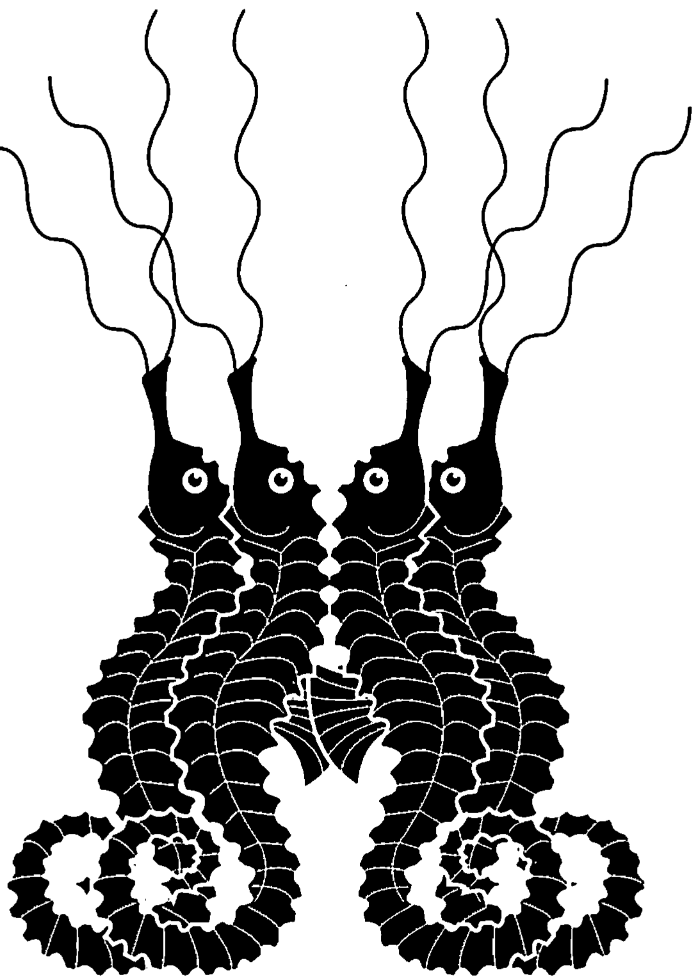
The Coastal Society
Thirteenth International Conference

CONFERENCE PROCEEDINGS

Organizing For The Coast



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Organizing for the Coast
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FEDERAL, STATE AND LOCAL PUBLIC AGENCY MANAGEMENT OF COASTAL WETLAND MITIGATION PROJECTS: THE BATIQUITOS LAGOON ENHANCEMENT PROJECT

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Introduction

Coastal wetlands along the Pacific Coast, especially Southern California, have undergone a substantial decline during the past 100 years. This dramatic decline in historically thriving coastal habitat has been due primarily to urban development and the introduction of human activities, including recreational opportunities, transportation corridors, coastal harbor structures, and other influences. Approximately 75 percent of the coastal wetlands in Southern California have been lost due to development activities in the last 50 years alone. As a result of the lost coastal wetlands, associated marine, wildlife and vegetation resources have been substantially altered. Federal and state resource agencies have assessed the potential of the numerous Southern California wetlands and have identified those sites with the greatest opportunity for enhancement.

The purpose of the Batiquitos Lagoon Enhancement Project located in Carlsbad, Calif., is to restore continuous tidal action within the lagoon at the same time balancing existing vegetation, habitats and wildlife populations that use the lagoon. Restoration of tidal action would enhance the resource value of the lagoon by restoring a marine ecosystem within the lagoon, providing a diverse range of intertidal slopes; maintain the existing coastal salt marsh and brackish marsh vegetation; and provide suitable nesting habitat for special endangered species.

The Batiquitos Lagoon Enhancement Project involves the participation of 16 federal, state, regional and local government agencies and has been the subject of countless meetings, public hearings, work study sessions, concept plans, and a variety of other examinations. In 1987, a comprehensive memorandum of agreement (MOA) was signed by the six principal government agencies involved with the project, outlining the agencies' roles and responsibilities, and the general objectives of the project. In 1990, the project Environmental Impact Report/Statement was certified under the California Environmental Quality Act (CEQA) and the National Environmental Protection Act (NEPA). As of February 1992, the project has secured the majority of the numerous public agency permits and approvals required to facilitate initiation of construction tentatively scheduled to begin in early 1993. The project has not been without controversy. The National Audubon Society and the Sierra Club have filed suit challenging the underlying project concepts, the standing of the participatory agencies, and the entire environmental review process for this project. This issue continues.

This paper will examine the current direction of federal, state and local agency management practices of coastal wetland mitigation projects focusing upon the proposed Batiquitos Lagoon Enhancement Project. This project has been viewed by both public agencies and the environmental community as a landmark example of man's attempt to resurrect and enhance degraded coastal wetlands. This project has also been characterized as an example, potentially national in scope, of off-site mitigation for development impacts.

Project History

In 1985, the California Coastal Conservancy established the Batiquitos Lagoon Enhancement Group, consisting of local citizens, officials, and members of the long-standing non-profit Batiquitos Lagoon Foundation. The purpose of the Enhancement Group was to create a series of goals and recommendations for the enhancement of the lagoon, which culminated in the draft *Batiquitos Lagoon Enhancement Plan* (California Coastal Conservancy, 1987) released in October 1986.

Concurrent with the development of the *Batiquitos Lagoon Enhancement Plan*, representatives of state and federal agencies were meeting with representatives of the City of Los Angeles to discuss the possibility of jointly pursuing enhancement of Batiquitos Lagoon as off-site mitigation for Port of Los Angeles development and landfill activities scheduled for the Los Angeles Harbor District. The Port of Los Angeles is a major Pacific Rim port development with numerous facilities and landfills to be constructed in the outer harbor areas to satisfy future cargo-handling requirements. Habitat replacement or creation of new habitat within the boundaries of the Port of Los Angeles had been considered impractical because of the lack of available space and quality of the existing port environment. Creating new or enhancing existing fish and wildlife habitats inside the port's boundaries was considered to be severely restricted due to incompatibility with future development plans as determined by involved public agencies including the U.S. Fish and Wildlife Service, the California Department of Fish and Game, and the National Marine Fisheries Service. The primary in-kind mitigation measure for port development projects is now considered to be the creation of new tidally influenced waters and wetlands, or alternatively, the restoration of tidal flows to suitable low-lying coastal areas located off-site.

The designation of Batiquitos Lagoon as a potential Los Angeles Harbor District mitigation site was first made during the environmental process for the future Pacific-Texas (Pac-Tex) Pipeline Project scheduled for the Los Angeles Harbor. The identification of Batiquitos Lagoon as a potential off-site mitigation target area evolved after several years of evaluation involving a multitude of public agencies. Subsequently, the Final EIR/EIS for the Pac-Tex project was certified in November 1985, followed by the California Coastal Commission's approval of the required Coastal Development Permit in 1986. In 1989-90, the Pac-Tex project was delayed indefinitely due primarily to economic influences.

Discussions began in January 1987 between the Port and the City of Carlsbad, within whose jurisdiction the lagoon lies, regarding the joint development of a project to enhance Batiquitos Lagoon and provide off-site mitigation for Port development impacts. Thereafter, a detailed preliminary engineering study was undertaken, titled *Preliminary Design Report* (CH2M Hill Inc., 1988), funded in full by the port to determine the feasibility of the enhancement project from an economic, environmental and engineering standpoint. In particular, the feasibility study sought to determine the following:

Compatibility with resource and wildlife agency mitigation policy to provide in-kind compensation for project impacts;

Cost/benefit analysis to implement the enhancement project;

Compatibility with future Port of Los Angeles development plans;

Technical feasibility;

Ability to implement the enhancement plan as a mitigation project within the project timeframe.

The original Pac-Tex project, as well as the port's own development plans, involved filling a substantial subtidal area within the port boundaries. Because the fills would constitute a permanent loss of marine habitat, the port was required to compensate for the loss of habitat under federal and state statutes and permit processes. It was determined very early in the feasibility study phase that adequate space existed at Batiquitos Lagoon for the development of a mitigation area sufficient to provide compensation for the port's development plans. Because the resource and wildlife agencies had long ago targeted Batiquitos Lagoon as a high-priority enhancement opportunity, formal discussions began in late 1986 among all concerned parties to target Batiquitos Lagoon as a recipient of off-site mitigation required by future Port development activities.

In November 1987, the MOA for the Enhancement of Batiquitos Lagoon was signed by the port, City of Carlsbad, California State Lands Commission, California Department of Fish and Game, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. This unprecedented agreement marked one of the first times in which federal and state resource and wildlife agencies formally participated in the implementation of enhancement opportunities and obligations for an off-site mitigation project.

Lagoon Environment

Batiquitos Lagoon is located on the Southern California coast approximately 40 miles north of San Diego. Entirely within the jurisdiction of the City of Carlsbad and immediately adjacent to the Pacific Ocean, the lagoon is elongated and extends approximately 2.5 miles inland from the ocean. Approximately 0.5 mile in width, the steep canyon slopes along the southern border contain at their toe La Costa Avenue, a major regional arterial highway separating the boundaries of the City of Carlsbad to the north and the City of Encinitas to the south. Along the northern shore of Batiquitos Lagoon are more gradual slopes that buffer ongoing intense land development including the Aviara Resort complex and several surrounding housing developments. Immediately to the east of the lagoon is the world-renowned La Costa Resort and Spa, a 300-acre resort, golf and tennis, and health spa complex.

Figure 1 depicts Batiquitos Lagoon, identifying three distinct basins; West, Central and East, which are dissected by transportation corridors including two bridge structures on U.S. Highway 101, the Atchison, Topeka, and Santa Fe Railroad bridge structure, and two bridge structures along Interstate 5.

Beginning in the 1920s, the periodic construction of bridge structures interrupted the hydrological connection between the lagoon and the Pacific Ocean. Historically, tides entered the lagoon and extended their influence to the eastern portions of the lagoon, resulting in tidal flushing of suspended sediments from two freshwater streams to the east. As a result, the tidal inlet to the lagoon has been closed. The frequency and duration of inlet closure substantially increased over the last 60 years to the degree that the tidal inlet is now virtually closed continuously. Ocean tides no longer influence the lagoon, and the predominant flow of water into the lagoon is from the freshwater sources to the east.

Flows into Batiquitos Lagoon vary according to the season and local storms. Water in the lagoon varies considerably from relatively shallow conditions to relatively full conditions after a series of storms. In the past, when the lagoon surface water elevation rose to a height that might jeopardize adjacent roadways and utilities, local public agencies manually removed a portion of the cobble berm closing the lagoon to the ocean. The lagoon thereafter drains until ocean currents and wave action close the cobble berm. Water quality within Batiquitos Lagoon varies according to the amount of inflow from upstream drainages and the temperature associated with each season of the year. Because the lagoon is no longer connected to the ocean on a continuous basis, the lagoon has become, in essence, a depository of nutrients, sediments, and other materials contained within the freshwater inflow. The *Preliminary Design Report* indicates that the salinity of the lagoon varies seasonally from approximately 15 ppt to more than 40 ppt. Samples taken from Batiquitos Lagoon have measured salinity in excess of 2.5 to 4 times that of seawater. Additionally, salinity varies with the amount of freshwater inflow, which decreases salinity, and the amount of evaporation of lagoon water, which increases salinity.

The marine environment within Batiquitos Lagoon has essentially been eliminated with the termination of tidal influence. This environment has been replaced with nontidal fresh-and brackish-water systems that contain a limited number of aquatic species. Only those capable of tolerating extreme variation of water quality survive in the lagoon.

The lagoon is also the home of a variety of wildlife, including the federally listed endangered California Least Tern, the Western Snowy Plover, the State of California listed endangered Belding's Savannah Sparrow, and a multitude of diving water birds, dabbling ducks, and other shorebirds. The lagoon contains a wide variety of habitats, including open water, nontidal flats, nontidal coastal saltmarsh, brackish marsh, and brackish woodlands. Because of the wide range of environmental quality on a seasonal basis at Batiquitos Lagoon, the overall quality of the lagoon for both fish and birds ranges from excellent to poor based upon climatic conditions and the lack of tidal influence.

Project Description

Following the completion of the feasibility study, a *Draft Environmental Impact Report/Environmental Impact Statement*, was undertaken to establish project alternatives that would subsequently be evaluated as a joint environmental impact analysis under the California Environmental Quality Act and the National Environmental Protection Act. The overall construction objective of the Batiquitos Lagoon Enhancement Project is to restore tidal action to the lagoon through the installation of a non-navigable tidal inlet structure and by dredging the lagoon to produce adequate subtidal and intertidal zones that would create an adequate tidal prism to ensure tidal flushing. Other secondary objectives include:

The disposal of approximately 3.5 million cubic yards of dredged lagoon sand on two adjacent beach sites in an attempt to renourish these currently sand depleted beaches;

Construction of nesting sites for the federally endangered California Least Tern and other shorebirds that would be available during a variety of lagoon surface water level conditions;

Replacement and/or rehabilitation of those bridge structures impacted by tidal flushing and increasing currents;

Installation of a pedestrian and emergency accessway over the proposed tidal inlet to provide continual lateral beach access.

An expanded evaluation of alternatives to enhance Batiquitos Lagoon was prepared in the Draft EIR/EIS. The alternatives described a wide range of lagoon enhancement proposals that would meet the objectives of both the resource and wildlife agencies and the general public. The alternatives are described below.

The **No Project Alternative** involves no enhancement of Batiquitos Lagoon. The lagoon would continue to be closed to the ocean except when breached for flood control or by storm conditions. Extreme changes in physical conditions within the lagoon would continue to occur on an annual cycle. The overall condition of the physical environment would continue to degrade over the next 40 to 50 years.

Alternative A involves a fully tidal lagoon with substantial dredging of materials depending upon the selected disposal alternative. Over-dredging the Central Basin would be required to create a disposal area for the deposit of finer sediments and other materials not suitable for beach disposal. Dredging quantities for Alternative A range from 3.1 to 5.2 million cubic yards. The mean diurnal tidal prism associated with Alternative A is approximately 70 million ft^3. The West and Central Basins would be excavated to -5.5 feet MLLW. The East Basin would be excavated to a general depth of -2.5 feet MLLW. Intertidal slopes would be created generally steeper than the other project alternatives ranging from 1:10 to less than 1:20, with most slopes steeper than 1:100. A 4-acre California Least Tern nesting site island with an elevation of 10.0 feet MLLW would be created in the West Basin with three other sites totaling 30 acres in the East Basin.

Alternative B involves a fully tidal lagoon with dredging and disposal quantities ranging from 2.6 to 4.1 million yd^3. The conditions of the West and Central Basins would be the same under Alternative B as Alternative A. In the eastern half of the East Basin, the width of the subtidal area would be approximately 200 feet narrower. Lagoon bottom slopes would average steeper than 1:230. The number and size of the proposed California Least Tern nesting sites would be the same as proposed for Alternative A. The mean diurnal tidal prism associated with this alternative is approximately 64 million ft^3.

Alternative C involves a fully tidal lagoon with dredging and disposal quantities ranging from 2.4 to 3.6 million cubic yards. The conditions of the West and

Central Basins would be the same under Alternative C as Alternative A. In the East Basin, the floor of the lagoon at elevation -2.5 feet MLLW would average approximately 150 feet wide. Lagoon bottom slopes would average steeper than 1:230. The number and size of the proposed Least Tern nesting sites would be the same proposed for Alternative A. The mean diurnal tidal prism associated with this alternative is approximately 61 million ft^3.

A tidal prism of 60 million cubic feet is considered the minimum sufficient to maintain a continuously open tidal inlet at Batiquitos Lagoon. Consequently, several other alternative designs, referred to as Alternative D (Intermittent Tidal Alternative), Alternative E (Managed Inlet Alternative), and Alternative F (Water Level Management Alternative) were determined to have an insufficient tidal prism and therefore judged not to meet Enhancement Plan goals.

The *Preliminary Design Report and the Final Environmental Impact Report/Environmental Impact Statement* for the project outlined the equipment, materials and construction schedules expected for the development of the proposed project. Project construction sequencing will be essential to the potential success of the project. Dredging activities could vary from six months to two years in duration depending on the equipment and scheduling outlined during final design and subsequent construction. Construction would proceed in phases so that only limited portions of the lagoon are subjected to disturbance at any one time. A conceptual 18- to 24-month construction schedule was developed utilizing the following critical path components:

Equipment Mobilization. Equipment mobilization would begin during the summer months. Activities associated with this effort include establishing construction staging sites and installing required support facilities; establishing the fuel, oil, and other equipment related fluids storage site and necessary containment facilities; establishing the tidal inlet and bridge construction/rehabilitation staging areas; and installing required administrative, management, safety, and related support facilities.

Tidal Inlet. The construction of the jetty and tidal inlet structures constitutes a primary work activity. This construction would be initiated in the fall to avoid high-use periods by the general public on adjacent public beaches.

Dredging. Dredging of the West and Central Basins would begin in the fall and continue until March of the next year when it would be terminated to preclude disturbance to local Least Tern nesting areas. It is anticipated that a floating dredge with a 12-inch- to 14-inch-diameter nozzle would be suitable for dredging operations in the West Basin. With equipment of this size, dredging of the West Basin could be completed in approximately one to two months. Dredging of the Central Basin is anticipated to require two floating dredges with 20-inch- to 24-inch-diameter nozzles. The Central Basin would be over-dredged to accommodate the disposal of fine sediments subsequently dredged from the East Basin. The East Basin can be dredged in several ways, depending upon the preference of the contractor selected for the project. Two small floating dredges operating concurrently with other dredging operations in the Central Basin could accomplish East Basin dredging, although it would take longer. Another way to dredge the East Basin would require multiple larger dredges moving in a west-to-east direction. This operation would occur simultaneously with the operation of a single smaller dredge operating in the eastern portion of the East Basin. Dredged sand materials from the western portion of the

East Basin could be deposited directly to the beach disposal site. The collection of finer sediments would be transferred from the eastern portion of the East Basin to the Central Basin disposal site during all dredging operations. A water elevation control structure and silt curtains would be required under any dredging scenario.

Bridge Reconstruction and Rehabilitation. Construction of a new west Carlsbad Boulevard (U.S. Highway 101) bridge and rehabilitation of the four remaining bridge structures would require completion prior to lagoon opening. Work on these structures would be performed separately to allow traffic on U.S. Highway 101 to use one for crossing while the other is under construction. Work associated with the bridge construction could likely extend into the California Least Tern nesting season, because there are no sites near any of the bridge structures.

Special Areas Including Nesting Sites. Following the beginning of dredging, two California Least Tern nesting sites totaling a minimum of 20 acres would need to be constructed and available during the nesting season. The balance of the newly created nesting site acreage would be constructed as dredged materials are available and scheduling permits.

A number of other construction activities are associated with the project including:

Fuel, oil and materials storage;
Fuel, oil and materials transfer station;
Inlet and jetty construction materials storage;
Water intake structures;
Dredge launching ramps;
Bridge revetments;
Pipeline route for beach sediment disposal;
Bridge construction materials and equipment on public beach; and
Public information, traffic control and safety.

The specifics of these and other construction activities are the subjects of both final design and conditions of approval of the various regulatory and wildlife agency permits and approvals required of the project.

Environmental Process

The *Preliminary Design Report* was completed and published in early 1988. The City of Carlsbad and the U.S. Army Corps of Engineers, as lead agencies under the California Environmental Quality Act and the National Environmental Protection Act, respectively, initiated the project EIR/EIS process, including formal public scoping in July 1988. Public workshops on the Draft EIR/EIS content were held from July through October 1988 with the formal Draft EIR/EIS document released for public review in early May 1989. A 75-day public comment period on the draft document closed in late July 1989.

The public comment period on the Draft EIR/EIS resulted in 45 letters with 1,195 individual comments. Public comments, as well as those received formally from the regulatory and wildlife agencies, assisted in determining the scope of the Final EIR/EIS. During the period of January through April 1990, several meetings were held with various agencies and public interest groups to discuss the approach, content and progress of the Final EIR/EIS. In association with those meetings, responses to all of the comments were completed and the Final EIR/EIS was published in June 1990. Thereafter followed two local agency public hearings resulting in the certification by the City of Carlsbad of the Final EIR/EIS in August 1990.

Mitigation and Monitoring Plans

The mitigation plan developed for the Batiquitos Lagoon Enhancement Project was designed to be implemented with the mitigation monitoring plan. The mitigation plan describes the measures that would be employed in order to minimize or eliminate each impact resulting from project implementation. These mitigation measures apply to all of the project alternatives considered in the Final EIR/EIS. The mitigation measures address anticipated impacts resulting from the three stages of project construction including:

Preconstruction planning and site preparation;

Construction activities; and

Post-construction activities associated with termination of construction and restoration of the site.

As the lead agency for the project, the City of Carlsbad will be responsible for managing the implementation of the mitigation plan for the Enhancement Project through the creation of a Mitigation Monitoring Group. This group will implement the plan and be responsible for its monitoring and documentation in accordance with the plan as outlined in the Final EIR/EIS. Those impacts identified in the Final EIR/EIS requiring mitigation include:

Structures;
Water quality;
Air quality;
Fish and wildlife;
California Least Tern;
Western Snowy Plover;
Belding's Savannah Sparrow;
Coastal resources;
Recreation;
Transportation and circulation;
Noise;
Public health and safety; and
Post construction restoration.

An important mitigation measure for several of the existing resources at Batiquitos Lagoon is the timing of construction activities to minimize the extent of disruption and to avoid critical time periods for wildlife at the lagoon. Continuous monitoring of construction activities to ensure that significant resource elements are not inadvertently damaged or destroyed will be required. The mitigation monitoring plan will provide a vehicle to monitor and document the effectiveness of the mitigation measures for the project. This plan was prepared conceptually to comply with the requirements of the interested resource and wildlife agencies' responsibilities to monitor the implementation of the mitigation measures identified in the Final EIR/EIS. The mitigation monitoring plan's objectives include:

To establish a framework for supervising and monitoring the implementation of planned mitigation measures;

To provide a mechanism for initiating corrective action if mitigation measures are deficient, omitted or not implemented properly; and

To ensure that both the implementation of mitigation measures and the outcome of corrective actions are fully documented.

The Mitigation Monitoring Group will consist of five individuals who will be responsible for ensuring that the mitigation measures are implemented or, alternatively, documenting deviations in the plan. The group will include:

Representative of the City of Carlsbad;
Construction manager;
Construction contractor;
Environmental consultant; and
Environmental monitor.

The group will, collectively, certify as to the implementation of the mitigation monitoring plan to both the City of Carlsbad and the resource and wildlife agencies. Upon completion of both construction and the monitoring plan, the project will become the responsibility for the purposes of maintenance and operations of the California Department of Fish and Game, as stipulated in the project MOA. The MOA additionally established a maintenance fund sufficiently capitalized to ensure funding for the perpetual maintenance and operation of the Batiquitos Lagoon Enhancement Project.

The Future of the Batiquitos Lagoon Enhancement Project

On March 21, 1991, the California Coastal Commission approved the Batiquitos Lagoon Enhancement Project, finding the project to be consistent with the California Coastal Act, and concurrently approved the required Coastal Development Permit. On Sept. 11, 1991, the California Coastal Commission amended its approval of the Enhancement Project by adopting what is referred to as the "Mitigated Alternative B" project alternative.

As of March 1, 1992, issuance of the Section 404 Permit was pending from the U.S. Army Corps of Engineers, Los Angeles District Office. As of this date, final permit conditions were being drafted.

In May 1991, the Sierra Club and the Buena Vista Audubon Society petitioned the County of San Diego Superior Court for a writ of mandate, the petition of which was subsequently amended in November 1991. The petition alleges several causes of action challenging the underlying project concepts, failure to adopt the "least environmentally damaging alternative," inconsistencies with the California Coastal Act, and a number of other alleged violations of the California Public Resources Code. Without discussing the merits, as of March 1992 negotiations between the petitioners and the various respondents were underway. The current litigation has suspended final design engineering activities and other project development tasks necessary to implement the "Mitigated Alternative B" at Batiquitos Lagoon.

The proposed Batiquitos Lagoon Enhancement Project represents one of the first multi-agency mitigation and restoration projects of a coastal wetland along the Pacific Coast. The project is intended to be an example of off-site mitigation resulting from impacts caused by major infrastructure development which would otherwise be incapable of on-site mitigation. Cost estimates for the "Mitigated Alternative B" project approach $40 million, including the establishment of the ongoing maintenance fund for the completed Enhancement Project. Resolution of the current litigation is anticipated during 1992, with construction tentatively scheduled to begin in 1993.

