impacts and, consequently, the appropriate buffer width. Many states have set a minimum allowable wetlands buffer width and increase the distance depending on the intensity and type of land use. Widths ranging from 0 to 1000 feet have been variously set with and without data support. If the establishment of effective buffer zones is to be incorporated into management policies, then there has to be supporting data. Additional studies are needed to define the criteria affecting effective buffer width.

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A COMPARISON OF ALLIGATOR HARVEST TECHNIQUES

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Introduction

The methods of taking alligators (Alligator mississippiensis) range from live capturing with harpoons and nooses to shooting. If an alligator is killed or incapacitated while in water, the body will sink and is difficult to retrieve in deep water. Consequently, most hunting techniques are designed to capture alligators so that they can be dispatched under more controlled conditions or released alive elsewhere. Alligator capture methods can also be divided into those used during daylight hours and those used at night. Each method has various advantages and disadvantages which are not readily apparent. The wildlife departments of Louisiana and Florida require different harvest techniques in their management plans. These alligator management plans have included both nuisance alligator control and commercial harvest programs. Results from harvest programs in these states have allowed us to examine and compare the basic types of alligator hunting methods.

Alligator Harvesting in Louisiana

After implementation of alligator conservation programs in the 1960's, not only did alligator numbers increase but also problems associated with rapidly expanding alligator population. Large alligator populations were cited as competing with the valuable state fur trapping industry (A. Ensminger, pers. commun.). Louisiana legislature in 1970, granted the Louisiana Department of Wildlife and Fisheries (LDWF) full regulatory authority over alligators in the state under Act 550, and classified alligators as non-game quadrupeds along with other valuable furbearers (Joanen and McNease, 1980). With alligators considered as a renewable natural resource, a regulated commercial harvest program was implemented in 1972. This program has been continued every year except 1974 (when all alligators were listed under the Endangered Species Act) and 1978 (when unstable marketing conditions forced cancellation of the season) (Moody et al., 1980). The Louisiana harvest program has grown from one southwestern parish to a statewide harvest in 1981.

The harvest methods outlined in the original 1972 harvest have been retained with little alterations through the 1986 season. The harvest parameters of the Louisiana 1972 harvest and the first experimental alligator harvest in Florida (1981) had similar goals but dissimilar methods were used. Louisiana hunters were restricted in capture methods to daylight shooting or setting baited hooks overnight and checking the line the next morning. All harvesting had to be done from sunrise to sunet. "Pole" hunting was outlawed to bias the harvest toward adult male alligators and away from the breeding females (Palmisano et al., 1973). Also, the season was set in the fall, after the summer hatching period, when the females, juveniles, and subadults are in the marsh, and the adult males in open water (Joanen and McNease, 1974).

A program of nuisance alligator control has always been in effect in Louisiana due to human/alligator conflicts in many rural and metropolitan areas. The earlier programs (before 1979) dealt with nuisance alligators by relocating them. Yet relocating alligators was taking up to 50% of LDWF personnels' time during the summer months (Joanen and McNease, 1980). In 1979, a new alligator management program was instituted in 12 coastal parishes incorporating nuisance control into the regular commercial alligator harvest system. Private hunters, chosen by the local governments, were used to hunt alligators that could not be harvested by the regular tag allotment system. Yet, these hunters were required to follow the same alligator hunting techniques that applied to commercial hunters. Results of the Louisiana nuisance alligator control program conducted in 6 parishes in 1979-1980 yielded a 63.08% hunter success (Joanen and McNease, 1980).

<u>Alligator Harvesting in Florida</u>

By the 1970's alligator complaints in Florida numbered from 5,000 to 10,000/yr and the rate of alligator attacks on humans appeared to be increasing (Hines and Keenlyne, 1976, Hines and Keenlyne, 1977). In 1977, the status of the alligator population in Florida was changed from "endangered" to "threatened" (Hines and Woodward, 1980). Clearly, with ever increasing human and alligator populations, a large scale alligator nuisance control program was needed. To implement this program, the Florida Game and Fresh Water Fish Commission (FGFC) divided the state into 5 management regions, each with individual coordinators. Complaints were verified by the regional offices and the nuisance animals were removed by contract agents assigned by FGFC. Based on a study of nuisance alligator control in 11 counties of north-central Florida in 1977, FGFC determined that contract hunters or agents were more economical and effective than state wildlife officers at resolving alligator complaints (Hines and Woodward, 1980). In 1981, 1552 alligator complaints were received and 485 nuisance alligators were harvested in the Everglades region alone (Hord, 1982). Capture methods used by the Florida contract agents set aside the Florida nuisance program from that of Louisiana.