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California Coastal Conservancy. 1987. *Batiquitos Lagoon Enhancement Plan.* Draft 1986, revised draft.

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CH2M Hill Inc. 1989. *Batiquitos Lagoon Enhancement Project Draft EIR/EIS.* Prepared for City of Carlsbad, California, and U.S. Army Corps of Engineers, Los Angeles District.

FIGURE 1

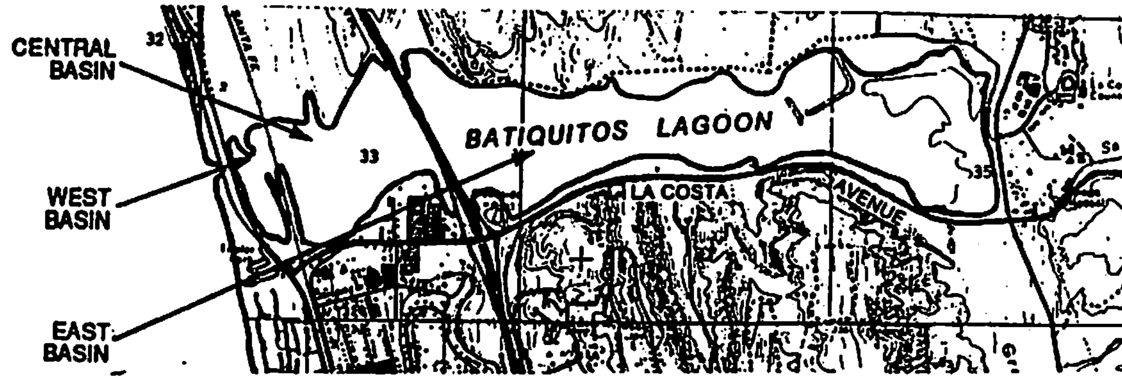

Figure 1. Batiquitos Lagoon.

REGULATED DEVELOPMENT IN COASTAL WETLANDS: AN ANALYSIS OF TRENDS IN THE SECTION 10/404 PERMIT PROGRAM IN PORTIONS OF THE UNITED STATES

Michael Ludwig, Susan Mello and Tamra Faris
National Marine Fisheries Service

In the past two decades federal, state and local government regulatory communities have developed and implemented progressively more conservative wetland protection programs. These programs have evolved largely in response to declining habitat and resources, escalating pressure to protect those dwindling commodities and legal action. They have been legislated, implemented, adjudicated and revised in a cycle of action and response by the environmental and development communities. This process of action and reaction has fostered ill-will, misunderstanding and court actions even in the same branches of government. The conflict in the federal government over the U.S. Army Corps of Engineers and the Environmental Protection Agency's (EPA) Memorandum Of Agreement (MOA) on Mitigation and the release of the Bush administration's Comprehensive Plan for Wetlands along with the associated revised Wetland Delineation Manual are examples.

In 1988 President Bush made a campaign promise that under his administration there would be no net loss of wetlands. This statement was made in response to findings, including the 1988 Conservation Foundation report, that the United States has lost approximately half of its pre-colonial wetland acreage. Today a stressed economic climate and the belief that environmental protection must be restrained is limiting our ability to protect the remaining half. However, it is widely held that loss of habitat, like vegetated wetlands, is a major cause of the decline of most of the U.S. fishery resources.

One of the National Marine Fisheries Service's (NMFS) responsibilities is the application of the Fish and Wildlife Coordination Act (16 *U.S.C.* 661 *et seq.*) to federally authorized activities. We are joined in these efforts by the U.S. Department of the Interior and our counterparts at state fish and wildlife agencies. This coordination group, in turn, is typically joined by representatives of the EPA. Routinely, our collective mission is assessment of the public interest and environmental impact of construction in waters of the United States. The "lead agency" role in the review process is the responsibility of the local district unit of the Engineers (Executive Order 11574). The NMFS has found that this regulatory process is considering virtually all of the activities in the coastal zone (Mager, 1987).

Corps of Engineers' permit requests are typically activities regulated under Section 10 of the Rivers and Harbors Act (33 *U.S.C.A.* 403), Section 401 and 404 of the Clean Water Act (33 *U.S.C.* 466 *et seq.*), Section 103 of the Marine Protection, Research and Sanctuaries Act (33 *U.S.C.* 1401 *et seq.*), the Magnuson Fishery Conservation and Management Act (16 *U.S.C.* 1801 *et seq.*) and the Coastal Zone Management Act (16 *U.S.C.A.* 1451-1464). The Corps reports that in 1989 approximately 44,000 permit requests were processed. In 1990 and 1991 those values rose to about 46,000 and 48,000 respectively. In all three years slightly more than half of the requests were dealt with under the Nationwide Permit (NWP) Program (USACE, 1992). The method of counting these actions varies from region to region. The variation has some aspects of the recollections of recreational fishermen in that the size and difficulty of the catch varies with the telling.

Over the past two decades the level of regulatory involvement in wetland issues has been shaped by legislative and judicial action. However, there is no unified method of interpreting or applying the regulations. Compounding these problems are the effects of decentralized command and control and a reluctance by all of the regulatory agencies to apply environmentally conservative interpretations to the regulations. Although there have been some attempts to provide a more uniform regulatory process (including the Corps of Engineers Regulatory Guidance Letter program), no action to date has been a complete solution to the inconsistencies of application review. However, a recent expansion of the regulatory monitoring role in the Office of the Chief of Engineers does show potential value. On the negative side, draft language for the revised 404(Q) interagency MOA for regulatory conflict resolution appears so restrictive that, if accepted, this avenue will be virtually unusable. Additionally, the nature of the final revisions to the Wetlands Delineation Manual remain unclear.

Mitigation of adverse impacts has always been a portion of construction activities. It gained favor and increased importance with the passage of the National Environmental Policy Act (42 *U.S.C.A.* 4371 *et seq.*). Almost immediately, proponents and opponents of mitigation began the process of evolving implementation procedures in regulatory actions. Success, initially measured by the amount of "green" on a site at selected times, quickly proved an elusive goal. Generic attempts to provide construction guidance suffer from a lack of specificity and continue to rely on the faulty, amount of green at time *x*.

By the mid-1980s mitigators were receiving mixed messages: develop site-specific wetland-creation plans. But success applying such plans was unlikely. This conflict reached its zenith in 1989 when wetland biologists across the United States released technical and grey literature reports filled with adverse findings on the success of earlier mitigation attempts. Most notable were the determinations that long-term success, in terms of vegetative survival, can be measured only after the third or fourth growing season and that full establishment of functional values may not be visible within 50 years. Additionally, the crucial role of hydrology in marsh management procedures was identified.

The Atlantic Coast and Southwest are particularly focused hot-spots of mitigation investigation. As a result of the adverse publicity, wetland mitigation proposals began a decline that has almost swept them from applicant's options list. NMFS still seeks wetland mitigation but with a more cautious approach. Atlantic states continue to seek wetlands creation but often require use of a recognized wetland expert and a thorough mitigation plan (see NWP #27). Success has yet to be defined. Never a significant component of Alaska regulatory action, wetland mitigation remains a novelty.

In an attempt to track the regulatory activities occurring across the nation, NOAA/NMFS began a data-gathering effort during the past decade. We have been able to determine such things as the frequency of incorporation of our recommendations in permits and identify potential habitat losses by NMFS region. In some areas we can subdivide our data by individual Corps of Engineers districts. With these data we are able to identify, to some degree, how each of the 38 Corps districts within the nine divisions that NMFS deals with apply the national regulations and our recommendations to their local situations.

Portions of the NMFS data collected from 1988 to 1991 were selected for a view of the nation's regulatory actions. In 1988 and 1989 a variety of developmental and innovative measures were espoused, authorized and implemented across the nation. The use of large platforms rather than fill for residential and commercial space in harbors, barge-mounted prisons, helicopter and vehicle holding areas and wetland creations that incorporated a full mixture of possible species were all being considered. In 1990 and 1991, overdevelopment, slumping oil exploration, mitigation implementation problems and the need to maximize the return on investments were contributory to a marked downturn in these applications. Coastal development as recently as early 1990 included a moderate level of wetland creation/enhancement as mitigation for real and perceived impacts on the construction site.

Mitigation is often made possible by the availability of land that is not integral to the development. By late 1989, waterfront real estate had become so valuable and the market so stressed that to achieve a return on investment, activities without economic benefit were precluded. By mid-1990 projects were being abandoned and unnecessary components of those actions advancing to construction were often postponed. The postponed elements routinely included the mitigation measures. Occasionally, the mitigation features were not done because the property where it was to occur became needed to enhance the profit margin. These actions shifted the work from environmentally compatible or even beneficial to one requiring regulatory enforcement.

In many residential areas, once waterfront property has been secured, access to deep water becomes the most frequent permit request. Dredging access channels, boat basins and the construction of pile-supported piers across wetland and shallow-water habitats creates the largest block of individual and cumulative development activities along the East and Gulf coasts. The topography and oceanic nature of the coastline in the West, as well as the commercial focus of harbor development, has limited private, recreational expansion. In the Southeast, impounding wetlands in Louisiana is the largest single source of habitat modification.

Two actions are limiting the ability to protect wetlands in Alaska. Because of a limited availability of development property in population centers, the focus has been on filling wetlands and nearshore zones for increased space. However, the most insidious problem is the failure to apply the wetland analyses required under Section 404 (b)(1) of the Clean Water Act. The latter problem is allowing coastal wetland destruction to occur in a manner unlike anywhere else in the country. As a result of the pressures and disregard of regulations as well as the novel applications of statistics, it is in Alaska that environmental consideration is receiving minimal lip-service and even less application.

In 1988 the northeast region of NMFS responded to 1,511 requests to modify more than 3,250 acres of aquatic habitat. By 1991 the number had declined to 1,138 requests affecting approximately 830 acres. Mitigation proposals peaked in 1989 at more than 300 acres. Today it stands at less than 20 acres per year. In 1988 Alaska received 410 requests to fill 3,174 acres. In 1990 requests remained at almost 400 but acreage of impact had declined to approximately 1,850 acres as the economic downturn settled in and NMFS recommendations were occasionally accepted. There were no obvious requests to mitigate for wetland destruction in

Alaska. In 1988, 3,935 projects were reviewed in the southeastern states. The involved acreage was approximately 360,000. Mitigation proposals accounted for a modest 1,827 acres. By 1991, requests had fallen to 3,341 and acreage to 20,753. However, unsolicited mitigation had risen to approximately 4,100 acres.

Repair of the transportation infrastructure has become a major component of both state and federal budgets. With the passage of the 1991 Intermodal Surface Transportation Act renewal of interest in the pooling of wetland mitigation is occurring throughout the country. This action builds on the concept of consolidated mitigation. Because of the flexibility inherent in "marsh banking," it is preferred over the more environmentally desirable options of on-site/in-kind and on-site/out-of-kind mitigation.

Since the "need for green" mentality is still present, off-site/in-kind and off-site/out-of-kind mitigation will probably be the dominant choices for linear projects for the near future.

These regional data indicate also that there is a wide disparity in the manner in which the Section 10 and 404 regulations are implemented. The disparity is expected. Local issues and the need to determine site-specific impacts limit the utility of generic concerns, i.e., while we agree that habitat protection is important, the types receiving that protection vary from region to region. Polling a variety of agency representatives we find regional or more local attitudes dominate the decision process. In the Northwest, Northeast and portions of the Southeast and Southwest, where environmental conservation has become institutionalized, the regulatory community generally shapes decisions reflective of those attitudes. In other parts of the Southeast and some parts of the mid-Atlantic, Southwest and Gulf coasts environmental appreciation continues to be secondary to economic forces. In the broad expanse of Alaska there is little evidence of regulatory commitment to environmental considerations. Review of recent legislative and regulatory history is most telling in this regard. Of particular concern is the "one-percent rule." Elements of both EPA and the Corps of Engineers have indicated their desire to allow a much more liberal wetlands destruction policy in states which have less than a one-percent loss of their wetlands. Alaska is such a state.

Perhaps no region of the United States suffers more from the use of statistics than does Alaska. With estimates of more than 170 million acres of wetlands it is easy to state that humans have impacted less than 0.05 percent. However, many of these millions of acres are tundra. If we focus solely on coastal wetlands, where much of the development has occurred, we are looking at a resource of approximately 21 million acres. Comparing impacted acres to this more representative acreage causes the percentage of loss to rise. If the coastal wetlands are divided into vegetated and non-vegetated acreage, the vegetated, nearshore areas at risk are some 357,000 acres. However, these nearshore habitats are the first to be filled owing to the minimal cost involved.

While it is inappropriate to suggest that all wetland loss in Alaska has been in coastal vegetation, it is possible to infer from these data that the development impact has occurred disproportionately in this habitat and has resulted in a loss of around 10 percent. In Juneau, the loss since 1948 exceeds 13 percent. The Anchorage area habitat loss is estimated at approximately one-third of the original vegetated coastal wetlands. Applying the "one-percent loss" concept to Alaska means that all coastal vegetated wetlands could be forfeit without approaching the magical action point. Coastal systems are vital to the well-being of the Alaskan fishery resources. The impacts of habitat destruction are, in all likelihood, being experienced. Evidence of this impact is available from landing statistics that reveal a marked decline in stocks.

The national perspective, viewed from the regional level, appears equally gloomy. The recent activities regarding the Wetlands Delineation Manual, the proposed use of categorization of wetland "values," the shift in reasoning in the draft 404(Q) MOA and the special interest espousal that environmental regulations are regressive during this economic period all bode poorly for the institutionalization of protective wetland policies. Because the social costs of habitat degradation are not directly experienced or readily perceptible, individual actions by regulators and developers may appear to have minimal environmental harm. Having a history of authorizing all but the most egregious encroachments has sustained those perceptions. Nationwide, about 20,000 acres of coastal wetlands are lost annually through these authorizations and natural forces (Alexander et al., 1986). Now, when 22 states have lost the majority of their wetlands, the fishing industry no longer provides even 50 percent of the seafood consumed nationally and flood damage occurs more frequently and with greater cost to society, it is disheartening to see that even the modest measures of conserving aquatic resources over the past two decades are under attack.

Acknowledgements

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WETLAND CREATION EFFORTS IN GALVESTON BAY, TEXAS

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Abstract

The shoreline of the Galveston Bay estuary is eroding at an average annual rate of four feet. The Galveston Bay National Estuary Program has identified shoreline erosion and the subsequent loss of wetland vegetation as two of the four priority problems in Galveston Bay. Loss of wetland habitats and coastal erosion will continue unless low-cost effective measures are developed and implemented for shoreline erosion control and habitat enhancement. Once established, smooth cordgrass, *Spartina alterniflora* Lois, provides an effective means of shoreline erosion protection.

The Texas A&M University Marine Advisory Service and the USDA Soil Conservation Service initiated a project in 1989 with funding from the Galveston Bay National Estuary Program to study the impacts of vegetative shoreline erosion control measures in Galveston Bay. Smooth cordgrass was transplanted in three sites in Galveston Bay. Each site has different shoreline configurations, salinity regime, and soil types. Transplant survival data were documented by site during the study. Baseline erosion rates and fisheries species abundance data were collected at the three sites during the study prior to wetland creation. Data collected during this study represent only preliminary findings. A monitoring program throughout the term of the grant may indicate other significant long-term impacts of wetland creation. Species of fishes and shellfish mentioned in this paper are listed in Table 1.

Introduction

Coastal salt marshes are a very valuable resource. They serve as a nursery for over 90 percent of coastal marine organisms in the Gulf of Mexico. Under favorable conditions, they will produce more vegetation than almost any ecosystem on earth. The production will far exceed the production of any intensive agricultural crop. Tidal marshes are also important in the storage and assimilation of nutrients from the surrounding estuarine waters. They are also very important in trapping sediment and reducing turbidity in runoff water. Marshes are important in reducing flood control impacts by storing floodwater and releasing it slowly after peak flow. In many situations these coastal wetlands also stabilize shorelines and afford protection to upland areas during storms by absorbing and dissipating wave energy.

Coastal wetlands in the Galveston Bay complex are rapidly disappearing. Channelization, salt water intrusion, pollution, shoreline erosion and the possible impact of sea level rise are contributing factors to the loss of coastal wetland habitats (White et al., 1985). Wetland surveys conducted in Galveston Bay between 1956 and 1979 indicate that approximately 25,000 acres or 16 percent of its coastal marshes have been lost (Paine and Morton, 1986).

Transplanting vegetation to re-create lost wildlife habitat and mitigate impacts of shoreline erosion has been used with success in Louisiana wetlands (Cutshall, 1985) and in Galveston Bay (Webb and Dodd, 1976).

Vegetative shoreline erosion control methods will not work in all cases along the Texas coast. Conditions where steep banks and/or deep water predominate are not conducive to vegetative treatment. However, where bay bottoms have a gradual slope, suitable soils and proper salinity range, this vegetative method can be applied.

The objectives of this study are to:

Demonstrate to local landowners, organizations, and state and federal agencies an alternative to traditional expensive shoreline erosion control measures through a vegetative transplant method using smooth cordgrass which has been proven to effectively halt shoreline erosion.

Test vegetative shoreline erosion control measures under different shoreline and environmental conditions.

Document transplant survival at three sites in Galveston Bay.

Document fisheries abundance and utilization by site.

Description of the Study Area

The authors identified three sites to be treated vegetatively during the first year of the study.

Trinity River Delta. The Trinity River delta is eroding at an average annual rate of five feet. Records from the Trinity River delta from 1935 to 1980 show a continuous decline in the suspended sediment load beginning in 1950, coincident with the increased dammed reservoir capacity (White et al., 1985).
The site chosen has a southwestern exposure with a fetch of 20 miles. The present vegetation consists of alligator weed, *Alteranthera philoxeroides* Griseb. and Common Reed, *Phragmites australis* Trin. There is no intertidal vegetation but there are numerous plant roots and crowns exposed that give support to a rapidly eroding shoreline.

The soil is classified as a Harris clay at Site 1. The substrate is a soft, freshly accumulated alluvial clay. The slope of the bottom is very gentle with approximately 20 feet of exposed mud at low tide. There is a small amount of California bulrush (*Scirpus americanus* Pers.) in the emergent zone but it does not appear to be spreading.

Little Cedar Bayou (City of LaPorte, Texas). Site 2 is located approximately one-half mile south of Sylvan Beach Park in LaPorte, Texas. The shoreline along the bay is protected by concrete rip-rap and bulkheading. No erosion protection exists for the mouth of Little Cedar Bayou.

It is the opinion of the authors that ship wakes generated by vessel traffic on the Houston Ship Channel contributes to most of the erosion problems at this site. Fetch is less than one mile and water currents originating upstream are minimal.

The soil is classified as a Vamont clay. The substrate is a sterile yellow clay. The slope is approximately three percent and the exposure at low tide is approximately 20 feet. No vegetation exists on the shoreline. Numerous trees have recently washed into the bayou as a result of the sloughing bank. The estimated erosion rate is approximately eight feet per year (City of LaPorte Parks and Recreation Department, pers. comm.).

Taylor Lake. Taylor Lake is a tidal lake associated with the waters of Clear Lake on the west side of Galveston Bay. Site 3 has been impacted heavily in the past by subsidence and shoreline erosion. Numerous tree trunks seaward of the shoreline indicate evidence of recent subsidence and erosion. The authors estimate the erosion rate at Site 3 to be three feet per year. The bottom slope is very gentle and the tidal range is very slight. The soil series at Taylor Lake is Vamont clay with a very dark clay substrate.

The site has a northern exposure of about one mile. All sides of the lake appear to be eroding at approximately the same rate. Emergent vegetation is not present at this site. Taylor Lake appears to have been a fresh water swamp at one time but has been dramatically altered by salt water intrusion and subsidence.

Materials and Methods

U.S. Army Corps of Engineers General Permits and easements from the General Land Office were obtained to carry out demonstration plantings of smooth cordgrass at each site in the study.

Wave Barrier Construction. Prior to conducting transplanting efforts at all sites in the study, an artificial wave barrier was constructed approximately 50 feet from the mean high tide elevation (Figure 1). Strips of used cargo parachutes and plastic barricade fencing materials are attached to three-inch diameter wooden fence posts. The installation of the wave barrier protection increases the success for smooth cordgrass establishment. The barrier dissipates some of the wave energy, thus protecting the cordgrass transplants until they are rooted and well-established.

Single stems of smooth cordgrass were transplanted between the natural shoreline and the wave barrier in the intertidal zone. All transplants were spaced on three-foot centers. A planting unit consists of a single plug containing from one to four culms.

Transplants obtained for the study were sprigs or plugs from native plants growing in the general area. Transplant harvesting was randomly spaced across the area to avoid damage to the natural stand.

Fisheries Collection Methods. Fish and shellfish were collected during this study using a 20-foot "common sense" minnow seine with one-eighth-inch mesh. Two 50-foot seine hauls periodically were conducted at each site adjacent to the transplant plots to determine initial species diversity and relative abundance. Fish and shellfish collected at all sites were identified, enumerated, recorded and released.

Results and Discussion

Trinity River Delta. A single plot of smooth cordgrass was placed along the bay side of the west bank of the Trinity River delta. The plot measures approximately 0.14 acres. The wave barrier protection method used at this site consisted of plastic snow fence completely encircling the plot.

There were a total of 721 plants transplanted at this site. As of October 1991, only 141 plants had become established for a 20-percent survival rate (Figure 2).

Significant unforeseen problems with predators occurred at Site 1. Evidence of high nutria, *Myocaster coypu* Molina, predation was present. The authors recently began documenting large concentrations of nutria estimated at over 30 per acre consuming not only the transplanted plot, but also all native vegetation. Because of this predation, Site 1 will require re-transplanting and extra predator protection.

White shrimp and brown shrimp numbers dominated the catch at Site 1 with 53.2 and 12.5 percent of the catch, respectively (Table 2). Other species captured at Site 1 include Atlantic croaker, sheepshead minnow, bay anchovy, Gulf menhaden, Gulf killifish, spot, blue crab, and striped mullet.

Little Cedar Bayou. A single plot of smooth cordgrass was transplanted along the south shore of the mouth of Little Cedar Bayou in LaPorte. Wave barrier methods implemented were a double row of used cargo parachutes. Several fallen trees had to be removed from the transplanting site to prepare the site for transplanting.

A total of 497 smooth cordgrass plants were planted at Site 2. To date, 428 plants or 86 percent are surviving (Figure 2). Regular maintenance of the wave barrier protection is necessary to minimize the impact of ship wakes on the newly established plants.

Significant pressure has been exerted on the parachute barrier causing periodic wave barrier failure. Cross-section reference benchmarks have been placed on treated and untreated shoreline to determine erosion rates and the long-term effectiveness of vegetative shoreline treatment.

Bay anchovies dominated the catch at Site 2 with 36.2 percent (Table 3). White shrimp (19.2 percent), Atlantic croaker (18.5 percent), and spot (10.9 percent), were also captured at Site 2. Site 2 proved very difficult to collect fisheries samples because of numerous underwater obstructions. Therefore, the sample size at Site 2 was significantly lower than other sites.

Taylor Lake. Four plots of smooth cordgrass totaling 0.66 acres were established at the Taylor Lake site. Plastic snow fence was placed around the transplants to serve as wave barrier protection and to protect plants from unanticipated predator problems. Single stem transplants were placed on three-foot centers.

A total of 1,333 plants were planted at the four plots at Site 3. A total of 1208 plants were alive at the end of 60 days for a survival rate of 91 percent (Figure 2).

Predation from whitetail deer, *Oidocoileus virginianus* Zimmermann, was significant at Site 3 initially. Two plots required re-transplanting efforts due to the predation.

Overall success of plant survival at Sites 2 and 3 was sufficient to assure wetland creation. The most significant problems encountered in the study were related to herbivore predation. Natural vegetation is absent from most of the severely eroding areas in Galveston Bay. The authors believe that this not only contributes to the problem of shoreline erosion but to a decline in the productivity in the bay and a deterioration in the overall water quality.

White shrimp were most abundant at Site 3 with 28.2 percent of the catch (Table 4). Tidewater silversides and Gulf killifish were also abundant in the catch, having 18.1 and 13.0 percent of the catch, respectively. Although it is too early to confirm, the authors have recently noted increased utilization of the newly created plots of smooth cordgrass particularly at Site 3 by fish and shellfish.

Future efforts should include better methods to protect young transplants until established. It is felt that once established, the created wetlands will survive assaults by predators and chronic wave energy. Another long term objective will be to use the benchmark data to document the erosion rate for each site. Additionally, the authors plan to collect additional fisheries abundance data over time to determine if fish and shellfish species increase utilization of these newly created plots of smooth cordgrass.

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Table 1. Scientific names of fishes and shellfish used in this paper.

White shrimp	*Penaeus setiferus* Linnaeus
Brown shrimp	*Penaeus aztecus* Ives
Blue crab	*Callinectes sapidus* Rathbun
Grass shrimp	*Palaemonetes pugio* Holthuis
Sheepshead minnow	*Cyprinodon variegatus* Lacepede
Gulf killifish	*Fundulus grandis* Baird and Girard
Longnose killifish	*Fundulus similis* Baird and Girard
Rainwater killifish	*Lucania parva* Baird
Sailfin molly	*Poecilia latipinna* Lesueur
Bay anchovy	*Anchoa mitchilli* Valenciennes
Tidewater silverside	*Menidia beryllina* Cope
Rough silverside	*Membras martinica* Valenciennes
Striped mullet	*Mugil cephalus* Linnaeus
Gulf menhaden	*Brevoortia patronus* Goode
Atlantic croaker	*Micropogonias undulatus* Linnaeus
Sand trout	*Cynoscion arenarius* Ginsburg
Spotted sea trout	*Cynoscion nebulosus* Cuvier
Red drum	*Sciaenops ocellatus* Linnaeus
Spot	*Leiostomus xanthurus* Lacepede
Sea catfish	*Ariopsis felis* Linnaeus
Spadefish	*Chaetodipterus faber* Broussonet
Bay whiff	*Citharichthys spilopterus* Gunther
Pinfish	*Lagadon rhomboides* Linnaeus
Hog choker	*Trinectes maculatus* Bloch and Schneider
Bluefish	*Pomatomus saltatrix* Linnaeus

Table 2. Relative abundance of fish and shellfish captured at Site 1.

Species	No. captured	Relative abundance (%)
White shrimp	328	53.2
Brown shrimp	77	12.5
Sheepshead minnow	61	9.9
Bay anchovy	40	6.5
Spot	39	6.3
Striped mullet	28	4.5
Atlantic croaker	16	2.4
Blue crab	15	2.4
Gulf killifish	8	1.3
Gulf menhaden	4	0.6
	N = 616	

Table 3. Relative abundance of fish and shellfish captured at Site 2.

Species	No. Captured	Relative Abundance (%)
Bay anchovy	96	36.2
White shrimp	51	19.2
Atlantic croaker	49	18.5
Spot	29	10.9
Striped mullet	22	8.3
Sea catfish	11	4.2
Blue crab	5	1.9
Spadefish	1	0.4
Bay whiff	1	0.4
	N = 265	

Table 4. Relative abundance of fish and shellfish captured at Site 3.

Species	No. Captured	Relative Abundance (%)
White shrimp	215	28.2
Tidewater silverside	138	18.1
Gulf killifish	99	13.0
Sheepshead minnow	57	7.5
Brown shrimp	38	5.0
Grass shrimp	36	4.7
Rainwater killifish	29	3.8
Atlantic croaker	29	3.8
Blue crab	26	3.4
Spot	23	3.0
Bluefish (juv.)	16	2.1
Striped mullet	15	2.0
Bay anchovy	14	1.8
Gulf menhaden	5	0.7
Pinfish	3	0.4
Rough silverside	3	0.4
Sand Trout	2	0.3
Red Drum	1	0.1
Hog Choker	1	0.1
Sailfin molly	1	0.1
Spotted sea trout	1	0.1
	N = 762	

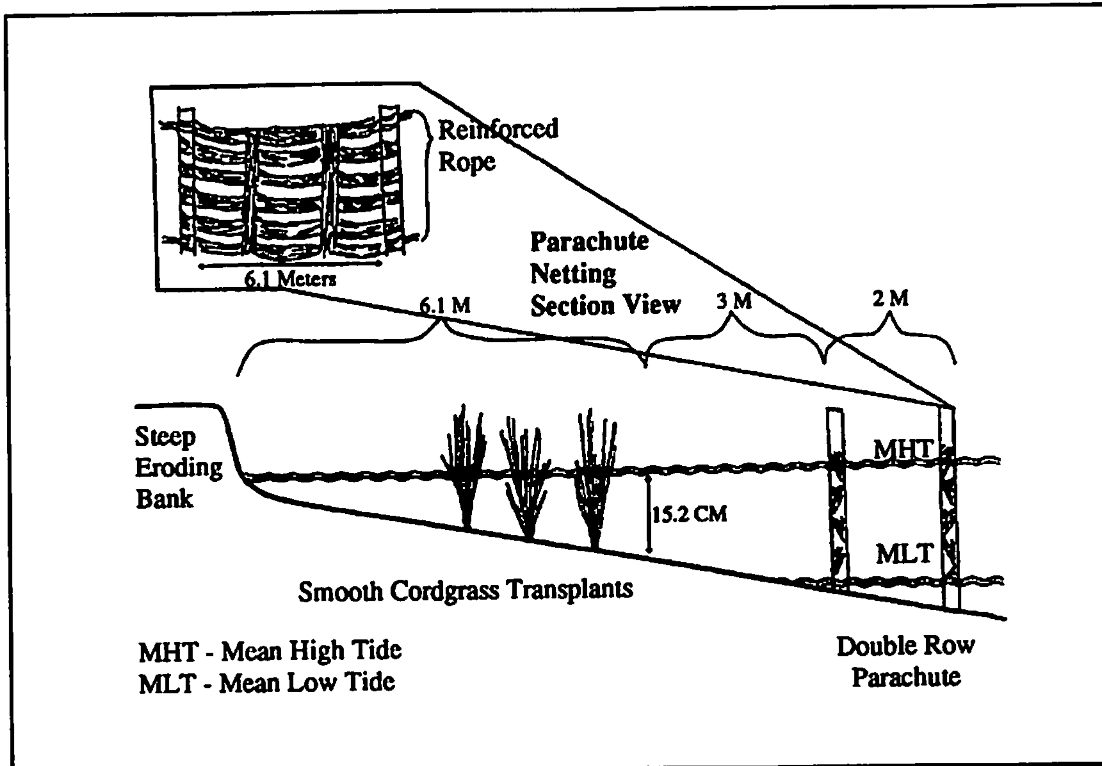

Figure 1. Shoreline cross-section, illustrating placement of artificial wave barrier made with double row of cargo parachutes.

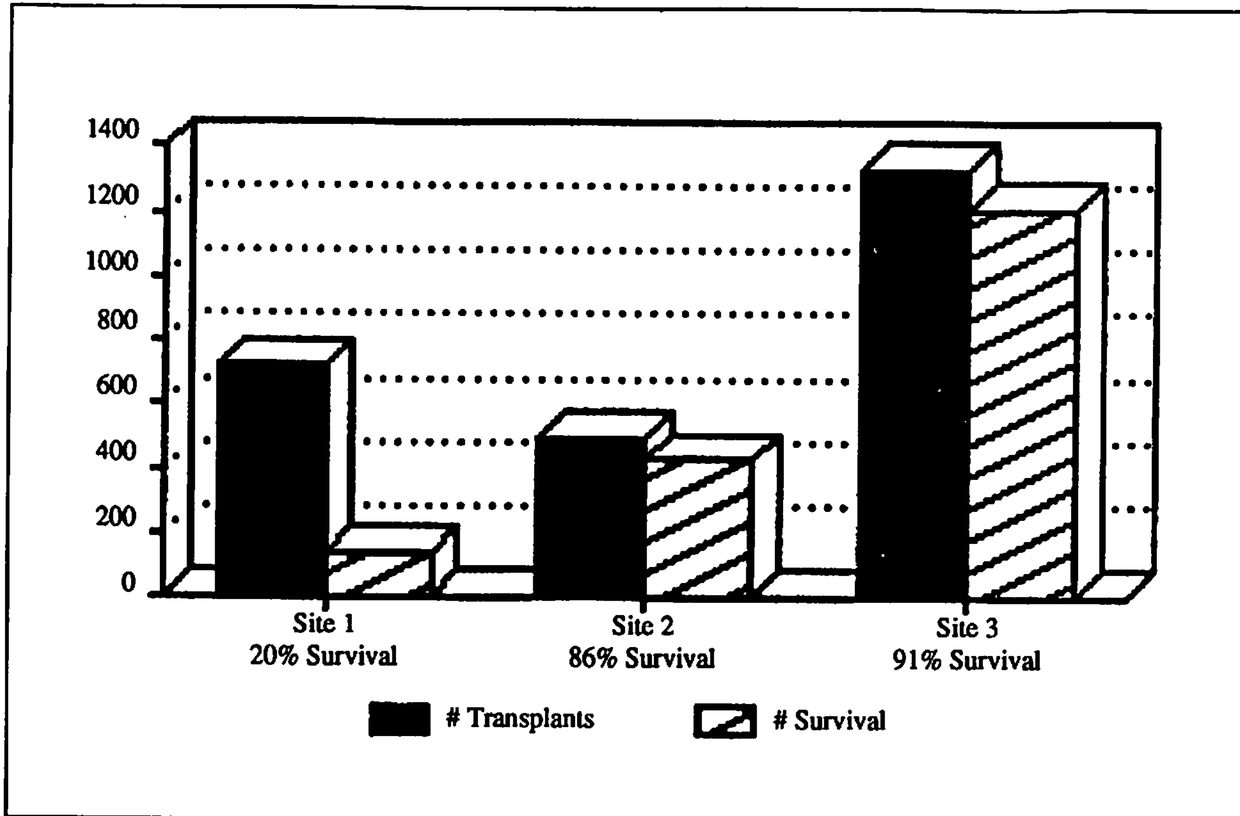

Figure 2. Transplant survival at Galveston Bay wetland creation study sites.

REMOTE SENSING OF BIOMASS TO DETERMINE CONDITION OF COASTAL WETLANDS

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Abstract

Satellite and airborne remote sensors have been used for several decades to map the acreage of wetlands lost to natural processes and human activities. Determining only the area of marsh lost, however, may not give an accurate description of the total degree of environmental degradation. For example, a marsh may have lost only 20 percent of its area, yet if the hydrology has been seriously disturbed, the productivity of the remaining 80 percent may be only a small fraction of its previous level. In response to this and other needs, new remote sensing techniques have been developed that enable researchers to determine not only the change in marsh area but also the marsh's biomass production and other indicators of condition and functional health.

We have used Landsat Thematic Mapper and SPOT images to quantify and map the distribution of live aerial biomass of tidal marshes along the East Coast of the United States. Such biomass estimates were within 13 percent of those derived from ground-gathered radiance and harvest data. Above-ground and below-ground biomass of *Spartina alterniflora* was harvested during the period of peak aerial biomass from six sites along a latitudinal gradient from Georgia to Nova Scotia. An equation relating live above-ground to live below-ground biomass for short-form plants was formulated using data collected in Delaware marshes. When data from the other sites were substituted into the equation, the mean live below-ground biomass it predicted was within 15 percent of the value determined by harvesting at four of the five sites.

Even though remote sensors can directly detect only the floral component and not the faunal component of marsh productivity, we expect that these techniques will significantly enhance our ability to determine marsh condition and functional health over large areas and at various repeat intervals. Biodiversity (defined by the variety of species inhabiting the wetland) and sustainability (defined as wetlands persistence over long periods of time) are two other condition indicators that appear amenable to remote sensing.

Acknowledgement

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Coastal Resources Management

BIOPHILIA AND HUMAN ATTRACTION TO THE OCEANS

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Abstract

"Biophilia" is defined as the attraction to or love for life and living things. In 1984, Edward O. Wilson described the biophilia hypothesis as "the innate tendency to focus on life and lifelike processes." "Biophilic experience" may be expressed in several ways, most prominently through human kinship with animals, by owning pets, or by pursuing a relationship or interaction with a domesticated or tame wild animal, such as at a zoo. It is also commonly expressed by people's tendency to travel, sometimes long distances, to experience nature and wildlife. "Marine biophilia" has been developed in prominent literature from many perspectives. Herman Melville, Henry David Thoreau, Henry Beston, John Steinbeck, Jacques-Yves Cousteau, Farley Mowat, and Barry Lopez, among other authors, have written of their fascination with and exploration of the marine and coastal environments. There are many types of human-ocean interactions, such as those available at aquaria and theme parks; programs in Florida and Hawaii that allow individuals to swim with captive dolphins; and, for those more willing to take on the elements, whale watching and other boat-based excursions and scuba diving. Exploring an unknown environment to gain knowledge and experience, however, must be done with caution.

Introduction

"Biophilia" means, literally, attraction to or love of life and living things. Herein we will explore the biophilia hypothesis as developed by Edward O. Wilson in his 1984 book *Biophilia*. To better understand how the biophilia hypothesis may be expressed in relation to the marine environment, it is useful to look at selected literature that presents human interactions with the ocean and coastal environment, and that describes the influence that the oceans and ocean life may have on human attraction to nature and wildlife. We will also examine ways in which marine biophilia may be expressed—the different methods of interaction with the marine environment that have developed as a part of popular culture.

Biophilia Revisited

In *Biophilia*, Wilson develops the hypothesis through a personal account of his beliefs and experiences. He describes biophilia as "the innate tendency to focus on life and lifelike processes" (1984:1). He finds its basis in the fact that "humanity is exalted not because we are so far above other living creatures, but because knowing them well elevates the very concept of life" (1984:22). Indeed, Wilson believes that:

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> to explore and affiliate with life is a deep and complicated process in mental development. To an extent undervalued in philosophy and religion, our existence depends on this propensity, our spirit is woven from it, hope rises on its currents.
>
> There is more. Modern biology has produced a genuinely new way of looking at the world that is incidentally congenial to the inner direction of biophilia. In other words, instinct is in this rare instance aligned with reason. The conclusion I draw is optimistic: to the degree that we come to understand other organisms, we will place a greater value on them, and on ourselves (1984:1-2).

Wilson traces the roots of biophilia to an understanding that, as humans,

> our sense of wonder grows exponentially: the greater the knowledge, the deeper the mystery and the more we seek new knowledge to create new mystery. This catalytic reaction, seemingly an inborn human trait, draws us perpetually forward in search of new places and new life (1984:10).

According to Wilson, the biophilia hypothesis is manifested in our search for knowledge and experience; it can be expressed as the exploration of relationships and interactions between humans and nature or other living organisms. But it is also necessary to examine why this tendency may have developed. What is it about human history that justifies defining biophilia as innate?

Wilson describes Alfred Bierstadt's 1868 painting "Sunset in Yosemite Valley," which depicts a Yosemite Valley free of human influence, as natural as it was ever known to European settlers. Wilson places himself inside the painting, and describes the experience: "History is still young, and human imagination has not yet been chained by precise geographic knowledge. Wherever we wish, we can strike out through the valley to the unknown terrain beyond..." (1984:11).

It is this feeling, the desire for exploration with even a remote possibility of new knowledge to be gained, that is central to the biophilia hypothesis. By extrapolating from Wilson's experience inside the Bierstadt painting, we can surmise that the biotic world of the 20th century must provide the forum experiences like those in the Yosemite Valley of 1868. If we need to explore and seek satisfaction in our explorations, then it is within our relationships and interactions with nature and other living things that such satisfaction should be found. Indeed, if biophilia were innate, then with time we would develop a keen sense of how to gain knowledge and experience from such relationships and interactions.

Wilson describes how the "catalytic reaction" of biophilia is triggered by the potentially infinite amount of knowledge to be gained from the biotic world. The biophilia concept thus encompasses the satisfaction resulting from any new knowledge gained from experiencing nature. That is, if biophilia is "the innate tendency to focus on life and lifelike processes," then we should (and do) have the ability (the keen sense) to gain this satisfaction from even the most minute detail or the most remote interaction.

Wilson certainly believes this to be true of his life. In *Biophilia* he describes his ability to perceive nature through a powerful cerebral microscope. For most people (especially those whose lives do not include significant amounts of time spent conducting field research in exotic locales), this perceptive development depends on a number of stimuli fostered through various behaviors.

There are several prominent expressions of the biophilia concept. One is kinship with animals. We may accomplish this two ways: by owning pets—animals that we consider companions or friends and whose lives we intertwine with our own, or by developing a relationship with or attachment to an animal at a zoo, aquarium or similar facility. These are the methods of biophilic expression that are most easily undertaken by the majority of people. They may provide us, within the comfort of our own homes or communities, with a connection to the biotic world and an outlet for experiencing it, and yet always in a familiar and non-threatening context.

We also travel, sometimes long distances, to view wild places and wild animals in their natural habitats. The proliferation and popularity of commercial nature tours and wildlife safaris attest to this, as do the physical stresses to which researchers and adventurers may subject themselves to study or see animals or plants in the most remote places.

Wilson proposes two methods of measuring biophilia. One is by analyzing our genetic and phenetic history—understanding how humans, and our simian ancestors, treated and interacted with the environment and other living organisms. Wilson proposes that throughout our developmental history, humans and human ancestors were inherently attracted to the most natural of life's experiences. In defense of this proposal, Wilson states:

> If the most general properties of human nature are shared with lower organisms in a manner similar to eating and elimination, they could be studied more efficiently in simple animals such as squirrels and bobolinks. But such is not the case. Although the rules of sexual choice, diet selection, and social behavior are to some extent shared with a few other species, the overall pattern is particular to *Homo sapiens*. Not only symbolization and language, but also most of the basic cognitive specializations are unique. Among them appears to be biophilia, which is richly structured and quite irrational, in conformity with a primate genetic history played out in the warm climates of the Old World (1984:114).

This propensity continues to manifest itself measurably, as modern—and particularly urban—society clings to what aspects of the natural world it can: house plants, lawns, gardens, pets. In light of this inclination and our ever-increasing dependence on technology, Wilson writes, "People react more quickly and fully to organisms than to machines. They will walk into nature, to explore, hunt, and garden, if given the chance" (1984:116). Even to the extent, Wilson believes, that we will treat the machines in our lives as living things. Many people, for instance, bestow upon their automobiles or other mechanical devices a distinct sense of personality.

Expressions of the biophilia hypothesis that are perhaps most easily quantified are the way in which we pursue interactions with nature and wildlife and the lengths to which we will go to have specific nature- or wildlife-oriented experiences. It is relatively simple to measure how much time or money is spent on a pet over time; how often, how far, and under what circumstances we will travel to interact with nature or wildlife; and what specific aspects of nature and wildlife we will travel to, pay money for, or otherwise go out of our way to experience. In short, how great an effort we will put into pursuing a "biophilic" experience.

Biophilia and Human Attraction to the Oceans

Attraction to the ocean and coastal zones spans all methods of "biophilic" expression. Marine animals may inhabit aquaria in our homes, or we may travel long distances and go to great expense to experience marine life in its natural habitat. We undertake many activities to satisfy the need to affiliate with living things. Though many of these activities have grown enormously in popularity only since mid-century, they have been a popular literary subject for at least the past 150 years or so.

Selected Literature. Human attraction to marine life may have developed with human use and exploitation of the oceans. Certainly as marine resource use prospered and grew into an industry central to the physical and economic well-being of coastal populations across the globe, intricate personal and even spiritual relationships between humans and the marine environment were developing. One prominent example is found in the growth of pelagic whaling. In the 18th and 19th centuries, whaling was more than just a resource use, as whaling captains' lives revolved around their long journeys and their quests for the great whales. Herman Melville, who travelled with the Massachusetts whalers of the mid-19th century, described the consummate love-hate relationship between man and whale in *Moby-Dick*. This was no mere search for sustenance, but rather a quest to legitimize the very existence of one man in relation to a great whale.

At the same time that Melville was writing of Ahab and the *Pequod*, Henry David Thoreau was discovering the Atlantic Coast in the first of two excursions he took from Walden Pond to Cape Cod in 1851 and 1857, respectively. These trips resulted in the posthumous publication of Thoreau's *Cape Cod* in 1865. Early in his wanderings, he realized that the sea and coast hold many mysteries, and that much can be learned from just a stroll on the beach. Walking the length of the Cape Cod's outer shore, Thoreau and his companion Ellery Channing were determined to learn the realm of experience that the ocean had to offer:

> We took to the beach for another day, walking along the shore of the resounding sea, determined to get it into us. We wished to associate with the ocean until it lost the pond-like look which it wears to a countryman (1987:207).

Seventy years after Thoreau's last journey along Cape Cod's shore, Henry Beston chronicled a solitary year living on that same shore in his 1928 book *The Outermost House*. In the forward to the 1971 edition, Beston reflects upon the meaning of his year on the beaches of Cape Cod, and in doing so presents an interpretation of the biophilia concept as apt as that offered by Wilson 13 years later. Beston writes:

> Now that there is a perspective of time, something else is emerging from the pages which arrests my attention. It is the meditative perception of the relation of "Nature" (and I include the whole cosmic picture in this term) to the human

spirit. Once again, I set down the core of what I continue to believe. Nature is a part of our humanity, and without some awareness and experience of that divine mystery man ceases to be man (1971:x).

Beston describes the foundation of his own expression of the biophilia hypothesis—the innate need to interact with nature that Wilson believes exists within all people. Beston expressed this in similar terms in his original text more than 50 years before *Biophilia* was published, and in *The Outermost House* his belief was manifested entirely in his relationship to the sea.

Others have followed Beston and Thoreau in their searches for knowledge and experience on the shores of the Atlantic. Anne Morrow Lindbergh's *Gift from the Sea* (1955), though more a statement of one woman's personal growth than an expression of the biophilia concept, includes many passages full of the mystery and wonder of the ocean and the shore, and many explorations of the life found there. In searching her innermost feelings, Lindbergh uses her examination of the sea as a metaphor for exploring her own self-awareness.

Rachel Carson's three books on the oceans and their resources are each valuable introductions to the experiences that the marine environment offers. In *Under the Sea Wind* (1941), *The Sea Around Us* (1951) and *The Edge of the Sea* (1955), she explores the ocean and coastal zone with a naturalist's eye, describing wildlife and the physical environment in a way that allows the reader to better enjoy and understand coastal and ocean life and ecology.

John Steinbeck, in *The Log from the Sea of Cortez* (1941), attempts much the same, but with a literary rather than ecological bent. He, too, perceives and communicates his experiences with the marine and coastal environment with a "biophilic" sense. The impetus for his trip along the coast of Baja California with marine biologist Ed Ricketts was primarily to collect specimens for Ricketts' research, but along the way the crew encountered not only animals but unexpected emotions as well. Steinbeck writes of one such occurrence:

> Now the sea turtles began to appear in numbers. (Tiny) stood for a long time waiting, and finally drove his lance into one of them. Sparky promptly left the wheel, and the two of them pulled in a small turtle, about two and a half feet long. Now we were able to observe the tender hearts of our crew. ... They hung the turtle to a stay where it waived its flippers helplessly and stretched its old wrinkled neck and gnashed its parrot beak. The small dark eyes had a quizzical pained look and a quantity of blood emerged from the pierced shell. Suddenly remorse seized Tiny; he wanted to put the animal out of its pain. ... Tiny swore that he would give up sea turtles and he never again tried to harpoon one (1977:50-1).

Steinbeck also describes another tenet of Wilson's hypothesis: an anthropomorphic appreciation for and relationship with one of the mechanical objects he encounters on his journey, in this case a small outboard motor, called a Sea-Cow, that all but confounds the crew. Steinbeck writes:

> The machine is at last stirred. A soul and malignant mind have been born. ... In the six weeks of our association, we observed it, at first mechanically and then, .

> as its living reactions became more and more apparent, psychologically. Whereas the forms that are familiar to us are the results of billions of years of mutation and complication, life and intelligence emerged simultaneously in the Sea-Cow. It is more than a species. It is a whole new definition of life (1977:24-5).

Much recent literature on human interaction with the marine environment has coincided with the extreme popularity that has come to surround marine mammals, particularly whales, dolphins and porpoises. Since the decline of whaling in the United States in the late 1960s and early 1970s and the subsequent rise in popularity of commercial whale-watching in the mid-1970s, whales and other marine mammals have become the objects of both a great outpouring of emotion and a rapidly growing recreation industry. Both factors have helped marine mammals to become the objects of biophilic expression for millions of people.

One of the first works to shed such a light on whales was Victor Scheffer's *The Year of the Whale* (1969), a fictional account of a year in the life of a sperm whale mother and calf. Scheffer, a marine biologist with the U.S. Fish and Wildlife Service for 30 years before becoming the first chair of the U.S. Marine Mammal Commission, uses to great effect both his broad biological knowledge and his love for whales to bring them into the hearts and homes of many people who had never had contact with these animals.