The Florida alligator nuisance program used capture methods which would minimize public disturbance and encourage selectivity in attempting to get the specific nuisance animal. All alligator hunting was done at night and the agents were not permitted to carry firearms. Agents were directed to capture the alligator alive and remove it from the area before killing it. Several potential capture methods were outlined in an operations manual for the control agents. These methods included using a gig (harpoon) (Jones, 1965), snare or noose (Chabreck, 1963), box trap (Murphy and Fendley, 1973), snatch hook, or bow and arrow. Fishing with set hooks was to be used only if these other methods failed to work (FGFC, 1979).

The efficiency (no. alligators harvested/no. tags issued) of Florida nuisance alligator agents during a particular month was not related to the number of tags issued that month. However, monthly change in the number of tags issued was negatively correlated ($r = -0.3881$, $n = 25$, $P < 0.05$) with hunter efficiency and a reduction in tags increased efficiency.

Alligator population levels have been monitored using night-light survey lines since 1974. From 1974 to 1980, a 40% increase from 5.0 to 8.3 alligators/1.5km was noted (Stanberry, 1981). In 1981, FGFC developed a new alligator management plan which included an experimental commercial alligator harvest program. The first harvest occurred in November 1981 (FGFC, 1982), and was similar to that of the first Louisiana harvest in duration and population model used. Florida deviated from Louisiana by designing the harvest after the nuisance control program, using mostly nuisance contract agents and the same night-hunting techniques.

Evaluation of Parameters for Each Technique

Land ownership patterns played an important role in the development of alligator management programs in Louisiana and Florida (A. Ensminger, pers. commun.). In Louisiana, the greatest alligator concentrations occur in the coastal parishes of the state, where land ownership consists of large tracts of marshland. The human density of the marshland is low and public support for the program is strong. The vastness of the area combined with the sparse human population and strong local support dictated a need for an economically efficient means of harvest with little need for increased public relations or acceptance of the program.

On the other hand, in Florida the highest alligator concentrations occur in the north-central lake region and the everglades region. With the exception of the Everglades National Park and the Big Cypress Nature Preserve, both regions are highly populated and the land is mostly divided into smaller parsels under private ownership. This more urban situation dictated a need for a more intensive form of alligator harvest that minimized public contact and visibility.

Any hunting or capture technique should be analyzed with public opinion in consideration. However, in Florida, this fact is of greater importance in the effectiveness of the management program. An opinion poll of Florida residents was conducted by FGFC in the mid-1970's (Hines and Schaeffer, 1977). The poll disclosed a wide difference in opinion concerning management of alligators in urban areas; opinions between hunters and the general public also differed concerning management of wild alligators. Relocation by wildlife officers was listed as the top choice for management of alligators of all sizes. However, relocation of the reported nuisance animals has been demonstrated to create many ecological, safety, and economic problems (Hines and Woodward, 1980). Opinions regarding management of alligators living in the wild differed between hunters and the general public; hunters preferred commercial harvests in rural and urban areas, but the general public favored harvests in rural areas and relocation in urban areas. This diverse public opinion probably indicated some prejudices against hunting, especially in urban areas, necessitating a low profile for effective nuisance alligator management. A program of information and education was also necessary to increase public awareness and acceptance of management techniques (Hines and Schaeffer, 1977). Night hunting of alligators with fireams has much less public exposure than checking set hooks in the morning and removing hooked alligators. Also, the general public will tamper with fishing lines when exposed, and secluded fishing sites are often not available.

Another consideration of any hunting technique is the associated efficiency or hunter success rate. This rate can be determined by manhours spent/number taken or simply by number of alligators taken/number of tags or permits issued. Because night hunting involves more active persuit by the hunter, more hours tend to be spent per alligator caught. Fishing requires only the time needed to set the hooks and then check them the next morning. Wariness of alligators greatly decreases the efficiency of night hunting if done in one area over an extended period of time (Chabreck, 1963). With the commercial harvest, the efficiency of the 2 types of alligator capture techniques can be measured and compared. Between 1972 and 1979, the percent hunter success for the commercial harvest was 91.98% in Louisiana while only 4 out of 14 hunters reached their quotas in the Florida 1981 harvest (Joanen and McNease, 1980, FGFC, 1982).