Two works of non-fiction helped to emphasize the plight of the whales and thus focus greater attention on them. Farley Mowat's *A Whale for the Killing* (1972) describes the life and death of a fin whale trapped in a bay on the Newfoundland coast. Mowat's emotional attachment to the whale, his insatiable desire for its well-being and loathing for those who needlessly would harm it promoted concern for one individual whale as well as for all great whales. In his book, he depicts an intense personal struggle with his own feelings and with those of the people who would kill the whale for no reason.

Jacques-Yves Cousteau and Philippe Diole's *The Whale Mighty Monarch of the Sea* (1972) chronicles a three-year expedition by the Cousteau flagship *Calypso* through the world's oceans in search of whales. Cousteau and his crew set out with a goal to increase their knowledge and understanding of cetaceans. Cousteau and Diole sought an emotional as well as physical connection to the animals they had come to know only in passing during their many previous journeys. Of their feelings at the outset of their journey they write, "contact with whales—with those enormous warm-blooded beings who bear such a strong resemblance to man, with their lungs, their intelligence, and their talent for communication—this is a uniquely exciting experience" (Cousteau and Diole 1972:12).

In his 1986 book *Arctic Dreams*, Barry Lopez explores the stark environment and diverse biotic resources of the Alaskan and Canadian arctic. He talks and travels with native peoples, and while describing their experiences and perceptions of the arctic environment, he discovers his own. In one passage, Lopez describes his first sight of narwhals on the coast of Baffin Island:

> I stood still occasionally to listen. I heard only the claver of birds. Then there was something else. I had never heard the sound before, but when it came, plosive and gurgling, I knew instinctively what it was... (1986:125).

Many other books, both fiction and non-fiction, explore human relations to the oceans and the life they hold. The books discussed herein are representative of authors, who, through their personal and professional interests, have communicated a feeling of enhanced experience and heightened emotion resulting from interactions with marine animals and their environment. These authors, and others who share their appreciation for and attraction to the oceans and coasts, promote the biophilia hypothesis in the topics they write about, in the ways in which they approach their subject matter, and, in some cases, through a direct and strong belief in the connection between people and nature that is the basis of biophilia.

Selected Interactions. Many activities can bring us into close contact with life in the oceans and coastal zones. A combination of the manifestation of "biophilic" tendencies, improved technology, and the potential for profit have led to the development of many methods of interaction between humans and the marine environment.

Many people bring the aquatic environment into their homes in the form of aquaria. In addition to offering the opportunity to manage a micro-ecosystem and to study its inhabitants at close range in the comfort one's own home, the contemplation of aquaria has been shown to have physiological and psychological effects, including reducing stress (Katcher, 1989).

Besides home aquaria, the most easily accessible experiences are those at commercial aquaria and related facilities. Most aquaria enable us to learn a great deal about marine life and the ocean environment, through exhibits, educational programs, and popular marine wildlife exhibits, many featuring marine mammals such as seals, sea lions, sea otters, and small cetaceans such as dolphins and porpoises.

Aquaria, zoos, and similar facilities allow urban (and in some cases, landlocked) individuals to experience the marine environment without requiring long travel times or potentially stressful conditions. These experiences, though not as natural as those availabel in the wild, do provide a forum for marine biophilic expression, as we can have closer and perhaps more personal contact with marine animals than is normally possible in the wild.

In the early 1980s, for example, the New York Aquarium exhibited two walruses that had been taken into captivity when they were orphaned as infant pups. Due to the young age at which these animals were brought into captivity, they became adapted and confident in the presence of humans and especially the aquarium staff, to the extent that they would approach the staff upon recognition (possibly triggered by the staff's blue-and-white uniforms) and come when called by name. Such interactions allowed not only the staff but also the visiting public to encounter these animals on a personal and emotional level not attainable in the wild, or even in most zoos or aquaria. This, in turn, allowed for a greater experiential value of the interactions, which could inspire greater manifestations of biophilic tendencies than might normally occur at the aquarium. Even in the absence of extraneous circumstances such as those that friendly walruses might provide, aquaria and marine theme parks allow us to get to know marine animals better, and thus to better develop our curiosity and desire to learn.

An extension of the aquarium or theme park is the recent introduction of "swim-with-the-dolphin" programs in Florida and Hawaii. For a fee, these programs allow people to enter and swim in a small enclosure with one or more trained dolphins. This type of experience, though controversial due to questions as to the appropriateness of such a use of animals, produces great emotion and excitement in most (human) participants. It brings us a step closer to having a natural interaction, or at least how we might envision a natural interaction, by providing a forum for observing marine mammal behavior at very close range and in a more personal context.

With larger marine animals, direct human contact is often dangerous if possible. Such is the case with the great whales. Whale-watching has, in the past 15 years, become a multi-million-dollar North American industry that each year brings millions of people to see whales in their natural habitat throughout the coastal waters of the United States and Canada (Tilt, 1985).

The great whales have largely retained the mystique that has developed since *Moby-Dick* was written, as they have shifted from a largely consumptive resource to a largely recreational resource. Whale-watching has enabled us to come to know and understand these animals better, both scientifically and in terms of the emotions that they elicit in us. As whales have become popular, our attraction to them has grown, and the whale-watching industry has reacted by providing more and greater opportunities to view and experience whales in their natural habitat.

Indeed, whale-watching has become a fine-tuned operation. Though it is impossible to predict exactly where or when a whale may be seen, enough is known about many coastal species to have a relative assurance of being in the right place at the right time to see a whale. Handbooks and guides to frequently observed species have been published for those seen on the Atlantic and Pacific coasts of North America (Corrigan, 1991; Hoyt, 1984; Katona et al., 1983).

Though a number of studies have analyzed the whale-watching industry (Center for Marine Conservation, 1988; Tilt, 1985), none has attempted to measure the importance of whale-watching for human emotional or biophilic impact. It is not difficult to understand the human attraction to whales in light of the mystery that surrounds them; they are perceived to be intelligent, communicatory mammals that live entirely in the ocean. Little enough is known about the great whales that they remain shrouded in biophilic mystery. Here is the potential for new knowledge and experience waiting to be discovered, and whale-watching allows us to explore these animals and perhaps shed some light on that mystery.

For an increasing number of people, the role of observer does not completely satisfy the urge to explore and learn about the marine environment. Nor does even the opportunity to swim with a dolphin in an enclosed pen. To greatly expand our realm of experience in the marine environment, in order to become, albeit temporarily and artificially, an aquatic creature, we must turn to scuba. Scuba allows us the opportunity, with the proper skills, to don the equipment necessary to swim in the ocean for extended periods of time. It gives us the sensation of becoming a marine animal, and brings us as close as we can come to sharing the experience of inhabiting the ocean. In this sense, its biophilic potential is perhaps greater than any other ocean-based activity we have learned to undertake for pleasure. Scuba creates for us a new world underwater in which to live, if limitedly, and learn from the life we find there on a personal emotional and physical level that we otherwise could not achieve.

Conclusion: The Limits of Marine Biophilia. As technology improves, so does the ability to manifest our tendencies toward experiencing nature in new and greater ways. As each improvement leads to the opportunity for new experiences, expression of the biophilia concept may continue to grow.

As with our exploration of any new environment or living being, the better we come to know it, the less natural it tends to remain. Our relationship to wildlife and the natural environment has historically been one of callous disregard or antipathy. Our impacts on the ocean and its resources have often been disastrous. By opening up a relatively new realm of human experience in our biophilic relationship to the oceans and coastal zones, we must be careful not to harm their ecological well-being.

The extent of potential experience yet to be gained from the marine environment is huge, but we must proceed with caution. As Wilson states, "nature is to mastered, but (we hope) never completely. A quiet passion burns, not for total control, but for the sensation of constant advance" (1984:10). Our attraction to the oceans, according to the biophilia hypothesis, should lead us to greater knowledge and emotional and experiential satisfaction, but never at the expense of the life to which we are attracted.

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EVOLVING MANAGEMENT FRAMEWORKS FOR COASTAL WATER RESOURCES

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Introduction

Like the coastal ecosystems found in different places, the agencies and organizations that manage them are diverse. Mandates for these organizations can be broad or narrow, and the organizational structures or management frameworks vary widely. Our use of the term *management framework* refers to the agencies and organizations whose major concerns are the management of coastal water resources. We assume that the management philosophies and the strategies for actualizing them are embodied in the organizations' programs.

This study presents a distillation of ideas collected from a survey of the current population of management programs and generalizations about their major characteristics. These major characteristics are the mandate, organization, funding and public involvement activities. This report is not intended to present an exhaustive analysis—of either management or organizational development—nor a catalogue of all active programs. It is intended to present some important and timely issues and recommendations to provide food for thought to coastal scientists, managers and interested lay persons. The recommendations are aimed at people who are involved in establishing or refining comprehensive management frameworks for estuaries or coastal ecosystems.

Management frameworks evolve with time and in response to different opportunities for growth and in response to different external and internal stresses. One of the current stresses is growing competition for support from federal and state agency budgets.. The programs we surveyed are evolving new strategies to find support from different sources to maintain their existing structures. Management frameworks are also evolving more complex strategies to respond to diverse demands from the multitude of users of coastal water resources. This is in response to more and more people with mutually exclusive demands for coastal water resources who are seeking to push their needs to the forefront of coastal managers' priorities. This multiplicity of demands for the resources and upon the managers will continue. Coastal managers will continue to be challenged to evolve strategies to balance the demands for use of coastal resources, while not compromising the resources' long-term viability.

Complex coastal problems demand interdisciplinary and interorganizational work. Formal and informal committees and task forces are being formed to address rapidly proliferating coastal problems.

Coastal resource management requires long-term vision. As resource managers consider what types of management frameworks are most effective for their situations, they should consider future working relationships and institutional arrangements among the current stakeholders. New relationships and arrangements must build on and strengthen management frameworks. Strengths and weaknesses of the current and potential political frameworks must be analyzed candidly. Each component of management frameworks should be examined separately, and the structure should be analyzed as a whole. Special efforts should be taken to define problems in terms of the uncertainties of the future, because political and economic climates inevitably change.

The following discussions and recommendations grew out of the collective wisdom of numerous people in the organizations contacted during a North Carolina project. This shorter paper attempts to relate the recommendations to the immediate challenges and tasks facing coastal resource management and restoration plans and ongoing projects.

Approach to the Study

This paper is based on information collected for the North Carolina Department of Environment, Health and Natural Resources in a project for the Albemarle-Pamlico Estuary Study, one of the National Estuary Programs. The purpose of that project was to identify successful elements of environmental management to help resource managers, scientists and citizens develop a comprehensive management plan for Albemarle-Pamlico sounds.

A list of screening criteria was developed by conducting a literature review and interviews with key individuals in federal, state, interstate and nongovernmental agencies and organizations. The following criteria were used to screen whether a program contains elements of interest.

Works within existing organizational frameworks;
Coordinates work of two or more governments or organizations;
Provides significant opportunity for public involvement in decisionmaking;
Involves both governmental and nongovernmental organizations;
Includes novel problem-solving techniques, such as conflict resolution and environmental dispute resolution;
Focuses on the goal of environmental restoration and protection; and
Meets environmental objectives while containing or reducing program costs.

Information about a program was sought if it met one or more of the above criteria; no program was expected to meet all of the criteria. More than 75 programs were identified, principally via interviews. Information was collected via a questionnaire and supplemented by written material from the interviewees.

We have tried to find an appropriate balance between discussing all of the individual programs and providing enough detail to let the reader get a sense of the richness that these programs contain. We have tried to use names of projects that clearly identify programs.[2]

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[2]A more detailed account of this work is found in a report by the same authors entitled *Environmental Management Strategies: Comparative Analysis and Selected Case Studies*, a report to the Albemarle-Pamlico Estuarine Study. February, 1992.

Background

Many of today's programs grew out of earlier programs, such as the Great Lakes Program, the Clean Lakes Program, the Chesapeake Bay Program, and the interstate coordination provisions of the Clean Water Act. Many of these were founded on natural resource boundaries, rather than political boundaries. Watersheds are increasingly used as frameworks for protecting and managing resources such as groundwater, drinking water, lakes, coral reefs, fisheries and wetlands.

Multijurisdictional programs usually evolve through similar growth patterns. These patterns or phases reflect the application of the scientific method of problem-solving to technical problems with a management context. The phases usually entail the following:

Recognition of the Need for an Alternate Strategy. Users and managers of the natural or coastal area determine that the existing management framework is inadequate to protect the resource. This determination for a change is usually bolstered by public or political support for a change.

Formation of a Multijurisdictional Body. Key players are identified to develop the plan, and a group with overlapping needs and goals is formed. Often, the players are organized into committees to compile expertise, to channel energies efficiently, and to define roles. Often a program, such as the National Estuary Programs, uses a hierarchical structure with an oversight committee supported by a citizen's advisory committee, a technical advisory committee, and sometimes an environmental managers committee.

Problem Definition and Characterization. Problems affecting environmental quality are defined, evaluated and prioritized. Concurrently, the characteristics of the natural resource are assessed.

Data Analysis and Collection. Datasets are examined to identify gaps. After plans for filling data gaps are developed, a strategy to collect data is developed and implemented.

Plan Formulation. As information becomes available, committees develop alternate actions to address each of the priority problems as well as a mechanism for plan implementation.

Plan Implementation. A mechanism is established for plan implementation that includes a vehicle for reassessment, periodic public involvement, and scientific input.

Many programs use this approach, including the Environmental Protection Agency's Clean Lakes, National Estuary, and Near Coastal Waters programs, and the Bureau of Land Management's Stewardship and Coordinated Resource Management programs. The schedule and sequence of the phases vary, in some cases, such as the Columbia River Estuary Project, dictated by legislative deadlines. In others, such as the Pinelands Commission and the Great Barrier Reef Authority, committees continually reassess their actions and revise their management plans based on changing knowledge and management pressures.

Many of the programs surveyed had not reached the stage of plan implementation. Despite this lack of maturity, most of the programs were those in which active, hands-on management decisions were being made.

Mandate and Organization

A mandate is the ultimate authority for a program and is of paramount importance to effectiveness. Some, such as the San Francisco Bay Conservation and Development Commission, which regulates actions within 100 feet of the shoreline, are narrowly focused. Others, such as the Delaware River Basin Commission, encompass all types of water quality and quantity issues. Still others, such as the Lake Tahoe Basin Management program and the Critical Area program in Maryland, have been given the authority to address both land-use and water quality controls.

Most mandates are defined when the organization is created. However some, such as the Virginia Council on the Environment's involvement with the Chesapeake Bay Program, and Morro Bay Task Force, developed their roles without waiting for a formal mandate.

The programs originally investigated included governmental, quasi-governmental and nongovernmental organizations.

Links with Existing Programs

Mandates for management frameworks often lump together all coastal and water management programs and issues. For example, the Cape Cod Commission's mandate encompasses surface water, coastal water and groundwater. The Delaware River Basin Commission addresses issues of both water quality and water quantity.

To build cooperation and alliances among complementary programs, coastal management programs could develop cooperative projects with other programs, such as the drinking water program, that have similar goals and objectives. For example, North Carolina's drinking water programs (within the health agency) encourage the adoption of land-use planning measures to reduce the water resources' susceptibility to pollution by controlling the type and location of human activities in the watershed.

Responsibilities for setting general goals and objectives lie with the state, while the power to implement control measures lies with the counties and local governments.

Recommendation: Coastal management frameworks should have broad mandates so that all issues regarding water quality and quantity can be addressed when necessary.

Evaluation

No plan or management framework applies to all circumstances and all times. Our state of knowledge is constantly improving with respect to natural resource management, pollution sources and pollution reduction strategies. Evaluation of plans and frameworks must be part of the management routine. There needs to be periodic review by all parties, scientists, industry and citizens. Mechanisms are needed for accommodating changes in circumstances and the level of our knowledge.

Recommendation: Coastal management frameworks should be required to review plans and programs regularly. This review and evaluation should include reassessing the program's technical foundations, progress related to the program's goals, the need to add, modify or delete goals, and the efficiency of implementation. Parties representing all interests should take part in this process.

Organizational Frameworks

Some coastal management programs developed within other institutional frameworks. Others, such as the Delaware River Basin Commission, created institutional frameworks especially for their purposes. Still others work in clusters of individual programs to create and conduct effective management strategies, as seen in the Tampa Bay programs.

Many programs were created to address specific problems and evolved to serve broader needs and to take advantage of funding and other opportunities. Such program clusters include Maryland's Critical Areas, Nontidal Wetlands and Forest Conservation programs, supported by the Alliance for the Chesapeake Bay and the Chesapeake Bay Foundation (and other programs and non-governmental organizations); Minnesota's Watershed Districts, Lake Improvement Districts and Joint Powers Organizations; and Tampa Bay's National Estuary Program, Surface Water Improvement and Management Program, and Agency for Bay Management.

Most programs created oversight boards to coordinate ongoing projects, consisting of members appointed by a governor or political body. Members of oversight boards reflect the range of stakeholders affected by the decisions about the coastal resource. Most programs also have subcommittees of less senior people from the same organizations that report to the oversight board. Many have technical advisory committees, state environmental manager committees, and citizen advisory committees. These committees meet more frequently than the oversight committee and are responsible for the working relationships that manage the resource.

Board decisions are reached through a variety of methods. Most boards strive for consensus, at least on overall policies. Votes are often taken in cases of regulatory and enforcement decisions, when timeliness in decisionmaking is essential. Representatives of federal agencies, when appointed to oversight boards, often serve as ex officio or non-voting members.

State, Local and County Government

In the past decade, federal assistance to the states and local jurisdictions has diminished substantially, a trend that is expected to continue. Therefore, environmental protection and restoration will increasingly be the responsibility of state and local managers. The temptation is great for states to pass program responsibilities on to local communities, often without providing fiscal or personnel support. Many activities, such as data collection and model ordinance development, are better handled at the state level and can provide a coherent framework for implementation locally or regionally.

The key to success is to create an institutional arrangement that contains a unified comprehensive planning framework for land and water resources addressing growth management, yet not overburdening counties and local communities. Local governments are a significant source of strength for implementing coastal protection.

Recommendation: Government agencies' current mandates, responsibilities and capacities should be examined to find effective ways to promote collaboration and reduce redundancy or overlap in coastal management programs.

Interagency Committees: Authority of Appointed Members

For an interagency decisionmaking body to function efficiently, its members must be able to speak with authority on policy and be able to make programmatic commitments. This allows each member to take an active and equal role in the decisions made at the meetings. In some programs, before the oversight board of senior officials meets, their key staff members meet to review the agenda for the upcoming meeting and to compile information that the senior officials will need at the meeting.

Recommendation: Guidelines for membership on committees and oversight boards are needed to ensure that members who represent various interests and agencies can speak with authority on policy issues and make programmatic commitments.

Responsibilities of Membership

All user groups must be represented on committees so that recommendations include and reflect their concerns. When all groups are represented, the agreements are more likely to be implemented effectively. Having a name on the membership list is not sufficient to provide representation; there must be ongoing, sincere participation. Essential to the successful functioning of multi-interest coastal management is a serious commitment of human resources and a continuous communication with the committee and board members' home organizations. This continuous feedback provides information and strengthens the links between the parties within the participating organizations.

Recommendation: Guidelines or membership on committees and oversight boards should ensure balanced representation of all affected user groups. Explicit descriptions should include items such as the authority of substitute members, attendance at meetings, and expectations of the group for individual members to communicate information among themselves and back to their home organizations.

Size and Support for Interagency Committees and Boards

It is never easy to determine the ideal size of decisionmaking groups; there are costs and benefits to both large and small groups. Some of the decisionmaking bodies surveyed were quite large, with more than 50 members (Santa Monica and San Francisco); others were quite small, such as the Delaware River Basin Commission, with five members. The tradeoffs are between complete participation, level of involvement and effectiveness. The larger the oversight committee, the more difficult it is for individual special interests to influence the decisionmaking. The smaller the group, the more rapidly it can reach decisions. In some small groups, however, individual members are expected to invest more time in the operational aspects of the management issues.

Most oversight boards appoint subcommittees (for example, technical and citizens advisory committees) to advise and make recommendations to them on specific aspects of management. Members of these committees are often drawn from a variety of agencies' technical staffs, independent experts, government managers and citizens. In most cases the participating agencies and organizations are expected to provide support to these subcommittees without financial compensation. Most organizations can contribute only a modest level of support, without sacrificing ongoing work. Obviously, this can create hardships for those involved, especially for newly created programs and organizations comprising citizen volunteers.

The members of the oversight board usually depend to some extent on technical staff for information about the issues and for analysis of alternate recommendations. The larger the oversight board, the stronger the support staff must be to keep work organized and to provide technical and policy support. Again, adequate resources are needed to provide for a sufficient staff and resources.

Staff

The ability to have a staff was directly related to funding. Programs with larger staffs, such as the Puget Sound Water Quality Authority and Delaware River Basin Commission, can raise funds through taxes or surcharges. However, many successful programs, such as Tijuana River National Estuarine Research Reserve, the Morro Bay Task Force, and Yakima Valley's Conference of Governments, implement their programs using staff from participating governmental organizations. In the smaller programs, staff positions usually included a director, public information officer, secretary, and possibly a scientist or lawyer. We found a greater variety of positions as the size of the staff increased.

Participants

Many programs contained guidelines that require broad and compulsory participation of, or representation by, affected user groups. For example, programs in the Pacific Northwest and the West generally include Native Americans; the Cape Cod Commission included minorities; the Columbia River Estuary Project added industry, environmental, commercial and recreational fishermen, and port representatives. At the Tijuana River National Estuarine Research Reserve, participants were required to have a natural science background. At Morro Bay, participants included anyone who chose to participate, that is, volunteers whose interests and participation varied depending on the current topic.

Public Involvement

Nontraditional public involvement activities occur in many of the programs surveyed. The use of citizens' advisory committees or other formal representation has become the norm. Many programs, such as the Pinelands Commission and the Great Barrier Reef Authority, use newsletters, conferences, slide programs and awareness days to promote public involvement. More and more often programs are reaching out to citizens, informing them about public involvement vehicles and the public involvement process.

Some programs have developed technical training workshops for specific interest groups. For example, Minnesota developed material for ranchers about manure management, the Great Barrier Reef Authority developed videos for fishermen, and Puget Sound Water Quality Authority, under the state's Public Involvement and Education Fund, supported farmer's wives to develop videotapes about best management practices for other farmers. The Minnesota Tri-County Commission instructed a group of farmers in best management practices and funded their initial efforts, hoping that their successes and savings will induce other farmers to adopt the methods.

The Chesapeake Bay Foundation, all three Tampa Bay programs, and the San Francisco Estuary Project use educational curricula, field trips and other hands-on techniques to teach and inform students and the interested public about their programs and natural resources. A few programs, such as those in the New Jersey Pinelands, the Mississippi Headwaters Board, and the Santa Monica Restoration Project, obtained foundation funding for the public involvement activities, such as citizen monitoring activities or public workshops.

The two primary questions to be answered are, what should be done to protect and restore coastal resources and who should take these actions? The issue underlying these decisions about what to do and who should do it is, who decides? Recently many coastal programs in the United States and abroad have created management frameworks that involve all stakeholders, those directly and indirectly affected by these resource management decisions, such as fishermen, tourism representatives, residents, port authorities, and other coastal interests.

The Role of Non-Governmental Organizations

As federal funding for environmental programs declined in the past decade, the burden of coastal management and enforcement shifted to state and local agencies. In states where there is strong public support for coastal protection, nongovernmental organizations (NGOs) have come forward to provide public education about the values of healthy ecosystems and to rally public and political support for environmental programs. Prominent examples of NGOs actively involved in environmental protection are 1,000 Friends of Florida, the Chesapeake Bay Foundation, and Great Lakes United.

NGOs can fulfill many roles, including citizen watchdog, lobbyist, educator, technical trainer, research sponsor and facilitator. Most coastal regions have many concerned individuals and groups, and public agencies have made substantial efforts to involve them in their work.

Recommendation: Coastal management frameworks should encourage nongovernmental organizations to play active roles and help ensure that they have the necessary resources and funding to fulfill these responsibilities.

Citizen Oversight of Coastal Management Actions

Public frustration about the need for coastal water quality improvement, the lack of compliance with coastal and other environmental regulations, and the ineffectiveness of enforcement actions are becoming more serious. Many enforcement authorities, especially in the current economic climate, have limited staffs for identifying and correcting permit violations. Regulation systems, usually based on punitive actions, do not work to everyone's satisfaction.