When comparing the 2 alligator hunting techniques in relation to a commercial harvest program, one needs to remember that most harvest plans are based on the theory of compensatory replacement. Management is sought through maintaining an optimum sustained yield by reducing the population density to increase the growth, survival, and reproductive effort of the rest of the population (Stanberry, 1981). Most harvest plans seeks to restrict the killing of adult females and are bias toward adult males. Alligators are polygamous and usually have a surplus of males in the population (Chabreck, 1971). By restricting hunting to after the summer hatching period and banning "pole" hunting, the kill ratios produced a strong bias toward adult males with a minimum of adult females taken (Palmisano et al., 1973, Joanen and McNease, 1980). Both daylight and night hunting methods are primarily concentrated in deeper water areas and thus equally bias away from the adult females. In the case of alligator population dynamics, one cannot discuss sex ratios of a potential harvest without also directly dealing with size ratios.

In Louisiana, a computer simulation of a commercial alligator harvest yielded that proportional hunting rates (taking animals in proportion to their relative abundance) would be more productive than differential hunting (taking only certain size classes) in sustained yield management (Nichols et al., 1976). A night count on Rockefeller Wildlife Refuge, in Louisiana, indicated the following size distribution of the resident alligator population: 43.8% were <0.9 m long, 40.4% were 0.9 to 1.8 m long, and 15.8% were >1.8 m long (Chabreck, 1966; Nichols et al., 1976). Yet the commercial harvests in Louisiana from 1972 to 1977, using daylight techniques, yielded an average 26.7% from 1.2 - 1.8 m long and 73.3% >1.8 m long (Joanen and McNease, 1980). Of the daylight techniques allowed during Louisiana's fall season, shooting is seldom used and results in taking more smaller alligators. Fishing tends to be much more bias toward the larger animals and accounts for the high percentage of the alligators >1.8 m long in the harvest (Palmisano et al., 1973). Increased use of shooting would result in a greater harvest of smaller animals and would make the size ratios more proportional to that in the population (Nichols et al., 1976). Many subadults and juveniles are in the marsh and not in open water bodies and would be less frequently encountered when hunting is done in the fall. A possible alternative for correcting the size ratio problem might be to open a short spring season, when the subadults are still active in the deeper water. Night hunting methods might also be used in addition to a daylight program by issuing to certain hunters or landowners "small-alligator" tags and permitting them to use night methods (D. Taylor, pers. commun.).

Hunting alligators at night by boat is a more selective harvest method than setting fishing hooks. Eyeshine is an efficient method of locating alligators; and, since snout length is related to total length, size can be easily estimated (Chabreck, 1963; Dodson, 1975). Therefore, night hunting is more flexible in achieving proportional size ratios in the kill. During the 1981 Florida commercial harvest, only 15.3% of the kill was over 1.2 m, which was more proportional to the size structure of native alligator populations than the Louisiana harvest (FGFC, 1982).

When dealing with nuisance alligator control, the harvest size ratio must be proportional to the size ratios received in the complaints. In Louisiana, 7% of the nuisance alligator complaints in 1975 were of animals from 0.3 to 0.6 m, 60% were from 0.6 to 1.8 m and only 33% of animals >1.8 m (Linscombe, 1976). During 1978, 12.5% of those harvested in the Florida nuisance program were over 3.2 m long, indicating that many of the reported human/alligator confrontations were with very large animals (Hines and Woodard, 1980). The diversity in size ratios in complaints of nuisance alligators points out a need for flexibility in removing the specific nuisance animals. Night hunting has been shown to be the more selective and provides less public exposure than fishing, and so would probably be best suited for taking most nuisance animals. However, certain nuisance alligators may become "light shy" and fishing may be the only logical removal method. Night hunting methods are used in the Florida nuisance program, and the amount of complaints has decreased since the beginning of the statewide program in 1978. This decrease has been attributed to water level variations and to the fact that many of the "long-standing" nuisance alligators were dispatched in the beginning years of the program (Hines and Woodward, 1980). Also increased public acceptance of alligators may also be a factor.