Forums are needed at which violators and public representatives (with other interested stakeholders) can meet to discuss their problems and interests. To improve cooperation, discussion might focus on possible incentives, financial and non-financial, rather than on (or in addition to) punitive actions. To be workable, solutions must be practical ones that all sides can live with. At the same time, they must be enforceable and contain deadlines.

Recommendation: Coastal management frameworks should actively involve the public and invite their participation in creating innovative solutions to difficult management problems. Consideration should be given to developing incentives for compliance, as well as to punitive measures.

Materials to Inform and Encourage Public Support

Public support for coastal programs is vitally important when decisions are being made as to funding, direction and staffing. In many areas, such as the Great Lakes and the Mississippi Headwaters, programs are dedicating a part of their efforts toward educating citizens about the opportunities for public involvement. For example, the Great Lakes Sea Grant Program is developing materials to explain the remedial action plans in Great Lakes Areas of Concern and to identify opportunities for public participation. The Mississippi Headwaters Board developed informative materials about zoning. These materials are an excellent base for developing similar materials for other programs.

Recommendation: To increase and sustain public participation in coastal programs, the management frameworks should support efforts and develop materials to inform communities and other affected parties about the public decisionmaking process as it pertains to coastal water quality management.

Boundaries

Watershed Boundaries for Management Frameworks

Hydrologic boundaries are natural units of organization. Resource managers, property owners and citizens are recognizing the need to approach resource protection and management by natural watershed rather than by program. To be most effective, watershed management must be undertaken by multiple jurisdictions, because hydrologic boundaries seldom coincide with jurisdictional ones. North Carolina recently began to adopt the watershed approach in its National Pollutant Discharge Elimination System program.

Focus

Separating Short-Term Crises from Long-Term Conflicts

A program often will create a forum to deal with a "hot topic" crises and other short-term issues. Such forums allow people to voice concerns and to contact others who share them and who may wish to collaborate in developing solutions. The Morro Bay Task Force, for example, sets its agenda according to requests. Some groups limit their focus to short-term issues. In Tampa, the Agency on Bay Management addresses relatively short-term issues, such as red tides, while the Tampa Bay National Estuary Program, focuses on issues related to long-term management of the bay.

Recommendation: Coastal management frameworks should create a forum for groups and individuals to handle short-term topics so that such issues do not distract from the long-term management efforts of the Albemarle-Pamlico estuarine complex.

Tools for Managing Conflicts Productively

Many programs establish an organization or appoint a person to help groups work together. They use techniques of dispute resolution developed to help negotiate agreements that all parties can accept. Examples of this approach include the Florida Growth Management Conflict Resolution Consortium, which provides neutral persons to assist parties who are in conflict; the Lake Okeechobee SWIM program, which hired as director a person trained in alternative dispute resolution; and the Maryland Targeted Watershed Project, which also employed a facilitator to coordinate a project involving five state agencies and their counterparts at the county level and several non-governmental organizations.

Other programs regularly use alternative dispute resolution techniques in their planning. For example, the New Jersey Planning Office has a cross-acceptance program with local and county governments that built consensus on the contents of the state plan through extensive meetings with affected parties. The Tampa Bay Agency on Bay Management used similar techniques to reach consensus in formulating recommendations regarding management direction for the Bay.

Some programs, such as the Yakima Valley Conference of Governments, are considering the need to reach consensus on all issues. Other programs, such as the Delaware River Basin Association or the San Francisco Bay Conservation and Development Commission, use consensus-building techniques, but do not require that consensus be reached on all topics.

Recommendation: Coastal management frameworks should recognize the potential contribution of dispute resolution techniques to plan development and implementation and should provide training in teamwork and dispute resolution techniques to all interested persons.

Growth Management

Conflicts caused by economic development in environmentally fragile areas should be anticipated. Managing growth and protecting the environment are not mutually exclusive goals. Growth is inevitable, both in the number of people living in the Albemarle-Pamlico region and in the amount of impact that human development causes to the environment. Growth management is a difficult issue.

Environmental protection work has suffered where managers deliberately chose to avoid growth issues. Their program lost both credibility and public support when growth management became the foremost political issue. Although there are issues that a management conference can ignore, growth management is not one of them.

Some examples of programs that have handled growth successfully with a range of different techniques include the Pinelands Commission, for which limitations regarding land-use densities are directly incorporated in the local plans and regulation, and the Lake Tahoe Basin Management Unit, for which there are detailed land-use restrictions and residents are reimbursed for their land if they chose not to comply. In Florida, where growth is a priority issue, the state requires all counties to develop growth management plans. The Maryland Critical Area Program presents an interesting example of a state's creating a landward buffer to protect tidal waters from uncontrolled growth and development.

Growth management is ultimately the responsibility of local communities. Recognizing this, the management capacities of local governments should be developed so that the implementation of the regional growth management plans can be handled at the local level.

Recommendation: Coastal management frameworks should address growth management directly. The framework should work with existing growth management and planning groups to ensure that planning and management are based on a regional ecosystem framework that incorporates a long-term planning horizon.

Funding

Most programs rely on funding from the affected governments. A few, such as Minnesota's Lake Improvement Districts and Watershed Districts, have taxing authority and are financially self-sufficient. Many creative partnerships between government, industry and public interest groups have been worked out. An interesting example is the North American Waterfowl Plan, in which government, the private sector and public interest groups are actively working together to acquire and manage waterfowl habitat. Another example is the Columbia River Estuary Project, which is jointly funded by the states, local port authorities, and the pulp and paper industry. The Florida Trust for Corkscrew Regional Ecosystem Watershed is a partnership in which two public interest groups act as acquisition agents for environmentally sensitive lands and the water management district becomes the landowner.

Some coastal management programs, such as the Santa Monica Restoration Trust and the Buzzards Bay Coalition, created non-profit organizations to provide an avenue for private donations and lobbying that are not available under most government programs. More recently, these non-profit organizations have been established by legislation, as in the cases of the Puget Sound Foundation by the Washington legislature and the Lake Onondaga Conference established by Congress.

One of the greatest challenges to any resource management program is finding sufficient resources to fund and staff their activities. This is particularly difficult given the current economic climate. Locating funding and other support for environmental restoration and protection programs is becoming more difficult due to cuts in both federal and state budgets. Programs relying on outside funding many face financial cutbacks.

Coastal managers must consider ways to give their organizations the authority to raise funds through taxation, permit fees, water use fees and environmental impact fees. One of the most interesting models of this authority was found in the Minnesota watershed districts, where local communities have the authority to levy an ad valorem tax on waterfront properties. From an economic and public policy standpoint, this form of taxation is efficient in that it primarily affects the direct users of the watershed.

Some coastal management programs have created institutions (trusts, foundations, etc.) to receive and disperse money or services. Such instruments allow the receipt of private money and services to be donated to support a specific program's goals and objectives. These institutions are a flexible way to fulfill program needs that extend beyond the current framework.

Recommendation: Coastal resource program managers should help provide state and local governments with the authority to raise funds for coastal protection, restoration and management through a variety of means, including establishment of non-profit institutions. They should also work with the non-governmental organizations to help them obtain the necessary resources and funding to fulfill their responsibilities for project development and implementation.

APPLICATION OF MEDIATION PRINCIPLES TO COASTAL FISHERY CONFLICT RESOLUTION

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Introduction

Mediation principles and procedures are finding increasing application to environmental conflicts. Mediation opened the way for managing conflicts between coastal fisheries and offshore oil and gas companies in the Santa Barbara Channel, beginning in the 1980s (Knaster, 1985; Richards, 1990). "Alternative dispute resolution" techniques have also been successful in solving problems related to tidelands licensing in Massachusetts and wetlands restoration in California (Susskind and McCreary, 1985).

In October 1990 the author mediated a dispute among a kelp harvesting company and two groups of sea urchin dive fishermen. The mediation led to a series of coordinated research projects to enhance both kelp (*Macrocystis pyrifera*) and sea urchin (*Strongylocentrotus* spp.) resources.

This paper will discuss the situation that led to the dispute, mediation principles and procedures, how they were used to resolve the dispute, and the use of mediation principles in less formal settings.

Point Loma Kelp Bed Ecosystem and Harvesters

Point Loma is a high ridge protecting the mouth of San Diego Bay in southern California. A nearshore kelp bed supports numerous commercial and sport fish and shellfish species. The kelp stand is periodically reduced by winter storms (Kelco, 1991) and warm water El Niño events (North and Schaefer, 1963).

The sea urchin fishery is the largest in San Diego County. During 1991, dive fishermen landed 1.5 million pounds, representing about 4 percent of the statewide total of 41.1 million pounds (California Department of Fish and Game, 1991). Sea urchin gonads are extracted and sold in "sushi bars" as a high-value product called "uni." Most urchins landed in California are processed and shipped to Japan. United States sea urchin exports to Japan had a value of $53.7 million in 1988; California shipments constituted 73 percent (Phu, 1990).

Tops of rapidly growing kelp plants are harvested by Kelco Division of Merck and Co. Inc. under a lease from the State of California. Kelco extracts algin from the kelp for food and industrial use. Kelco participates in the world algin market.

Reduction of natural sea urchin predators, such as lobsters and sea otters (pers. comm. Phil Swartzell, California Department of Fish and Game), allowed sea urchin populations to multiply and increase grazing on adult, juvenile and microscopic kelp plants. Kelp losses from weather and heavy grazing produced extensive areas dominated by sea urchins and lacking kelp forage. Urchins in these areas had poor gonadal development (pers. comm. David Leighton, Marine Bioculture Inc.) and accumulated in grazing "fronts" near kelp beds (North and Schaefer, 1963).

History of Inter-Industry Conflict and Sea Grant Involvement

History of Destructive Sea Urchin Control Efforts. In the early 1960s, Kelco began spreading quicklime to control sea urchin populations (pers. comm. Ron McPeak, Kelco). This method was developed by scientists at the University of California, who sought to reestablish kelp in areas decimated by an El Nino warm water event (North and Schaefer, 1963).

Development of a sea urchin harvesting, processing and marketing industry successfully controlled populations of the larger, red sea urchin, *S. franciscanus*. Quickliming was stopped in 1980 in response to sea urchin industry concerns (pers. comm. Ron McPeak, Kelco). Populations of the smaller, purple sea urchin, *S. purpuratus*, remained unchecked. The yield of gonads from these generally undernourished stocks was too low for commercial purposes.

Kelco continued physical control measures for purple sea urchin populations at Point Loma to protect kelp. Fishermen were concerned that purple urchin control was wasting a potential resource and could include destruction of juvenile red urchins. Kelco began to experiment with different approaches to protect kelp from grazing sea urchins. Fishermen became interested in enhancing growth and gonadal development of undernourished red and purple sea urchins in areas denuded of kelp and along the edges of kelp forests.

History of the Research Project and Sea Grant Involvement. Kelco wanted to protect kelp and reduce conflicts with the sea urchin fishery by:

Collecting urchins and feeding them in pens;
Removing urchins from a large area of the sea floor, and constructing barriers to prevent immigration of new urchins into that area; and
Continuing destructive control measures outside the study sites (pers. comm. Mark Otjens and Dale Glantz, Kelco).

Some fishermen wanted to replenish red sea urchin populations and make purple sea urchins marketable by developing methods to:

Replace harvested stocks of red sea urchins by feeding malnourished individuals from urchin-dominated or "barren" areas;
Improve recruitment of smaller red sea urchins to legal size stocks; and
Increase yield of purple sea urchins, making them economically feasible to process (pers. comm. Peter Halmay, fisherman and David Rudie, processor).

Research proposed for calendar year 1990 was blocked by longstanding disagreements and distrust between the industries. The author attended an inter-industry and California Department of Fish and Game meeting in January 1990 at which a few fishermen expressed concerns that Kelco was not sincere about its research goals, that attraction of urchins to feeding sites would make it easier to destroy them, and that urchin populations would be seriously disrupted by construction of barriers and removal of urchins from the barricaded area.

Fishermen supporting the study requested the author to participate as a neutral member of the research team.

Fishermen opposing the study blocked it for 1990. Their efforts included:

Focusing research planning and industry association meetings on their concerns and inter-industry conflicts;
Distributing flyers and petitions;
Working with news media (Griffin, 1990); and
Advising the California Coastal Commission that Kelco planned to build unpermitted structures offshore.

Time required to obtain a Coastal Commission permit would have caused the project to miss the critical winter-spring reproductive season for kelp, so that year's crop of sporelings (newly settled plants) would have remained subject to urchin grazing.

In the summer of 1990, urchin fishermen advised the author that Kelco was considering a revised research project and that some fishermen still wanted the Sea Grant Extension Program to participate as a neutral party. The new project would not barricade large areas, but would instead focus primarily on feeding free-roaming sea urchins. The sea urchin processor felt that there was good potential to raise the yield of purple sea urchins to marketable levels.

This proposal differed significantly from other studies, which had focused on laboratory culture and subsequent outplanting of young urchins collected from the wild (Tegner, 1989) or feeding of confined urchins (Hudson, 1991). If it were successful, it held potential for statewide application.

However, a research planning meeting was again dominated by concerns of a few fishermen who opposed the study. Kelco biologists and fishermen who supported the research expressed concerns about further problems with those who opposed it and considered abandoning the project. A new approach was needed.

Mediation Principles and Procedures

Mediation principles are based on a process developed by the Harvard Negotiation Project and explained in *Getting to Yes*, by Roger Fisher and William Ury (1981). They include four basic points:

People: Separate the people from the problem.
Interests: Focus on interests, not positions.
Options: Generate a variety of possibilities before deciding what to do.
Criteria: Insist that the result be based on some objective criteria.

This method is often called "interest-based" negotiation, as opposed to "positional" negotiation. In positional negotiation, parties start with a position, or what they want to have happen. This position is generally chosen in the belief that it will allow them to achieve their interests, or needs. Problems arise when one party's position threatens the other's interests.

Interest-based negotiation begins by identifying and discussing each party's interests, needs and concerns. Next, each proposes a series of actions that could help to satisfy those interests. Then objective criteria are developed for evaluating the proposed actions. Finally, negotiation proceeds to evaluate, modify as needed, and select a mutually agreeable set of actions that will resolve the dispute.

Separating the people from the problem can also be described as identifying two sets of interests: substantive (what you need) and relationship (how you would like to be treated by the other party). Dealing with both types of interests is influenced by perceptions and emotions, which determine how people interpret what they hear and see.

Achieving an understanding of the other party's point of view and their feelings about the dispute is essential to effective negotiation. If this is not done, negotiation can be stopped in its tracks.

It can be accomplished by a process in which each party explains his or her outlook and feelings, then discusses them with the other party. The process is facilitated by a technique known as "active listening," which includes paying close attention to the other party and occasionally interrupting to ask, for example, "Did I understand correctly that you are saying...?" This improves one's understanding and satisfies the other party that he or she is both heard and understand.

Dealing up front with perceptions and emotions clears the deck for dealing with substantive issues, such as who will provide how much of something by a given date. The next stages of interest-based negotiation involve generating and evaluating options to resolve the dispute. This is best accomplished with the aid of a facilitator. Generating the options is done in a non-critical atmosphere, but participants are encouraged to make them positive, fair and conducive to mutual gain. Creativity is valuable for finding solutions to difficult situations.

Options are then evaluated according to objective criteria, such as safety standards or a realistic timetable for achieving a given level of performance. Ideally, a set of actions is selected that will be balanced and fair to both parties and produce a realistic and enduring solution to the problem.

A non-profit organization, the San Diego Mediation Center, has developed detailed procedures for formal mediation (Community Mediation Program, 1991). Highlights augmenting the principles discussed above include:

Getting agreement to ground rules for speaking, listening and stages of the process.
Getting signed agreement that the mediator(s) will maintain confidentiality and cannot be subpoenaed if legal action is initiated later.
Creating a "group memory" by recording concerns and suggestions for agreement, on large paper and posting them for all to see.
Using neutral language to "defuse" concerns while still acknowledging their importance.
Having disputants discuss a positive factor they hold in common.
Writing an agreement which is specific, balanced among the disputants, measurable, achievable, realistic and sets times by which elements will be completed.
Having parties sign the agreement, encouraging them to follow through on it, and offering follow-up meetings.

Involvement of Mediation in Resolving the Dispute

After the 1990 project was canceled, the author attended a demonstration by the San Diego Mediation Center and concluded that mediation could help to resolve the research dispute. Professional mediators brought in by Sea Grant Marine Advisor John Richards had resolved fishery and oil industry conflicts in the Santa Barbara Channel (Knaster, 1985; Richards, 1990).

Discussions were initiated with Kelco's chief biologist and fishermen who supported a 1991 research project. Kelco and "pro-research" fishermen were discouraged by continuing domination of research discussions by "anti-research" fishermen. The author explained mediation principles and how mediation had helped to resolve fishery and oil industry disputes.

Kelco and "pro-research" fishermen agreed to try mediation if "anti-research" fishermen would, too. The author contacted two "anti-research" fishermen who agreed to participate. All parties remained skeptical, but willing to try.

Background Work Was Crucial in Planning the Mediation

The author developed a better understanding of each group's underlying concerns and perspectives in conversations held prior to the mediation. They also provided insights on conditions needed for success. Underlying concerns included balance of power, fear for the future, frustration and trust.

Fishermen generally felt that, as a large company, Kelco had an advantage in negotiating with state agencies and could draw on extensive resources. They feared Kelco's activities could have a negative impact on sea urchins and the kelp ecosystem.

"Pro-research" fishermen were frustrated that their efforts to improve sustainability of their fishery had been thwarted by a few colleagues.

Kelco staff feared losses of kelp would continue and were frustrated that their efforts to improve sustainability of the kelp beds had been thwarted by a few fishermen.

Each group questioned whether the others would negotiate in good faith.

A "level playing field" was established to demonstrate equality of status. A neutral meeting time was important. Fishermen felt that Kelco staff were paid to come to meetings held during weekday working hours. Fishermen could not earn a living fishing or preparing to fish while attending meetings.

A neutral location was also important. The mediation was held on a Sunday afternoon at Scripps Institution of Oceanography, a part of the University of California at San Diego.

Opportunities for good faith negotiation were maximized. A Kelco decision maker, the chief biologist, attended, as well as the research project leaders. "Pro-research" fishermen closer in age to the generally younger, "anti-research" fishermen were included to reduce differences among the two groups of fishermen.

Two positive goals Kelco and the fishermen held in common were selected for discussion: their desire for a healthy and productive kelp ecosystem and their desire to continue earning a living through sustainable harvest of the kelp ecosystem.

Personal invitations were sent to six sea urchin fishermen, the local sea urchin processor, Kelco's chief biologist and two project leaders for the proposed study. Letters explained the author's understanding of the dispute and that there appeared to be an opportunity to work together for mutual benefit. The letters also invited them to discuss the issues at a meeting and outlined structure and ground rules for it.

Conducting the Mediation

Principles and selected procedures outlined above were used to plan and conduct the mediation. Ground rules were explained at the beginning of the meeting, including a three-hour time limit. All agreed, except one of the "anti-research" fishermen. He wanted to make a statement similar to those that had focused previous meetings on his concerns. The author negotiated an agreement that, after his statement, he would follow the ground rules and participate in the meeting.

Following that statement, each participant in turn spoke without criticism, but within reasonable time limits on:

What he personally wanted from the sea urchin and kelp resource, for example, income, lifestyle and future security.
What he thought an ideal future might be with regard to the kelp ecosystem and what might be preventing it.

The author, serving as mediator/facilitator, maintained adherence to ground rules and recorded each statement in neutral language on large paper placed in front of the group. Accuracy of the written record of each participant's statement was verified before going on to the next person. Reviewing all of the statements produced the following insights:

All participants wanted a healthy kelp ecosystem that could provide a sustainable harvest.
"Pro-research" fishermen and Kelco staff felt a strong need for action to ensure this sustainability.
The importance to "pro-research" fishermen of a sustainable harvest had been obscured in previous meetings when discussions had focused on distrust and past conflicts.

After brief discussion it became clear that fishermen would only make an agreement if Kelco ceased *all* destruction of sea urchins, not just that in the study area. Kelco staff were concerned that unchecked sea urchin populations would damage kelp beds at Point Loma, but they agreed to this provision.

Fishermen agreed to support the research project, to form an advisory committee to help clarify research goals, and to observe and participate in some research activities. Kelco staff agreed to provide boat and diver time and an experienced sea urchin scientist as research leader. Fishermen and Kelco staff agreed that the author should participate as a neutral scientist.

Outcomes of the Mediation

Fishermen reported results to their association and formed a research advisory committee. Two follow-up meetings, one facilitated by the author, were held to clarify research needs and plan projects. The author sent follow-up letters to participants stating terms of the mediated agreement and results of the research needs identification meeting.

Three related scientific studies were planned and implemented with cooperation of Kelco staff, fishermen and the local sea urchin processor, David Rudie of Catalina Offshore Products. Kelco provided boat and diver time to all three projects for feeding sea urchins, collecting samples, and making field observations. Fishermen monitored the research projects and conducted a partial harvest that went directly to the processor for commercial evaluation. The fishermen's advisory committee continued working with industry members to resolve concerns and maintain support for the project.

The three studies included:

Kelco staff assessed effects of feeding sea urchins on survival of kelp plants.
The author worked with Dr. David Leighton to assess effects of feeding sea urchins on their growth, density, and gonad maturation from an applied research perspective. This project was also coordinated with commercial yield assessments by the processor.
Drs. John Dixon and Stephen Schroeter assessed effects of feeding sea urchins on their density and growth from a basic life history perspective. (Kelco, 1992)

The agreement held from October 1990 until February 1992 when it became moot. The Point Loma sewage treatment plant's ocean outfall pipe broke in shallow water, ending all diving activity in the area. The project ended a few months early, but sufficient data had been collected to yield results.

Although data analysis is still in progress, preliminary findings showed that feeding sea urchins could enhance their growth and commercial yield and also protect kelp from urchin grazing. This preserved adult plants and allowed new plants to become established in areas where kelp had been destroyed by storms or warm water El Niño events, which had become dominated by malnourished sea urchins.

Conclusions and Recommendations

Mediation is effective in resolving disputes that have not yielded to other methods. It is a formal, structured process.

Mediation principles, or interest-based negotiation, can also be used constructively in other situations. For example, a mediator can facilitate constructive, early discussion of complex issues involving large groups by using mediation techniques (pers. comm. Barbara Filner, San Diego Mediation Center). The author used such techniques to help a mixed industry, agency and campus scientist workgroup identify research priorities as part of a statewide conference sponsored by the California Sea Grant College Program and the sea urchin industry.

Mediation principles can be used where follow-up is needed after a formal mediation. Participants are on a more open and communicative basis. They know and accept mediation techniques, which have succeeded in resolving their dispute. For example, the author used selected mediation techniques to facilitate sea urchin fishermen, scientists and Kelco staff in clarifying research needs following the formal mediation.

Principles of interest-based negotiation can also be used on an informal, interpersonal basis (Fisher and Ury, 1981).

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Estuarine Management: Marine Sanctuaries

SITE SELECTION FOR U.S. MARINE SANCTUARIES

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The National Marine Sanctuary Program was established in 1972 for the purpose of identifying, designating and managing discrete areas of the nation's marine environment which are found to have important natural resource or human use values. Title III of the Marine Protection, Research and Sanctuaries Act provides that areas of "special national significance" may be set aside as a National Marine Sanctuary due to their conservation, recreational, ecological, historical, research, educational or aesthetic qualities.

Designation of an area as a National Marine Sanctuary reflects the vision of the National Marine Sanctuary Program to identify, designate and manage a comprehensive and integrated system of the nation's most significant marine areas. This management will be based on ecologically and archeologically sound, well-researched principles of resource protection and sustainable use and will focus on improving public understanding of the nation's marine heritage. An important characteristic of the National Marine Sanctuary Program is that it is the only federal management program in the United States that explicitly attempts to conserve living marine resources on an ecosystem-wide basis, as opposed to regulating a narrow scope of activities or managing single species which are of primarily economic or ecological interest.