Conclusions

Differences in land ownership dictated the development of the varying harvest techniques used in Louisiana and Florida. Night harvest techniques were initiated primarily for use in the Florida nuisance alligator control program but were later used in the commercial harvest program. Night hunting allows for minimal public contact, which can be very advantageous in nuisance alligator control. Night hunting (without firearms) also allows for more flexibility in choosing the size of the alligator taken. This flexibility is an advantage not only in capturing the specific nuisance alligators, but also in achieving proportional, commercial harvest, size ratios. On the negative side, night harvesting is more time consuming and difficult to regulate, making this technique less efficient when dealing with large numbers of alligators.

Daylight harvest techniques (shooting and fishing) were developed primarily for use in the Louisiana commercial harvest and were also used in the nuisance alligator program. Daylight harvesting (with firearms) is more efficient in rural areas, where animals are less wary; also, it increases the harvest of smaller animals and makes the resultant size ratios in the kill more proportional to that of the population. Fishing with baited hooks is biased toward larger animals.

Nuisance alligator programs depend on minimal public contact and yet good efficiency in ridding the area of the problem animals. Night hunting is more selective and secretive and is, therefore, more suitable for controlling most nuisance animals. Yet, when complaint numbers peak in the early summer (Linscombe, 1976; Hord, 1981), fishing with set hooks could be more effective for meeting the higher demand. However, fishing is effective only in areas where the public will not tamper with lines and at a time of the year that alligators will accept baits.

Commercial alligator harvests need to be both efficient and yet proportional to meet compensatory replacement requirements. Fishing combined with daytime shooting is more efficient than night hunting, but alone does not meet proportional size ratios in the kill. Correct size ratios could be achieved by either initiating a short spring season or by supplementing the daylight techniques with some night harvesting techniques.

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Abstract only

EFFECTS OF FIXED-CREST WATER CONTROL STRUCTURES ON THE ABUNDANCE OF FISH AND CRUSTACEANS MIGRATING FROM A SHALLOW MARSH NURSERY TOWARD THE GULF OF MEXICO

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Weirs (low-level dams with their crests usually 15 cm below marsh soil level) are commonly used in Louisiana to improve wildlife habitat and stabilize eroding coastal marshes. We suspected that these weirs may impede the migrations of estuarine-dependent organisms. To test this hypothesis, a 70-ha marsh pond was leveed to create two nearly identical 35-ha ponds. The single outlet from each pond connected through a common vestibule with a major tidal bayou. One outlet contained a weir and the other did not. All fish, shrimp, and crabs emigrating from the two ponds were trapped continuously. The trapping continued for two years, with the weir being switched from the outlet of one pond to that of the other pond after the first year. Comparisons of catches, for most species, indicated that the standard, fixed-crest weir caused major reductions in both numbers and biomass of important estuarine-dependent fisheries resources migrating back toward the Gulf of Mexico.

Once the adverse effect of the weirs on fisheries resources had been established, we began a second investigation of an alternative weir design which might reduce negative fisheries impacts. Using the same study area we installed a standard fixed-crest weir in one outlet and an identical weir, except with a vertical slot, in the other outlet. We compared the catches of animals leaving the pond having a standard fixed-crest weir to the catches from the pond with a vertically-slotted, fixed-crest weir. Comparative catches indicated that a weir with an opening extending to the bottom of the channel will increase the use of the marsh nursery behind the structure by about 50 percent for all species combined.

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THE ROLE OF RESEARCH IN DEVELOPING RESOURCE MANAGEMENT TOOLS AT GULF ISLANDS NATIONAL SEASHORE

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Gulf Islands National Seashore (Figure 1) is comprised of approximately 57,000 hectares of barrier islands and their adjacent waters in northwest Florida and coastal Mississippi. Established in 1971, the Seashore stretches from West Ship Island in Mississippi, 240 kilometers east to the middle of Santa Rosa Island in Florida. The park's resources range from remote wilderness barrier islands with very limited visitation, to readily accessible recreational beaches and historic sites visited by several million people each year. The undeveloped portions of the Seashore represent the best example of an undisturbed barrier island ecosystem remaining in the Gulf of Mexico. Research efforts at the Seashore are aimed at providing park resource managers with the information and tools required to carry out their difficult and often contradictory responsibilities of preserving park resources for public use. Research has been focused in four major areas; (1) understanding the resource by obtaining spatially and temporally referenced baseline data on the major components of the park's ecosystems, (2) identifying indicator species or communities that can act as barometers of overall ecosystem health, (3) restoring extirpated populations, and (4) developing the management tools to conserve threatened park resources. A fundamental objective of the research program is the development of simplified long-term monitoring programs of key species, populations, and communities. These long term monitoring programs will be the primary tool used by park resource managers to identify adverse impacts on park resources.