The designation process is a lengthy and detailed evaluation of the contribution that a particular site can make to the national system of Marine Sanctuaries, and depends on a host of ecological, economic, political and sociological factors. The first step in this process is the listing of areas on the Site Evaluation List (SEL), which is the working list of sites from which the National Oceanic and Atmospheric Administration (NOAA) selects candidates for further evaluation as National Marine Sanctuaries. The minimum test that must be met for listing on the SEL is a showing of special national significance due to the presence of the natural resource or human use and historical values enumerated above. In order to be considered nationally significant, a site must satisfy all of the following standards:

It is an outstanding example of a particular type of resource;

It possesses exceptional value or quality in exemplifying the diversity of natural or cultural resources or themes of our nation's marine heritage;

It offers superlative opportunities for human uses such as recreation, education, compatible multiple uses, or research and monitoring; and

It represents a true, accurate, and relatively unspoiled sample of a particular natural or cultural resource.

In many ways, the SEL is the "blueprint" for the future system of National Marine Sanctuaries. This follows from the fact that the SEL sites have satisfied the basic criteria for identification and selection, and because the criteria themselves reflect the vision and goals of the program. Only sites which are listed on the SEL may be considered for designation as a National Marine Sanctuary, although not all SEL sites will necessarily be designated. The SEL is therefore an inventory or catalog of areas of the marine environment which have been demonstrated to be of special importance; these areas are judged to have significant potential for meeting the standards for designation as a National Marine Sanctuary. However, designation is not a certainty for all SEL sites. It is important to note, too, that being listed on the SEL does not confer any regulatory authority to the federal government to control, prohibit, or manage activities. The SEL is strictly a way to "keep an eye" on areas of national importance so that if threats arise, or if the site could meet an important need of the program, the first steps will already have been taken to implement mechanisms for enhanced protection and conservation.

Because candidate sites for sanctuary designation must be selected from the SEL, it is important that the SEL sites incorporate the vision, the values, goals and objectives of the program. Then when sanctuaries are eventually designated they will protect important resources as well as contribute to the functioning of the larger network of National Marine Sanctuaries. Because the vision and goals of the program have changed in recent years, the SEL must be amended accordingly. In addition, over the years since the SEL was last developed, new concepts, technologies and resource management roles for sanctuaries have evolved which were not explicitly considered during the previous site selection process. Important among these changes are:

Protecting historical, cultural, archeological, and paleontological resources in the marine environment. In 1984, amendments to the Sanctuaries Act specified that sanctuaries could be designated on the basis of their historical qualities. These values were not considered when the first SEL was done in 1983, so it is now necessary to revise the SEL to incorporate these qualities into the site selection process to ensure that sites of historical significance are included in the national network of marine sanctuaries;

Developing models for sustainable uses of important resources within the context of protecting the integrity and viability of the resources. An example of this role for marine sanctuaries is the delineation of management zones within sanctuary boundaries. Zones are likely to be an effective approach to monitoring and managing human activities to ensure that responsible uses of marine resources can be sustained indefinitely without adversely affecting those resources;

Using the network of marine sanctuaries to detect and measure large-scale, long time frame phenomena such as global climate change, water quality trends, the status of populations of rare or threatened biota, etc. A well-planned system of marine sanctuaries requires that future sites be selected on the basis of their potential contribution to such studies;

Conserving marine biodiversity. A great deal of attention has been given recently to the importance of conserving the diversity of gene pools, species, communities, and ecosystems in the marine environment. Although marine sanctuaries are established to manage and conserve "functioning ecosystems," the conservation of marine biodiversity has not heretofore been explicitly applied as a criterion in identifying or delineating future sanctuary sites;

Establishing new methods for updating the SEL. The existing SEL was prepared in 1983 and consisted of 29 sites. However, several key regions of the United States were not represented on the SEL. In addition, only four of the sites have had a change in status in six years, and no new sites have been added to the SEL in those six years. Program regulations state that a new area can be added to the SEL only if it is an "important new discovery," or a known site is determined to be of special national significance on the basis of "substantial new information previously unavailable." NOAA is now considering whether these methods are sufficient for maintaining an up-to-date SEL; and

Prioritizing the list of future sites. The existing SEL does not reflect a priority ranking of sites; it is therefore not possible to use the SEL to help in the selection of active candidates for designation. By assigning a relative priority ranking based on vulnerability to the impacts of human activities, or on the potential contribution that a site could make to the national system, the SEL can be a much more useful tool for decisionmakers in allocating scarce program resources to designation activities.

The Site Evaluation List development process is applied to identify, evaluate, select and prioritize the sites for inclusion on the SEL. The process consists of the written standards for site selection and the procedural mechanisms for implementing the process. The written standards are comprised of the Site Classification System, a method of initial site identification based on principles of biogeographic characterization; the Site Identification Criteria, the standards for establishing the special national significance of resource values; and the Site Evaluation Matrix, the criteria for ranking selected sites in order of priority for future consideration as a National Marine Sanctuary.

Our proposed site selection process will occur in three phases, as shown on the flow chart. These phases are: refining the Site Classification System; revising the Site Identification Criteria; and applying the Site Evaluation Matrix. Fundamental to understanding the Site Selection Process is the recognition of the change in emphasis on evaluation factors as sites flow through the process. This is shown diagrammatically by the flow line at the bottom of Figure 1.

Phase 1, refining the Site Classification System, is being driven by recent changes to the Marine Sanctuaries Act as well as by the desire to take advantage of improved databases and information analysis techniques. Essentially, new information on faunal distributions, oceanographic processes, and geomorphological features is being used to update the biogeographic framework for the initial identification of sites. Superimposed on the biogeographic classification system is a typology of ecosystem types, ecological characteristics, and habitat types. The typology and biogeographic framework are taken together and applied as a matrix to initially identify and inventory areas of interest.

Phase 2, revising the Site Identification Criteria, is also being driven by changes in the Sanctuaries Act, but changing expectations of the role of marine protected areas are also important in shaping new criteria. New demands on marine sanctuaries include: conserving biodiversity; establishing zones for improved management of multiple uses; developing models for sustainable uses; identifying harvest refugia; and contributing to the national system (and to international networks) for studying large-scale problems such as detecting and measuring global climate change. The process of revising the Site Identification Criteria will benefit from input provided by the public and from external review. Non-partisan review of the proposed criteria and Site Selection Process will be provided by the SEL Review Committee, which will be composed of about 15 experts from outside the program. This committee will consider the evolving role of marine protected areas within the context of the program and will recommend appropriate changes to our identification criteria and selection process.

Phase 3, applying the Site Evaluation Matrix, will result in the priority ranking of sites on the SEL. As discussed above, by assigning relative priorities to the SEL sites, policy-makers will be better equipped to determine which sites should be selected as active candidates for further evaluation.

The Site Identification Criteria (Table 1) must be capable of documenting the special national significance of nominated areas. The criteria are grouped in four categories: Natural Resource Values; Human Use and Historical Resource Values; Impacts of Human Activities; and Management Concerns. The primary emphasis at the SEL stage of the marine sanctuary designation process is on natural resource or historical resource values.

The Natural Resource Values of importance to the program are:

Biogeographic representation
Biodiversity representation
Biological productivity
Ecological representation
Species maintenance
Habitat structure or features

Also of importance are human uses, which depend on the long-term viability of natural resources, and historical resources, which reflect the significant maritime tradition within our nation's history. The Human Use and Historical Resource Values are:

Renewable resources of importance for sustainable uses
Recreational and aesthetic resources
Research and monitoring opportunities
Educational and interpretive opportunities
Historical, cultural, archeological and paleontological resources

Information on the remaining two categories of criteria, Impacts of Human Activities and Management Concerns, is collected and used in the Site Evaluation Matrix to establish the priority ranking of sites on the final SEL.

The draft criteria will be published in final form following further comment by the public, input from the SEL Review Committee, and analysis by NOAA.

Phase 3 of the SEL Development Process is the application of the Site Evaluation Criteria. Sites on the existing SEL as well as new nominations will be measured against the revised criteria. This process will be performed initially by six Regional Evaluation Teams composed of local people with knowledge of resources of national significance within assigned biogeographic provinces. Their nominations will be reviewed by the public, evaluated by the SEL Review Comittee, and finally selected by NOAA and published as the new and improved Site Evaluation List. In the final evaluation of sites from the pool of nominations, NOAA will assign priority rankings to the sites selected for adding to the SEL. Table 2 shows the criteria used in determining priority rankings.

Having described the process NOAA is proposing for revising the SEL Development Process, we can return to the flow line I referred to earlier. We see that a site is initially identified on the basis of its ecosystem attributes and values or historical significance [RESOURCES]. Human uses of, and impacts to, the natural and historical resource values are identified [HUMAN USES]. The potential contribution of the area to program goals is determined [PROGRAM GOALS], and management concerns, such as economic costs and benefits, and political considerations, such as the degree to which the community supports sanctuary designation, are considered.

In conclusion, NOAA has embarked on an effort to improve its criteria and procedures for identifying, evaluating, selecting and ranking sites for future consideration as National Marine Sanctuaries. The proposed improvements will focus on establishing an SEL that is more truly representative of the important marine resources found throughout the nation; that is responsive to the resource protection needs of the United States; and that incorporates the input of the public in the selection process. It is my hope that the changes we are proposing will enable the National Marine Sanctuary Program to better meet the conservation, management and protection needs and challenges of the future.

Table 1. Site identification criteria for which sites must have national significance.

Conservation value
Recreation value
Ecological value
Historic value
Educatonal value
Research value
Aesthetic value

Table 2. Site evaluation and ranking criteria.

Special national significance
Potential value to the National Marine Sanctuary Program
Known or potential threats to resources
Potential for contributing to the global network of marine protected areas.

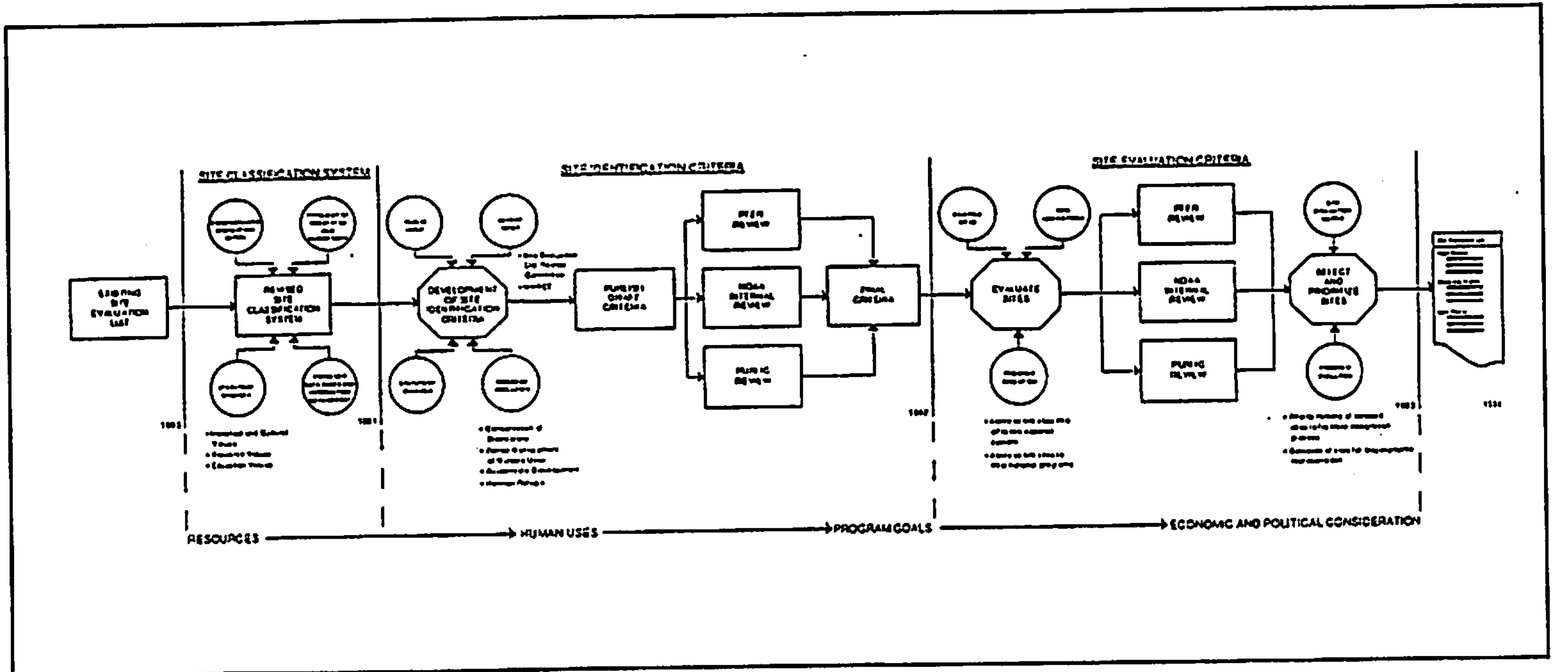

Figure 1. Site selection process for U.S. Marine Sanctuaries.

A PROCESS FOR SITE DESCRIPTION: THE NATIONAL MARINE SANCTUARY PROGRAM'S SITE EVALUATION LIST

Elizabeth Moore
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Abstract

The National Marine Sanctuary Program was created to identify, designate and manage nationally significant marine and Great Lake waters. There are currently nine National Marine Sanctuaries and eight in the process of becoming designated sites. Though the program has grown significantly in the past several years and will continue to do so, this growth occurs in a time of decreasing budgets and increasing population and coastal resource demand. The goal of the program is focused on the identification, designation and management processes to better allocate the limited resources of the program. In response to this challenge, the Site Evaluation List (SEL), first compiled in 1983, is being re-evaluated. The SEL review process will examine current and proposed sites to the SEL; the preparation of detailed, up-to-date site descriptions is an integral part of the process. The main purpose of a site description is to characterize the value of the location as a potential sanctuary, but its other purpose is to provide the basis for the preparation of an environmental impact statement, should the site be selected to continue the designation process. Many of the sites already have been recognized for their value and documented by local, state and federal agencies, universities, and private groups. However, the cost of locating, gathering and organizing such large amounts of information is both labor- and cost-intensive at a time when such effort is vital but unaffordable. Therefore the challenge has been to develop a site description format that provides a concise but adequately detailed description of the site, produced in a cost- and time-effective manner without sacrificing the high quality necessary for the SEL.

Introduction

The Site Evaluation List is the tool that the program uses to choose sites for further consideration. There are 25 sites on the SEL and 11 nominated for addition under 1984 re-authorization requirements (Figure 1). Being on the list does not guarantee sanctuary designation but it is the necessary first step. The SEL is undergoing re-evaluation in light of a series of changes and pressures to the National Marine Sanctuary Program, including the elapse of a long period of time since the original compilation, the continuing evolution of the vision and criteria of the program, the creation of a historical SEL under 1984 legislation re-authorization, and the recognition of a need for a sound, systematic process to choose future active candidates. The importance of the SEL lies not only in its use as the catalog of sites, but also in its potential role as a blueprint for the future of the program. But the basic unit and the underlying strength of the SEL is the site itself; the tool to define the unit (the site, and ultimately the whole SEL) is the site description.

This paper presents the format used for the site description, the sources and methods of data compilation, the format of the final SEL, and the applicability of the format to other purposes.

Site Format

Determination of a format for a site description in any project is an important step. In the case of the SEL it is vital, since the description will serve several functions:

To provide a concise but adequately detailed description to allow for valuation judgements;

To serve as the basis for and beginning of an environmental impact statement (EIS), should the site be chosen for further consideration;

To force consistency across sites but have the flexibility to adjust for site-specific needs; and

To serve as both a one-page site information sheet for those not interested in the full detail and the complete site description (5 to 10 pages) for those who are.

Approximately six months was spent in developing and refining the description format. Site planning guides, EISs, selection criteria, management concerns and the variety of sites were all taken into account in the evolution of the site format. Though time-consuming, this step is integral because:

It defines the research effort so that specific sources could be targeted; and

It organizes material into topics so that once information sources are compiled, specific subjects and areas can be pinpointed.

Another three months was spent testing the format on two SEL sites: Big Bend Seagrass Beds, Florida and Central California Coast/Morro Bay, California, representing two different biogeographic regions, contrasting management contexts, and varying sets of resources. Again, time is the biggest investment in the process, since weaknesses were discovered and revisions were made to only 2 sites rather than 35. The format was then applied to the remaining sites, including several cases in which natural and cultural resource sites that overlapped geographically were combined under one site description. The total time per site description, encompassing research, drafting, tables, graphics, maps and editing, took 27 to 30 hours to produce.

The final format is divided into four main sections (location, description, management concerns and bibliography), which are further divided into various sub-sections (Table 1). These sub-sections address the values, resources, issues and opportunities presented by each site that are key factors in determining its significance. An attempt is made to summarize the most salient and important points without sacrificing too much detail. Tables, graphs and maps (Table 2) are used to summarize and emphasize information that would either be too long or lost in text form. Not every description will contain every graphic; again, the site description can adapt to the resources and values of each site.

In order to streamline the process without losing quality or uniformity, tables are produced from basic templates into which new information can be entered for each site. Titles, spacing and notes are part of the template and are carried into each description after the table is adapted to the specific site. The land-use pie chart is produced in a spreadsheet program and is processed through a drawing application for cosmetic detail. Maps are produced by the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean Resources Conservation and Assessment (ORCA). A map of each site is lifted from ORCA's basic map database (or digitized as necessary), taken into Mapmaker and Adobe Illustrator for detailing, and imported to the site description. Tables and figures are produced simultaneously with the written text; maps are produced during writing of the final group of sites.

For those interested in software details, Aldus PageMaker 4.0 for the Macintosh is used because of its flexibility and ease in working with both text and graphics. The description is double-columned with 10-point type for the body of the text and smaller type for tables and notes. Text is produced from Microsoft Word and graphics from Microsoft Excel and MacDraw, and imported to PageMaker.

Information Sources and Methods

As anyone familiar with the EIS process or site characterization can attest, compilation of available research on a particular site can be an indefinite process. Since the SEL is being produced on a relatively short schedule, there was not the luxury of using all the information sources available. The most pertinent, easily accessible, and plentiful sources had to be targeted and utilized, though additional sources have also been consulted. These main sources are:

The NOAA library in Rockville, Md. (where literature searches can be conducted by site and regional name);

The Coastal Zone Information Center in Washington, D.C. (where publications are organized by state and territory);

ORCA, which houses such information as the National Coastal Pollutant Discharge Inventory, the National Status and Trends database, the National Estuarine Inventory, and the National Shellfish Register;

Other government agencies such as the Minerals Management Service, the U.S. Fish and Wildlife Service, and the U.S. Coast Guard;

Agency staff in the Sanctuaries and Reserves Division;

Old site descriptions produced in 1983; and

Regional and local experts.

One advantage to several of the above-mentioned sources is that the experts or keepers of the database usually prefer to pull the information for the researcher; it not only protects the integrity of their system, but it saves both time and effort for the researcher.

Once the best sources were determined, sites were grouped for information compilation by geographic location. This grouping reduced repetition of effort since a document appropriate for more than one site had to be accessed only once. This grouping also assisted by providing continuity among a group of sites in that the "flavor" of the region was familiar to the researcher. Information was gathered and organized onto seven worksheets (both hard copy and computerized) based on the site description's topics, tables, and graphics. Two of the computerized worksheets are designed to be directly transferred into the tables in the final site description. Even after the site description is completed, the hard-copy worksheets serve as a background for the description and provide a history of both the site and the process used to describe it.

Final Site Evaluation List

The final Site Evaluation List, tentatively scheduled for completion in spring 1994, will not only be the definitive catalog of potential sanctuary sites, but will also serve as a future blueprint for the National Marine Sanctuary Program. The document will include site descriptions for all sites ranked in priority order, as well as a detailed discussion of the program and SEL process, criteria, and ranking methods, a discussion of coastal and ocean biogeography, a master list of the common and scientific names of all species, a listing of agency acronyms and a glossary of unfamiliar terms. The final publication is intended to be a stand-alone document and reference work. The ranking and prioritization method to be developed may have wider utilization than only for the SEL. The biogeographic discussion may be referenced in the continuing development of coastal and marine province delineation. The species list is a comprehensive list of biota found in American coastal and marine habitats.

Conclusion

In these times of sustained financial austerity, increasing pressure on natural resources, and complex legislative and administration mandates, the characterization of sites becomes increasingly important. National Environmental Policy Act regulations call for environmental inventories, environmental assessments, and environmental impact statements. International, federal, state and local agencies are struggling with allocating scant resources on myriad areas needing protection or with deciding what sites are or are not suitable for development. Governments and environmental groups are trying to catalogue sensitive areas before something is inadvertently destroyed. Every day, on every level of government and in the private sector, sites are being listed, described, chosen or discarded.

Given these resource management decisions, the need for a concise, flexible site format is clear. The site description developed for the SEL is one example of an efficient methodology to make these decisions. The flexibility is achieved by the tables, graphics and maps that adapt to each site, the basic organization of the information into divisions and subdivisions, and the direct tie of the worksheets that can easily reflect any alteration to the format. The SEL site format lends itself to nearly every facet of work that involves site characterization, including EISs, resource inventories, sensitive area catalogs, development potential measurements, site planning and construction, site valuation for protected area status, and communications of site value to the public to build support. Site characterization is basic to all of these and related activities because of one simple principle that sometimes gets lost in the maze of activity: to adequately evaluate or manage a site, the resources of the site must first be known.

Natural Resource-Based (1983)
Green Bay (Lake Michigan), Wis./Mich.
Apostle Is/Isle Royale (Lake Superior), Wis.
Western Lake Erie Islands, Ohio
Cape Vincent (Lake Ontario), N.Y.
Nantucket Sound/Shoals, Mass.
Mid-Coastal Maine
Narragansett Bay and Block Island, R.I.
Virginia/Assateague Island, Va./Md.
Ten Fathom Ledge/Big Rock, N.C.
Port Royal Sound, S.C.
Florida Coral Grounds, Fla.
Cordillera Reefs, Puerto Rico
East End, St. Croix, U.S. Virgin Islands
Southeast St. Thomas, U.S.Virgin Islands
Big Bend Seagrass Beds, Fla.
Shoalwater Bay-Chandeleur Sound, La.
Baffin Bay, Texas
Tanner-Cortes Banks, Calif.
Morro Bay, Calif.
Heceta-Stonewall Banks, Ore.
Northern Mariana Islands, West Pacific
Southern Mariana Islands, West Pacific
Cocos Lagoon, Guam
Facpi Point, Guam
Papaloloa Point, American Samoa

Cultural Resource-Based (1988)
Manitou Passage (Lake Michigan), Mich.
Whitefish Point/Bay (Lake Superior), Mich.
Narragansett Bay, R.I.
Yorktown Fleet, Chesapeake Bay, Va.
Battle of the Atlantic/Cape Hatteras, N.C.
Apalachee Bay, Fla.
Tampa Bay, Fla.
Douglas Beach Site, Fla.
U.S.S. Tecumseh/Battle of Mobile Bay, Ala.
Attu and Kiska Islands, Alaska

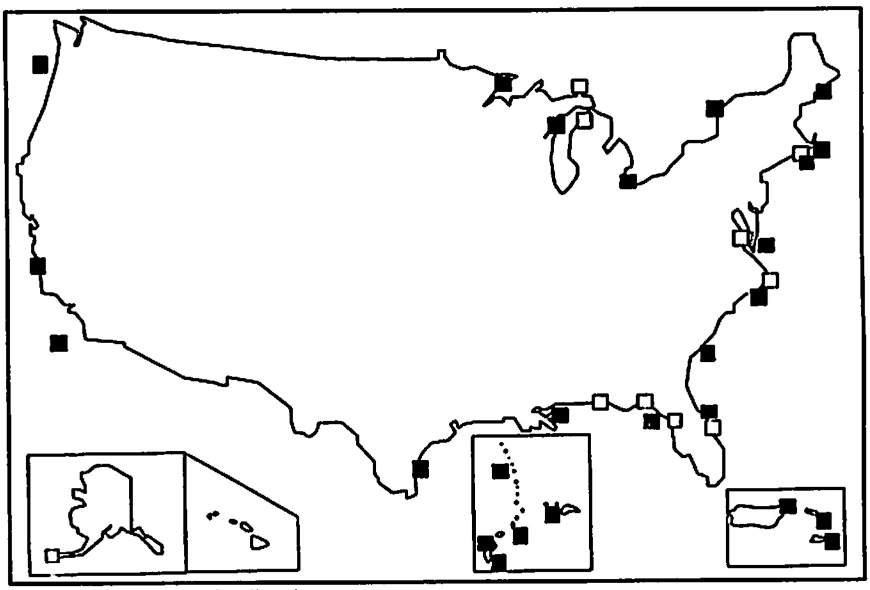
Figure 1. Site evaluation list sites.