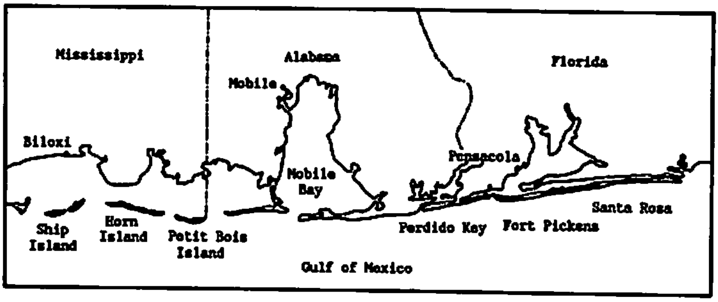

Figure 1. Gulf Islands National Seashore (shaded areas).

Understanding the Resource

An understanding of the species, communities, and populations that make up the Seashore is essential to making informed resource management decisions. Documenting the diversity, distribution, and abundance of these essential elements is a key component of several Park research projects. This baseline data is then incorporated into a geographic information system. The system provides an integrated approach to the management and analysis of the data, and it allows the interrelation of spatially and temporally referenced data from a variety of sources. Examples of on-going research projects in this category include; research on marine bird populations, a barrier island mammal study, and an inventory of the Park's aquatic habitats.

Marine bird research

Protected, predator-free breeding habitat for marine birds in the Gulf has declined steadily over the years. Today, significant populations of skimmers, terns, and shorebirds find refuge on a dredge spoil island between Horn and Petit Bois Islands. Research is underway to determine the habitat requirements, breeding biology, and tolerance to disturbance of these important populations.

Barrier island mammal study

At least eight species of mammals, including introduced feral hogs (*Sus scrofa*), cottontail rabbits (*Sylvilagus floridanus*), and Nutria (*Myocastor coypus*), are found on the barrier islands, but little is known of their basic ecology. An on-going research project is studying the Mississippi barrier island's native and exotic mammal populations through a combination of telemetry, life history, population, and vegetation studies.

Aquatic habitats study

Although they comprise over 88% of the area within the park's boundaries, the aquatic habitats (grassbeds, nearshore areas, beaches, ponds, and lagoons) are among the most poorly understood environments in the Seashore. Research is underway to develop an inventory of the seasonal diversity, distribution, and abundance of the major macrofaunal components of the Park's aquatic habitats. The research will initiate a simplified long-term monitoring program through which Park personnel could detect adverse impacts on Park resources related to petroleum development, chronic pollution, or dredging practices.

Identifying Indicator Species

Another objective of the Park research program is the identification of species, communities, or populations that could serve as indicators of environmental change, and the development of field methods to monitor their status. These indicator species will serve as the focus of long-term environmental monitoring programs in the Park. Two species, the Osprey (Pandion haliaetus) and the mud shrimp (Callichirus islagrande) have been identified as indicator species thus far, and long-term monitoring programs have begun.

Osprey

The Mississippi barrier islands support the largest concentration of breeding Osprey on the Gulf Coast. Feeding as they do near the top of the trophic web, Osprey are excellent indicators of environmental quality. Their populations are also fairly stable and easy to monitor. A long-term study is underway in the park to determine the population's productivity, habitat requirements, and vulnerability to human disturbance. A long-term monitoring program will be initiated on the basis of this research.

Beach invertebrates

Populations of beach invertebrates such as the common mud shrimp have been targeted as indicator species as a result of the aquatic macrofauna survey currently underway in the Park. Populations of nearshore and beach invertebrates are being monitored in hopes of detecting chronic long-term environmental degradation resulting from pollution and dredging practices, or the impact of catastrophic events, such as oil spills.

Restoring Extirpated Populations

Worldwide biological diversity is declining at an alarming rate. Scientists estimate that perhaps as many as one million of the earth's species will have become extinct by the turn of the century. Parks and reserves are an important means of preserving biological diversity, and providing refuge for endangered species. The National Park Service has led the way in the preservation of natural areas and endangered species research and management in the United States, and it has served as a model to developing nations worldwide. Several projects to restore extirpated populations are currently underway at Gulf Islands National Seashore.

Bald Eagle reintroduction program

A cooperative research project involving the State of Florida and the George Miksch Sutton Avian Research Center is underway at Gulf Islands to restore Bald Eagle populations along the Gulf Coast. Bald Eagles once ranged throughout the Southeast but populations have declined in recent years to about 25% of their historic levels due to the combined effects of pesticides, habitat loss and illegal poaching. The project is employing the ancient falconer's technique known as hacking in an attempt to reestablish a breeding population of Bald Eagles on the wilderness barrier islands of the Seashore. Young eagles hatched in the laboratory from eggs collected in Florida are hand reared at the Sutton Center for two months. They are then transferred to an artificial nest atop a 30 foot high hack tower at Gulf Islands and allowed to fledge naturally at about twelve weeks of age. Those that survive the four to six years it takes eagles to reach breeding age should return to the Gulf Coast and help to reestablish the species in the region.

Endangered beach mouse conservation efforts

The endangered Perdido Key beach mouse (Peromyscus polionotus trissyllepsis) was once fairly common on the Perdido Key portion of Gulf Islands, but that population was wiped out by Hurricane Frederick in 1979. The current total population is estimated at less than 50 individuals, making the mouse the rarest North American mammal. Pell-mell condominium development along Perdido Key has destroyed much suitable habitat, and reintroduction into the Seashore has been identified as the only remaining conservation option. A research project is currently underway that will establish a captive colony of the mice and begin their gradual reintroduction in the Seashore.

Brown Pelican conservation

Endangered Brown Pelican populations have been increasing steadily along the Gulf Coast after being virtually wiped out by pesticides in the in the early 1960's. Up to 150 birds have been observed on a dredge spoil island between Horn and Petit Bois Islands in recent years, and it is hoped that a nesting colony will become established in the near future. As part of an experimental project, Pelican decoys, nesting material, and artificial nests have been provided in hopes of attracting prospective nesters.

Developing the Management Tools to Conserve Threatened Park Resources

Research is providing park managers with the tools needed to minimize the adverse effects of several identified threats to park resources. Those threats include, beach erosion related to channel dredging practices, introduced and exotic species, and adverse impacts associated with recreational use.

Beach renourishment

An experimental project is underway on Perdido Key to determine if beach renourishment is an acceptable solution to a man-induced beach erosion problem. Channel dredging in Pensacola Pass has cut off the sediment supply to Perdido Key and accelerated beach erosion over the past twenty years. In August 1985 two million yards of sand were pumped from Pensacola Pass on to Perdido Key restoring approximately 20 hectares of new beach to the Seashore. A research project is currently underway to assess the project through an analysis of shoreline change and sediment transport processes on Perdido Key.

Exotic species management

Introduced feral hogs (Sus scrofa), nutria (Myocastor coypus), eastern cottontail rabbits (Sylvilagus floridanus), and black rats (Rattus rattus) are found on several of the Mississippi barrier islands. Research is underway to develop population control methods, and to assess the impact of exotic species on the native flora and fauna.

Recreational impacts

Preserving natural resources for public use is a difficult mandate for the National Park Service. Determining the carrying capacities of communities, the tolerance of species to disturbance, and the development of approaches to "people management" that reduce the adverse affects of recreational use, is a major goal of several research projects.

Summary

The major research challenge at Gulf Islands, and other natural coastal areas, is the development of the tools resource managers need to maintain and accommodate the dynamic nature of these areas in the face of relentless urban encroachment. Although we realize that plant communities go through successional stages, that fire is an important component of many ecosystems, that wildlife populations and water levels fluctuate, and that barrier islands move, we too often ignore these dynamic qualities in the management of coastal resources. At the same time, these areas are becoming ecological museum pieces, natural, dynamic islands embedded in a matrix of highly urbanized man-modified environments. The need for research will continue in the future if we are to minimize the adverse effects of urban encroachment, and preserve the diversity and ecological integrity of these unique coastal resources.