Table 1. Site description elements.

Site Location

Latitude and longitude coordinates
Biogeographic representation
- Coastal province
- Representativeness
- Other representation

Boundary alternatives

Site Description

Natural resource values
- Ecosystem features/community representation
- Biological productivity
- Biodiversity/species representation
- Species maintenance
- Habitat features
  - General description
  - Shoreline types
  - Geology
  - Hydrology
  - Natural hazards
- Human use values
  - Fisheries resources
  - Aesthetic and recreation resources
  - Education and interpretation opportunities
  - Research opportunities and resources
  - Historical, archaeological and paleontological resources and values
- Impacts of human use
  - Population trends
  - Land use
  - Commercial, industrial and service uses
  - Military uses
  - Ocean mining and mineral extraction
- Pollution and physical impacts

Management Concerns

Management of the site as a conservation unit
Relationship to existing programs
Accessibility
Surveillance and enforcement
Economic considerations
Possible issues
Support for designation
Probable designation impact

Site Bibliography

Table 2. Graphics elements.

Tables

Table 1. Species presence. Indicates species at the site as given by plant, invertebrate, fish, reptile, bird and mammal category and designating federal threatened and endangered species.

Table 2. Life history/utilization characteristics for selected species. Indicates biological maintenance uses of the site for selected species as given by residents, migrants, resting, breeding, nursery, juvenile and feeding.

Table 3. Commercial/industrial/service uses. Provides general discussion of such activities as given by agriculture, forestry, hazardous waste disposal, ocean dumping, wastewater treatment plants, power plants, mining, ocean floor uses, vessel traffic and air traffic.

Table 4. Probable designation impacts. Summarizes the probable short-term and long-term impacts of designation on certain activities as positive, negative, neutral or unknown.

Figures

Figure 1. Land use of adjacent counties. Presents the land use of counties adjacent to the site as a pie chart as urban, agricultural, residential, commercial, wetland, forest, range and barren categories.

Maps

Cover map. Indicates location of the site by coordinates and by state map inset, and provides study boundaries and major landmarks.

Map 1. Significant features. Shows the significant biological and cultural resources of the site as overlain on the cover map.

Map 2. Protected areas. Indicates the presence of federal, state and private protected areas within or adjacent to the site as overlain on the cover map.

Public Participation

THE APPLICABILITY OF CITIZEN PARTICIPATION IN BRIDGING THE GAP BETWEEN COASTAL ACCESS AND COASTAL PRESERVATION

Marisa A. Folsé
Environmental Planner

ABSTRACT

There exists an intrinsic conflict between the provision of coastal access to the nation's beaches and the preservation of the coastal environment from human impact. Although only a fraction of the Earth's land mass consists of coasts (including bays, estuaries and associated wetlands), nearly 50 percent of the coastal wetlands within the continental United States has been destroyed since the 1700s. The EPA estimates these losses have averaged 20,000 acres per year over the past 25 years. Preservation and/or restoration of this rapidly diminishing habitat is essential for the perpetuation of the life of this planet.

Conversely, approximately 70 percent of the U.S. population lives within 50 miles of a coastline. Between the years 1950 and 1984, the population of coastal counties within the United States grew by more than 80 percent. This large, and increasing, population requires adequate access to the nation's beaches for both profit and pleasure. The 18 Los Angeles County-operated beaches alone receive 60-65 million visitors per year. Without careful planning, the consequences of continued growth and its representative pressures to develop our coastal areas can be devastating to the coastal ecology.

The various governmental agencies and the private sector of this country share responsibility for the protection of our coastal environment. U.S. legislatures and citizenry are finally realizing the intrinsic value of America's beaches. Any success in meeting coastal access needs and balancing those needs with preservation and restoration goals and objectives will depend upon many regulatory and management programs to be implemented by the EPA and other federal, state, and local governmental agencies, as well as on an extensive citizen participation campaign to include the nation as a whole in educational outreach and program organization regarding America's coastal environment.

This paper will describe various organizational efforts and educational outreach programs which have been used successfully to increase citizen participation in the evolution of coastal environments, including a few newly developed programs planned for implementation.

Citizen participation programs may be the only way to bridge the gap between the provision of adequate coastal access to the population and the protection and preservation of our coastal environment from human impact. As the public becomes aware of the problems that exist which threaten the coastal ecosystem and are presented cognitive ways in which they can assist in achieving a better environment, they will develop a desire to have both access and preservation simultaneously and this desire may eventually enable both to coexist at all beaches.

THE PROBLEMS

Coastal water is relied upon for food, recreation and a wide range of commercial activities. The living resources of the coast contribute billions of dollars annually to the U.S. economy. Concurrently, innumerable ever-enlarging cities, ports and commercial centers are built along the coasts of the world.

The coastal environment has always been inviting to most people. Thus, with the eruption of the world population, the influx of participants in the migration to the coast also has increased. The citizenry of coastal cities demand clean, readily available access to the beaches to which they have moved. For them, coastal access is a necessary part of their personal well being, in addition to providing a necessary avenue for the coastal city's economic stability.

But, these activities demand fresh water and generate a multitude of wastes that must be disposed of. The increased population pressures threaten the sustainability of the world's coastal ecosystems. Widespread problems result from this increased population on the coast and its continually growing demand on coastal resources. These problems include the loss and degradation of natural habitat, pollution influx from non-point sources, the depositing of contaminated sediments, and an array of other disparaging effects.

The U.S. EPA estimates that each day over 2,000 sewage treatment plants and industrial factories discharge billions of gallons of effluent, treated to various extents, directly into estuaries and other coastal waters. This and other pollution incidents have caused 16 coastal states to issue consumption advisories for fish and three to issue advisories on consumption of waterfowl.

THE SOLUTIONS

As the public view of recycling has changed from the early 1970s to the present, the view of individual actions toward coastal preservation will also change in the near future. Within the past 20 to 30 years, the public knowledge and view of recycling and source-separating solid waste has evolved from a pipe-dream for a few individuals to a daily ritual for a majority of the nation's citizens.

This evolution of public opinion and the reasons for its occurrence can be applied to the problems inherent with coastal access. Public participation and educational efforts are the keys which will bridge the gap that currently exists between coastal access and coastal preservation.

A variety of approaches may be taken which incorporate the public in the enhancement and enrichment of the world's dwindling coastal habitat. The following paragraphs list and identify developmental approaches and educational efforts which have been successfully utilized or have been recently planned to increase public involvement and awareness in coastal issues.

Publications

Area Beach Maps and Guides. These types of publication can be organized to provide information, in a variety of languages, about beach access, coastal terrain, beach facilities, identification of marine plant and animal species, area rock formations and characters, and individual activities which threaten the coastal habitat and various immediate ways to preserve them.

Water Conservation/Beach Preservation Action Guides. Because water pollution begins on land, issues of clean coastal water should be of paramount concern. This type of publication can be geared to making citizens aware that everyday activities and land management have a profound impact on coastal water quality. Simple steps which can be accomplished by individuals, can be published in a water conservation guide like the one distributed by the New York Sea Grant Extension Program (1990).

Organizational Directories. Booklets can be published which list non-profit organizations, associations, federal, state and local agencies which work on projects in marine research, coastal conservation, marine education, maritime historic preservation, and marine trades and related fields which are willing to accept volunteers and distribute information regarding their efforts. These directory booklets can be provided at public libraries, city halls, beach hotels, information counters and kiosks, parks and beach recreational centers.

Education

Grade School Level Curriculum Programs. Implementation of a variety of curriculum programs can be provided which present tactile multi-disciplinary approaches to marine and coastal education. Extensive information on curriculum programs can be obtained from an array of governmental agencies and non-profit organization which may provide funding and incorporate students into existing and ongoing projects.

Coastal Awareness Weeks. Organization of this type of activity can include various creative information distribution methods. Incorporation of coastal awareness lectures and seminars aimed at public participation and education, information booths and displays, beach and/or harbor festivals, tidepooling excursions, coastal tours, planned recreation activities, slough exploring, etc., provide a widespread arena for educational opportunities.

Radio and Television Programs. Production of assorted public service announcements, talk shows and informative programs like the *Earthwatch* radio program of the 1980s (which was one of the longest running programs on science and the environment) (Sinclair et al.), is a means of reaching an easily attainable audience for information distribution and providing sources to contact for further information.

Personal Involvement

Inter-Organizational Cooperation. There is currently a multiplicity of agencies and organizations which overlap in their areas of expertise. Cooperative efforts like the Coastal America program which was organized to establish a coordinated, multi-agency effort to solve the numerous environmental problems which currently exist along the U.S. shoreline are being implemented.

Adopt-A-Programs. Adopt-a-programs have become the current trend in Southern California. Many businesses and individuals have contributed time, energy and money to various adoption projects. Application of this trend to beaches, species, etc. can be accomplished by organizing groups of volunteers for cleanup days, disentanglement and/or revegetation activities and other coastal preservation projects.

Dune Restoration/Revegetation Projects. Most restoration and revegetation projects undertaken as mitigation measures have inherent in their planning process some form of citizen participation mechanism. Expansion of these efforts can be accomplished by incorporating projects into voluntary, non-profit ventures similar to the current urban tree planting efforts.

Development Action

Marine Sanctuary and Coastal Reserve Programs. The development of coastal habitat sanctuaries and related programs which restrict public access will ensure the preservation of portions of the natural coastal environment. as a means of working toward a refuge for those species that have suffered due to the loss and overusage of coastal areas. These projects should include both on and offshore facilities which can incorporate visitor centers, sanctuary tours, research opportunities, educational cruises, and usage of the various other information distribution arenas mentioned for educational outreach.

Nature-Based Tourism. The coastal zones of many regions present a range of natural tourism opportunities. Nature-based tourism is a fairly new concept which requires the planning and protection of coastal resources in order to thrive. Most existing nature-based operations emphasize environmental education through the ecological and personal interrelationships and processes which help individuals develop an appreciation for their surrounding natural environments. Although there are environmental problems inherent in any coastal development approach, nature-based tourism is obviously more desirable as a preservation means than contemporary tourism development. Thus, every effort should be made to provide coastal developers with adequate information regarding this developmental option. The Regional Resources Development Institute at Clemson University in South Carolina has compiled an annotated bibliography on nature-based tourism. Copies are available on both d-Base and ASCII diskette formats, as well as hardcopy forms.

Conclusion

The previous section presents a few of the many informative areas which can be applied to protect the existing coastal resources from further degradation. These programs can be implemented by government agencies, non-profit organizations, environmental groups, or concerned individuals willing to contribute the time and energy necessary to instill within the public the means and desire to change their view of the coast and the need for their involvement in its preservation.

The Environmental Protection Agency has researched and developed a detailed document on building an effective public participation program (EPA, 1989). Information addressed in this document ranges from defining public education to assessing relevant public issues to organizing and staffing a citizens advisory committee. The document continually stresses how important it is to remember that the lack of involvement or insufficient involvement of the citizenry at an early stage of a program's planning process is a guarantee for program failure. Similarly, the lack of involvement of the public in efforts aimed at preserving the coastal environment is also a guarantee for failure.

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PUBLIC PARTICIPATION IN SHAPING COASTAL MANAGEMENT IN THE INDIAN RIVER LAGOON, FLA.

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Abstract

This study identifies major environmental concerns and conflicts in the Indian River Lagoon on the east coast of Florida and examines the relationship between public perception, public participation and coastal management priorities of the lagoon. A total of 31 interest groups were surveyed in the six counties within the Indian River Lagoon drainage basin. The survey ranked the groups' environmental concerns and usage of lagoon resources. User classifications were based on returns from a public opinion survey distributed to 3,500 residents representing the population living in the study area. The survey was distributed during the summer of 1991. The study tests the extent to which the public's perception and subsequent participation in the coastal decisionmaking process influences management decisions and plans for the use of lagoon resources and resource activities.

The study describes and quantifies environmental awareness and uses related to the Indian River Lagoon and relates them to the governing process in the federal, state and local governments with jurisdiction over the management of the lagoon resources. This paper discusses how the public's perception and subsequent participation in the coastal environmental decisionmaking process in the six Indian River Lagoon counties may have influenced private sector management decisions and plans. The significance of this study is two-fold. First, the study determines that the public does not perceive coastal issues in a homogeneous manner. Second, it identifies various interest groups and how they perceive the management of resources in the Indian River Lagoon. For example, outcomes may have been influenced by a classification of the uses based on the survey respondent's perceptions, involvement with and knowledge of the Indian River Lagoon coastal system. In addition, the study tests for statistical difference among those interest groups regarding how they perceive management. Also, it attempts to identify which group or percentage of the population is most effective in influencing federal, state and local management decisions.

Preliminary results from the study were presented at a public forum—The Coastal Lagoons Assembly—in Melbourne, Fla., during the fall of 1991. The purpose of this effort was to provide public officials, who draft coastal policy, and managers, who implement coastal policy, with a better understanding of the public's perception and use of the lagoon's resources. The information gained may provide managers with key information necessary to develop management plans that will reduce user conflicts while still basing the management plans on solid ecological principles.

Objectives: The Indian River Lagoon Experience

The Indian River Lagoon area, on Florida's east coast, is a prime example of rapid growth in coastal areas. Total population in the six counties, related in this study, grew from 318,200 in 1960 to 774,300 in 1983 and is projected to total 1,067,800 by 2000 (University of Florida, 1980).

This paper examines the extent to which citizen participation has played a role in shaping coastal management decisions for the six counties whose watersheds drain into the Indian River Lagoon. It identifies the major environmental concerns and conflicts in the Indian River Lagoon and the relationship between public perception, public participation and the management priorities of the lagoon. It tests the extent to which the public is a homogeneous group with respect to the perceived problems of the lagoon (Barile et al., 1985). The study identifies the major interest groups and rank the group's various environmental concerns for the lagoon. Once these concerns are identified, it determines the extent to which participation (i.e., a dialogue or other means of communication) has been established between the private sector, defined by these various groups, and the federal, state and local governments for the management of the lagoon resources.

The problems related to integration of public participation and increased public awareness are multifaceted. This study will test the extent to which the perception of user groups will vary with regard to the environmental quality in the six Indian River Lagoon counties and how the public's perceptions and subsequent participation in the coastal environmental decisionmaking process may influence management decisions and plans for the use of lagoon resources and resource activities.

The project studies the relationships between identifying the "public," their use of the environment, and how the public perceives the management of the resources in the Indian River Lagoon. It documents the notion that such groups define the importance of issues differently. In the past, scientific managers have proceeded on the assumption that all user groups value issues similarly. This paper identifies to what extent there is agreement and disagreement among the sample population residing in the Indian River Lagoon region. The study identifies the public as user groups. In addition, it recognizes the importance of differences in perception among these groups on the environmental issues for the region.

Citizen Participation

Citizen participation has always been important in U.S. decisionmaking. This was first recognized in American politics as early as 1800 regarding land exploitation (Zube, 1984). Since then, "increased citizen participation in the planning process," has become almost an American slogan, emphasizing the democratic ideal that "society participates in planning rather than being manipulated by planning" (Chekki, 1979). However, much of the participation has been limited to brief educational pamphlets, citizen and planner discussion groups, or public hearings held during meetings to obtain citizen approval of a plan. These hearings solicit public opinion but often do not allow that opinion to alter the plans. The approaches may be aimed at pacifying the active, interested citizen who anticipates having some effect on the nature of the goals set and on decisions made if allowed to participate in the decisionmaking process. Unfortunately, these approaches have not always integrated public opinion or public perception.

During the 1960s the environmental revolution began. This movement emerged from citizens eager to participate in the government's decisionmaking process and interested in promoting environmental stewardship.

Numerous legislation and associated programs incorporated important aspects of the grassroots movement, most importantly participation in the decisionmaking process. Four programs had a direct impact on the coastal zone. All mandated participation from the public in the decisionmaking process. The legislation, passed by Congress between 1969 and 1977, includes the National Environmental Policy Act (NEPA) of 1969, the Coastal Zone Management Act (CZMA) of 1972, the Reauthorization of the Coastal Zone Management Act, and the Clean Water Act of 1977. These acts established procedures for collecting environmental information with the objective of reducing the destructiveness of decisions affecting the environment.

Today, the programs, particularly the CZMA, which originated as a result of these grassroot efforts, incorporate public perception in the decisionmaking process. While well-intentioned, those efforts, too, often are satisfied by holding a public hearing after major components of the active plan have been put in place. Many coastal managers and citizens agree that this is not enough.

Why ask the people how they perceive the plan?

Collecting the evaluative judgments of a representative sample of the population to profile various users' satisfaction and dissatisfaction of current coastal programs could help to identify physical, social and economic aspects of issues most important to different sectors of the region's overall population. Such an approach may provide decisionmakers with important information on characteristics of the most successful existing programs and why certain approaches are perceived as more satisfactory than others (University of Florida, 1980; Sheng et al., 1990).

Involving the public raises a number of questions, including the extent to which citizens are interested in participating in the planning process; whether or not citizens are apathetic until the proposed actions have a direct impact on their lives; and the extent to which citizens are uninformed.

Public participation—the idea that interested citizens will have an opportunity to air their views—may be defined as "the act of sharing in the formulation of policies and proposals; the public is no longer simply asked to judge a finished or near-finished product" (Sewell and Coppock, 1977). Or to paraphrase President Truman, the public is being invited to share the heat in the kitchen of public policy discussions. This could be interpreted as making the information—facts, arguments, and explanations available to the public.

Unfortunately, these definitions, while well intended, fall somewhat short of this goal. Under ideal conditions, they offer the public an opportunity to be included in planning before decisions have been made. Ideally the process of decisionmaking should take into account the views of everyone; but more realistically, we strive to include all who have legitimate interests in the matter at issue.

The role of communication in planning is most important. It is the key to meaningful public participation (Chekki, 1979). Failure to communicate effectively is usually the central factor affecting public involvement in the planning process. If planners desire to be successful, or at the very least intend to avoid conflict from a misinformed opposition, they must provide sufficient information to the public (Chekki, 1979).

If we are to wisely plan for our coastal areas in the future, we should learn from the environment and from the people who use it. We need to know what is valued by the users of the environment, what satisfies their wants and needs, and what fails to satisfy their wants and needs (University of Florida, 1980). This kind of aggregate user evaluation is the primary focus of this study.

Methodology

A public opinion survey is the principal vehicle used in determining public perception in this study. The site selection, that is, the six counties spanning the Indian River Lagoon on the east coast of Florida, was selected on the basis of ongoing research under the direction of the sponsoring non-profit organization, the Marine Resource Council of East Florida.

Study Site

The Indian River Lagoon is a large, estuarine water body located on the east coast of Florida, 150 miles north to south in length and ranges from one to six miles in width. The lagoon comprises three water bodies: the Indian River, the Mosquito Lagoon and the Banana River. Mosquito Lagoon and Banana River make up the northern extent of the Lagoon in Volusia County, at the same latitude as Cape Canaveral, Fla. From here it runs due south crossing six counties, including Volusia, Brevard, Indian River, St. Lucie, Martin and Palm Beach, to Jupiter. It is protected from the Atlantic Ocean by developed and undeveloped barrier beaches paralleling the coast.

The area is an important natural resource both for the tourists it attracts and for residents living along its shores. Sport and commercial fishing in the lagoon support a substantial fraction of the regional economy. Boating and other recreational uses of these waters bring tourist dollars both directly and indirectly. It is important, therefore, that the ecology of the Indian River system be understood by scientists and policy makers as well as the public, and that the area be managed properly (Montgomery and Smith, 1983).

The lagoonal system is home to 57 percent of the local commercial and sport species of finfish during at least a portion of their life cycles (Gilmore et al., 1981). Marinas, marine supply dealers, boat builders and repair facilities, fishing gear manufacturers and bait and tackle dealers serving boaters, commercial fishermen, and sport fishermen are just a few of the users who are dependent on the lagoon and its biological and aesthetic resources. Tourists and new residents are attracted to East-Central Florida by the many attributes of the Indian River system. Many established homes and residences become contributors to the problems while also benefiting from the Indian River system. The growth includes the adaption of the watershed and basin for human use (Johnson, 1983). Clearing land and alteration of shorelines have affected drainage patterns (Hoskin, 1983; Rice et al., 1983). Man-made openings of inlets have allowed the oyster drill to access the lagoon waters while dredging and construction of causeways and spoil islands have altered circulation of water in the estuary (Sheng et al., 1990). Pesticides, fertilizers, thermal effluent from power plants, and industrial chemicals have all found their way into the lagoon (Trefery et al., 1983). Habitat changes and fishing pressures have affected plant and animal populations of the estuary (Gilmore et al., 1983). In fact, letters attached to the surveys by long-time residents testified to a drop in species abundance levels and the change in appearance of the entire system.

Data

During the summer of 1991 a survey composed of both open-ended and categorical questions was administered to 3,500 people through a newsletter distributed by the Marine Resource Council. The anonymous survey, which sampled the population working and living within the lagoon's drainage basin, was divided into three parts. The first collected socioeconomic information from the respondents. The second sought information on the degree of importance of coastal issues. The third section measured the respondents' environmental involvement in the lagoon's resources. The survey asked respondents to categorize themselves by selecting the three interest groups (University of Florida, 1980) they felt most closely associated with.

By soliciting public opinion, the survey results identified and described public perceptions of major concerns and interests of the lagoon and the degree of public participation in management decisions. These concerns are not necessarily the same for all interest groups or all six counties. Differences are tested among interest groups. In addition, the study tests whether correlation exists between the degree of use, the respondent's identification and perception of issues.

Results

The author recognized the impracticality and unrealistic attempt for decisionmakers to address a relatively large number of interest groups with related concerns. Moreover, if decisionmakers can identify which groups perceive issues significantly differently or similarly, the information gained could provide managers with key information necessary to develop management plans that will reduce user conflicts.

Recognizing the importance of establishing such groups or clusters, a cluster or linkage tree analysis was conducted that in effect reduced the 31 original user groups, identified by Barile, to a manageable classification. The cluster analysis examines how each respondent ranked the various Indian River Lagoon environmental issues and clustered them into a smaller set of groups. A total of four such user groups were identified on the basis of the responses and classified as the following:

Group 1: Land
Group 2: Business
Group 3: Government
Group 4: Boat

Group 1 is largely made up of land-based businesses—those businesses that use land-based resources and may have an indirect impact (e.g., non-point-source pollutants) on the lagoon's resources.

Group 2 is largely composed of indirect users of the lagoon's resources (e.g., a federal official may have an impact on the lagoon's resources by regulating the protection of mangroves). However, for the most part this cluster is a mix of business interests and state and federal officials responsible for the management of the lagoon's resources.

Group 3 is largely composed of those interest groups who are responsible or involved in managing or protecting the lagoon's resources.

Group 4 is largely composed of water-based businesses which use the lagoon's resources directly (e.g., the marine industry relies on the lagoon's resources for operation.)

The chi-square test was used to test the differences between the four major groups. Unfortunately, the analysis did not meet the sparsity requirements (more than 20 percent of the cells in the chi-square table must have expected counts of less than 5) (Blalock, 1979). Thus, the chi-square analysis proved to be inconclusive and inappropriate for the datasets.

Analysis of variance was used to determine the statistical significance of the differences in the mean values. Six analyses of variance were run on the four identified groups. This statistic tests whether the average values recorded for each of the four clusters vary from the mean of the total sample for each of the environmental issues.

Matrix 1 reveals the probability values or the analysis of variance statistic when comparing the mean responses of one group to the mean responses of another group for each environmental issue in the Indian River Lagoon region.

When comparing Group 1 to Group 2, the analysis of variance test statistic reveals differences in mean values for 13 of the 18 issues. From these results, we are able to conclude that the respondents from these two clusters view the importance of issues differently.

These results are not surprising since members of Group 2 represent federal officials, regulatory agencies, state officials and scientists, who are often protecting or managing the lagoon's resources, while members of Group 1 represent backgrounds such as farmers, citrus growers, and aquaculturists who use or exploit the natural resources of the lagoon for the development of their business needs.

The five issues that respondents from the two groups rated similarly are coastal habitat protection, mangrove protection, manatee protection, acquisition of sensitive and waterfront lands, and the protection of drinking water resources. These particular issues do not interfere with the pursuit of land development for the business purposes of Group 1.

Similarly, Groups 1 and 3 responded significantly differently on 8 of the 18 issues. As stated earlier, respondents in Group 1 represent business interests that exploit natural resources, whereas respondents in Group 3 represent such backgrounds as educators, resource information specialists, environmental group specialists, tourism professionals and civic organization specialists, all of whom are interested in protecting or managing the lagoon's natural resources.

The eight issues that respondents from the groups rated similarly include public access to the ocean and lagoon, coastal habitat protection, mangrove protection, shorefront development, improving water quality, reducing surface water runoff sea grass decline, boating safety, reducing sewer discharges, and protecting drinking water resources. Again, these issues do not interfere with the pursuit of land development for the business purposes of Group 1.

Similarly, the analysis of variance comparing Groups 1 and 4 reveals differences for 8 of the 18 issues. Respondents from Group 4 represent backgrounds such as bait and tackle suppliers, boaters, the marina industry, and port and inlet managers, all of whom depend on the lagoon's natural resources for their businesses or livelihood, while respondents from Group 1 represent users or exploiters of natural resources for the development of their business needs.

The two groups disagreed on such issues as shorefront development, manatee protection, improving water quality, and maintaining channels and ports. These issues are likely very important for Group 4, as they all have an impact on the quality of marine resources in the lagoon. They were likely not as important for Group 1, which is not as concerned with maintaining or protecting such resources.

The analysis of variance comparing Group 2 to Group 4 reveals differences for only two of the 18 issues. In reviewing Matrix 1, we are able to conclude that the individuals from these two groups view the importance of issues more closely than other groups. These groups have similar backgrounds; they are either dependent on the lagoon's natural resources for their businesses or interested in protecting and managing the lagoon's resources.

In reviewing the analysis of variance results, it is clear that all four major groups view issues statistically differently from one another. Though some of the groups may corroborate with another group on a particular issue, they also disagree on others. Therefore, it is important for resource policymakers and managers to solicit such opinions when addressing decisions concerning the lagoon's resources. Without considering the opinions of each of these groups, the decisionmakers act negligently.

Collecting the evaluative judgments from a representative sample of the population in the Indian River Lagoon region is intended to provide policymakers and managers with important information on characteristics of the most important issues perceived by the public.

The analysis of variance tests suggest that various groups perceive issues differently based on their backgrounds and relationship to the issues. Without the consideration of the opinion of a marine industry user or a fisherman, for example, who directly depends on the lagoon's resources for income, decisionmakers act negligent by overlooking the impacts on these users. Such decisions as restricting or banning the use of specific gear in the lagoon, or not improving water quality in the lagoon have significant impacts on these users.

Therefore, the public's perception and subsequent participation has a clear role in coastal and environmental decisionmaking process in the Indian River Lagoon system. This study recognizes the relationships among who the public is, their use of the environment, and how they perceive the management of the resources in the Indian River Lagoon.

Summary

For the most part, the majority of environmental management decisions have been based on scientific parameters of the past, discounting the notion of user groups. During that time, most environmental decisions have been based on the manager's or policymaker's perceptions of what should be the appropriate decision. This study casts doubts on this particular notion because it examines the public's perceptions, defined as users and their behavior. This study recognizes the importance of discrepancies or differences between user groups.

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Table 1. Statistical differences between groups. These numbers represent the probability values when comparing the means of the responses of one group to the mean responses of another group when rating the environmental quality of the Indian River Lagoon region.

ISSUE	GROUPS 1, 2	1, 3	1, 4	2, 3	2, 4	3, 4
Public access	.0297	.7324	.5092	.8255	.5329	.7274
Coastal habitat protection	.5637	.3117	.6570	.0529	.6258	.8115
Mangrove protection	.9182	.6263	.1839	.0706	.5712	.4646
Shorefront development	.0213	.6767	.0386	.4954	.1104	.1224
Navigational channel dredging	.0218	.0092	.0604	.2488	.3182	.0016
Manatee protection	.6468	.0405	.0006	.0878	.6957	.0004
Causeway/bridge construction	.0316	.0188	.6543	.5429	.2208	.2674
Encourage aquaculture	.0183	.0379	.6563	.5051	.4899	.0034
Transportation/route expansion	.0041	.0148	.9707	.1817	.0093	.1017
Improve water quality	.0155	.8979	.0353	.0444	.2439	.2845
Reduce surface-water runoff	.0060	.1364	.3223	.6084	.1218	.6893
Seagrass loss	.0480	.7437	.3161	.5329	.0474	.5751
Boating safety	.0486	.2552	.6104	.6166	.6772	.1812
Reduce sewer discharge	.0442	.3731	.0728	.2576	.7857	.2200
Acquire sensitive or waterfront land	.0885	.0051	.0688	.0702	.0593	.0016
Protect drink water resources	.5597	.1792	.3148	.0179	.2481	.2538
Maintain nav. channels, ports	.0016	.0075	.0096	.0584	.9641	.0049
Maintain fish populations	.0185	.0051	.4808	.3139	.9156	.0779

Coastal America: A National Partnership

COASTAL AMERICA: A PARTNERSHIP FOR ACTION

Virginia K. Tippie and Norman T. Edwards
Coastal America

The Concept

Coastal America is an innovative, action-oriented, interagency partnership to restore, preserve and protect America's coastal heritage. This unique, cost-effective partnership builds coalitions for action among federal agencies, state and local governments, the private sector and concerned citizens. It leverages resources, legislative authorities and expertise to accomplish together what no single program or agency can do alone.

The partnership was established in 1991 by the four federal agencies with coastal resource stewardship responsibilities: the departments of the Army, Commerce and the Interior and the U.S. Environmental Protection Agency. In spring 1992, the partnership was expanded to include the departments of Agriculture, the Air Force, Housing and Urban Development, the Navy and Transportation. The President's Council on Environmental Quality coordinates the partnership. State and local agencies and non-governmental organizations participate in specific partnership projects.

The concept of a multi-agency partnership for action evolved as a result of a growing realization that we are facing a coastal crisis that can only be addressed by a comprehensive intergovernmental approach. Although federal laws have slowed the rate of degradation, our traditional piecemeal approach to coastal protection is not adequate. We need "a new way of doing business." The Coastal America initiative represents a first step toward forging a strong long-term alliance between the public and private sectors, to address coastal problems by sharing information, combining legislative authorities, and pooling skills and resources.

National Coordination

The partnership is guided by a memorandum of understanding (MOU) which has been signed by policy-level representatives of the 10 federal partnership agencies. The MOU describes the purpose of the partnership as follows:

> The purpose of the Coastal America initiative is to protect, preserve, and restore the Nation's coastal ecosystems through existing Federal capabilities and authorities; to facilitate collaboration and cooperation in the stewardship of coastal living resources by working in partnership with other Federal programs and integrating Federal actions with state, local, and non-governmental efforts; and to provide a framework for action that effectively focuses agency expertise and resources on jointly identified problems to produce demonstrable environmental and programmatic results that may serve as models for effective management of coastal living resources.

The MOU also establishes the organizational structure for the partnership and defines responsibilities.

Coastal America is coordinated through a matrix-management structure that cuts horizontally across the agencies and extends vertically from the policy level to the field level. Policy guidance is provided by the principals group, which is comprised of policy-level representatives of the partnership agencies. A national interagency team of senior-level national program managers coordinates activities. Seven regional interagency teams of senior-level regional managers coordinate regional activities. Working groups and ad hoc groups to address special issues are established as needed. Figure 1 delineates the organizational structure.

While the organizational structure of the partnership at the national, regional and local levels facilitates communication, the operational structure encourages action:

National Level—Policy formulation
Role: Support action through programs
Framework: Memorandum of understanding

Regional Level—Planning
Role: Develop regional strategies
Framework: Regional action plans

Local Level—Project implementation
Role: Implement action-oriented projects
Framework: Project working lists

The resulting improved communication between agencies and effective dissemination of information nationwide enables successful implementation of the partnership effort.

National coordination activities focus on encouraging regional action through policy/planning guidance, education/outreach products, and a monitoring/evaluation process. Policy and planning issues are discussed by the principals and the national team, and consensus guidance is disseminated horizontally across the 10 agencies and vertically from the national policy level to the regional program level to the local level. Educational products are developed by the national office to better inform the general public on coastal issues, and outreach programs are implemented at the project level to encourage citizen action (see Table 1 for list of education/outreach products). Program efforts are evaluated at the national level through workshops and reports; ideas and monitoring results are exchanged among regional representatives and project managers.

Regional Coordination/Local Action

Coastal America priority planning occurs at the regional level, where the interagency teams have developed strategic action plans to address regional problems. These plans are used as frameworks to guide identification of candidate priority projects for implementation at the local level. This process has resulted in the initiation of 24 collaborative projects in 15 states during 1992 (Table 2). The strategies and selected projects of the northeast, southeast and Gulf of Mexico regions are highlighted in this paper.

The northeast region has identified habitat restoration of saltmarshes constricted by infrastructure development as one specific theme in its overall regional strategy. An example of a specific local project that emerges from this theme is the Connecticut coastal embayments project. This effort was initiated with a one-year reconnaissance investigation to evaluate priority opportunities for restoration of coastal marshes constricted by rail and road systems in Connecticut. Subsequently, the Coastal America federal partners and the state of Connecticut signed a resolution to commit resources to accomplish the restoration efforts. The major source of funding is expected to come from transportation funds authorized in the Intermodal Surface Transportation Efficiency Act of 1991.

The reconnaissance report will evaluate historic saltmarshes now inland of the Eastern Connecticut Railroad embankment and determine whether increased tidal flow through the embankment would restore marsh vegetation. Additionally, the study will resolve issues such as whether alterations in the coastal hydrology of these marshes would increase the potential for flooding of property, and identify any unfavorable ecological effects from increasing salinity. The report will also enable a consensus prioritization for restoration.

The southeast regional strategy emphasizes activities that will maximize the formation of successful alliances with non-federal and non-governmental partners to address critical coastal problems in the region. The ongoing project to mitigate obstructions to anadromous fish migrations in the Albermarle-Pamlico Sound watershed area of North Carolina and Virginia is an example of an important project that maximizes the abilities, resources and authorities of a full range of responsible parties. Access to approximately 200 stream-miles of historic anadromous fish spawning habitat will be restored during 1993 through the removal of dams and construction of fish passages. Subsequent activities include the modification of additional dams and transportation systems and the creation of tools to guide future transportation development.

Among the non-federal partners in this ambitious project are the North Carolina Department of Transportation, North Carolina Department of Health and Natural Resources, North Carolina Wildlife Resources Commission, Virginia Department of Game and Inland Fisheries and the Virginia Council on the Environment. The federal partners include the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Department of the Interior, the U.S. Army Corps of Engineers and the Department of Transportation for engineering expertise, and the U.S. Marine Corps for demolition services. Each partner has brought a unique contribution to the process, e.g., funding, technical or procedural expertise, material, etc., that has enabled this critical project to move forward at optimum speed.

The Gulf region adopted as its regional strategy a simplified endorsement process at the local level to implement projects as fast as possible. In its first year of operation, the Gulf region initiated more than half of its project working list of 16 projects. The Cockroach Bay project, a vast undertaking with myriad partners, will ultimately restore and enhance a 651-acre area that has been mined and farmed, channelized and invaded by exotic plant species. Phase 1, which has a total area of 200 acres, is underway. Citizen volunteers are a key component of this project effort. In fact, several youth groups and local volunteers have helped with clean-up efforts, removal of exotic vegetation and planting of indigenous vegetation. The collaborative process has advanced the project schedule by several years.

Summary

This innovative multi-agency partnership for action has proven to be a very cost-effective way of doing business. In its first year it generated 24 partnership projects in over 15 states valued at over $10 million with over half of the funds contributed by non-federal partners. Over 20 federal agencies and 100 non-federal organizations participated in project efforts, which will result in the restoration of thousands of acres of wetlands, the re-establishment of hundreds of miles of spawning stream, and the protection of critical habitat for over 10 endangered species of coastal birds, anadromous fishes and marine mammals.

Coastal America provides a nationally coordinated multi-agency partnership with a regional collaborative approach and a local action-oriented project focus. The value of this process is that it provides a forum where agencies and organizations participate as equal partners empowered to contribute to a collective creative effort. Coastal America puts everyone on the same team by encouraging collaboration rather than confrontation. The result is innovative solutions to critical problems and a spirit of cooperation that enables effective implementation.

Table 1. Coastal America education/outreach products.

Coastal America: A Partnership for Action, a colorful brochure describing the problems of the coasts and outlining the goals and overall strategy of the program as established in 1991.

The Coastal America Progress Report, *Building New Alliances to Restore Coastal Environments*, an overview of Coastal America; the structure, regional strategies and local level projects underway or planned for 1993.

The Fragile Fringe: Coastal Wetlands of the Continental United States, a consensus publication describing the functions and values of coastal wetlands. The document also reports the status and trends of wetland loss along the four coasts and the management programs implemented to protect current and establish additional wetland acreage.

A Reporter's Guide to Oceans and Coastal Issues, a publication designed to introduce reporters to the problems, regulatory history and current programs implemented to protect, restore and maintain the coastal living resources of the United States.

Clean Waters from the Mountains to the Sea and *A Perilous Passage*, a brochure and poster that show the importance of conserving aquatic habitats throughout watersheds.

Coastal America Reference System, a reference book with key coastal information. In addition, a CD-ROM-based coastal information reference and retrieval system is under development.

Project Events. Volunteer activities and media events are held at project sites to increase public awareness of coastal problems and efforts underway to address the problems.

Table 2. Coastal America, 1992 demonstration projects.

NORTHEAST	
Galilee, R.I.	Restore approximately 130 acres of saltmarsh.
Connecticut coastal embayments	Restore 1,000+ acres of saltmarsh.
SOUTHEAST	
Chesapeake Bay, Md. (separate congressional appropriation)	Reestablish oyster habitat.
Obstructions to anadromous fish migration, North Carolina	Open almost 200 stream miles for fish.
Right whale project, Florida and Georgia	Prevent right whale ship strikes and net entanglement.
Key Largo, Fla.	Protect seagrass beds from prop scarring.
GULF OF MEXICO	
Aransas National Wildlife Refuge, Texas	Prevent erosion of 75-100 acres of endangered Whooping Crane critical habitat.
Armand Bayou, Texas	Detention basin use to control residential non-point-source pollution.
Arroyo Colorado, Texas	Remediate and prevent non-point-source pollution from agriculture.
Cockroach Bay, Tampa Bay, Fla.	Restore and enhance a 650-acre-plus wetland/upland site.
Galveston Bay, Texas	Construct a two-acre oyster reef of dredged material.
Gulf Shores, Ala.	Create a saltmarsh to denitrify pondwater from a mariculture center.

Mobile Bay, Ala.	Restore and protect marsh, submerged aquatic vegetation and oyster reefs.
Sabine Lake, Port Arthur, Texas	Restore approximately 2,275 acres of bay bottom.
Salt Bayou structure, Texas	Provide management capabilities on about 60,000 acres.
Shell Island, Fla.	Restore primary dune system and prevent interior dune deterioration.
SOUTHWEST	
Sonoma Baylands, San Francisco Bay, Calif.	Restore approximately 31 acres of wetlands.
NORTHWEST	
Duwamish River estuary, Seattle, Wash.	Protect and enhance intertidal wetlands at multiple sites.
ALASKA	
Kenai River Peninsula, Alaska	Demonstrate techniques to prevent stream erosion and development damage.
GREAT LAKES	
Little Lake Butte des Morts, Winnebago County, Wis.	Plans to remediate contaminated sediments.
Maumee River, Wis.	Feasibility of prescriptive fertilizer application in the reduction of non-point-source pollution.
Monroe County, N.Y.	Accelerate and enhance implementation of water quality management plan.
Piping Plover habitat, Wisconsin	Develop habitat for both Piping Plover and Common Tern.
Milkhouse waste discharge, Wisconsin	Demonstrate wetland filter strip reduction of non-point-source pollution.

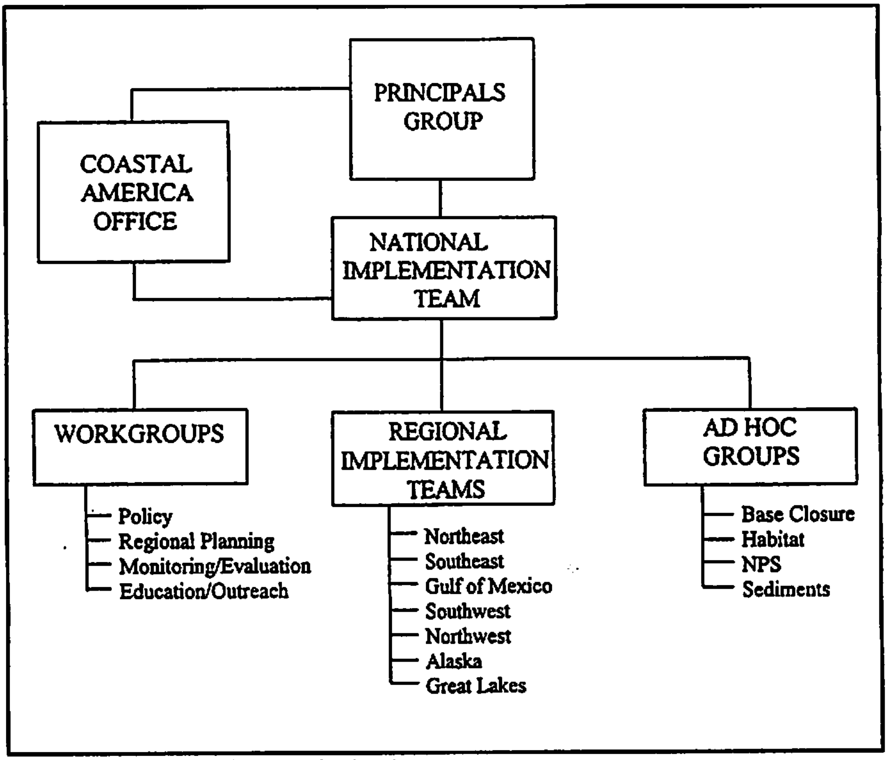

Figure 1. Coastal America organizational structure.

Oil Pollution

WASHINGTON'S MARINE OIL SPILL COMPENSATION SCHEDULE: SIMPLIFIED RESOURCE DAMAGE ASSESSMENT

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Introduction

In 1989, the Washington State Legislature passed the Resource Damage Assessment Act (ESHB 1853). This innovative law directed the state's Department of Ecology to develop a simplified approach for determining public resource damages for oil spills into state waters in the form of a compensation schedule. The need for a new approach for resource damage assessment for oil spills became apparent after several moderately large spills in the period of a few years. For these spills, resource experts were not satisfied that damages recovered represented adequate compensation. An added problem was that the cost of assessing resource damages for some of these spills exceeded recoveries by an order of magnitude. Given this relatively high cost of assessing resource damages, and the uncertainty involved with recovering assessment costs and damages, state resource agencies became understandably timid about aggressively pursuing damage assessment for all but the most obvious resource injuries (i.e., oiled birds).

The Act directs that the compensation schedule be based on three factors, characteristics of the oil that affect severity of effects on resources, sensitivity of the resources affected by the spill, and actions taken by the party responsible for spilling the oil. Damages calculated under the schedule are to be no less than one dollar per gallon of oil spilled, and no greater than fifty dollars per gallon of oil spilled. The compensation schedule is to be applied in place of traditional damage assessment methodologies when resource trustees determine the following: restoration or enhancement of the injured resources is not technically feasible, damages are not quantifiable at a reasonable cost using traditional damage assessment approaches, and the restoration and enhancement projects proposed by the responsible party are insufficient to adequately compensate the public for damages sustained as a result of the spill. The compensation schedule has been developed by the Washington Department of Ecology in conjunction with other state and federal resource agencies, Indian tribes, affected industries and environmental organizations and will soon be adopted as state regulations. Compensation schedule development has required substantial coordination among these groups, and extensive compilation and synthesis of existing resource information. This paper describes the process and methodologies employed to construct the Washington Compensation Schedule for oil spills into marine and estuarine waters.

Development of the Washington Oil Spill Compensation Schedule

The compensation schedule for marine and estuarine environments consists of two main components, the resource vulnerability rankings and the oil effects rankings. The resource vulnerability rankings collectively rate the sensitivity of the receiving environment to spilled oil. For purposes of the compensation schedule, resources are divided into the following seven categories: habitat, marine birds, marine fisheries, shellfish, salmon, marine mammals and recreation. The oil effects rankings rate the propensity of a spilled oil to cause the following types of environmental harm: acute toxicity, mechanical injury and to persist in the environment.

The Resource Vulnerability Rankings

To incorporate specificity into the compensation schedule, the marine and estuarine waters of Washington State were divided into 131 zones (excluding those established for the Columbia River Estuary). The majority of the zones were based on those established through earlier research efforts. In general, the resource vulnerability rankings rate the vulnerability of resources to spilled oil in a particular zone during a particular season. The habitat and salmon vulnerability rankings are, however, based on the proportion of habitat types exposed to spilled oil. The resource vulnerability rankings were developed using best available information and expert advice. Each of the resource vulnerability rankings were developed in consultation with an advisory committee. Advisory committee participation consisted of resource experts from state and federal agencies, academic institutions, consulting firms, Indian tribes and environmental organizations. Several of the resource vulnerability rankings were derived from variations of a methodology developed to rate marine bird vulnerability to oil spills (Wahl et al., 1981; Manuwal et al., 1979). Two resource vulnerability rankings are based on type and proportion of habitat affected by a spill. The recreation vulnerability ranking is based on the attributes of recreational facilities within zones and seasonal participation in recreational activities. Each of the resources vulnerability rankings is described in more detail below.

Habitat Vulnerability Ranking. The habitat vulnerability ranking employs the marine/estuarine habitat classification and ratings developed by Dethier (1991) for the Washington Compensation Schedule. Habitats are classified into 35 types based on substrate type, depth and energy regime (Dethier, 1991). The habitat classification developed for the compensation schedule is a "scaled-down" version of a more detailed classification that the state is using for detailed mapping of state marine and estuarine habitats (Dethier, 1990). Habitat types described in the compensation schedule classification can be translated to Dethier's (1990) more detailed classification scheme, as well as to the Cowardin et al. (1979) habitat classification. For purposes of the compensation schedule, habitat is defined as including the substrate and all flora and fauna not incorporated into the other compensation schedule resource vulnerability rankings. Each habitat type is rated on a 1-to-5 scale for two factors, magnitude of resources at risk (hm) and sensitivity to the acute, mechanical and persistence effects of spilled oil (hs_{AT}, hs_{MI}, and hs_{PER}, respectively). A rating of 5 represents the greatest magnitude of resources at risk or the most sensitive condition, and a score of 1 represents the lowest magnitude of resources at risk or the least vulnerable condition. The ratings for the two factors have then been combined to derive an overall habitat vulnerability score to the acute toxicity, mechanical injury and persistence effects of spilled oil, as follows:

$$hv_i = hm * hs_i$$

where:

v_i = habitat vulnerability to oil effect i;

hm = magnitude of the resources at risk;

hs_i = habitat sensitivity to oil effect i; and

i = acute toxicity, mechanical injury or persistence.

The habitat vulnerability score for a spill is determined after a spill occurs to accommodate the following special considerations. Areas with seagrass or kelp are treated as separate habitat types and the habitat vulnerability scores (hv_i) for these areas is multiplied by 1.5. When more than one habitat type is exposed to spilled oil, the habitat vulnerability score for the spill is the weighted average of the habitat vulnerability scores, where weighting is dependent on the size of the spill. For spills of 1,000 gallons or greater, weighting is defined by percent coverage of the habitat types within the area of spill exposure. For spills of less than 1,000 gallons, weighting is defined by percent coverage of the habitat types within the zone(s) exposed to spilled oil. Weighting differs depending on spill size in an attempt to reduce administrative costs associated with determining damages for smaller spills. Therefore, once the percent coverage of habitat types within any zone was calculated, these values could be used to calculate damages for all subsequent spills under 1,000 gallons where the compensation schedule is applied.

Marine Bird Vulnerability Ranking. The marine bird vulnerability ranking directly incorporates the bird oil index (BOI) developed by Wahl et al. (1981). Marine bird vulnerability to oil spills is rated for each season and compensation schedule zone on a 1-to-5 scale, where 5 represents the most vulnerable condition and 1 represents the least vulnerable condition. Vulnerability scores are based on population abundance and composition of 116 seabird, shorebird, waterfowl and raptor species in particular compensation schedule zones by season, as well as life history characteristics and habitats of the species present. Wahl et al. (1981) did not determine marine bird vulnerability to oil spills for all of Washington marine and estuarine waters. Where BOI values were not available, marine bird vulnerability to oil spills was determined from existing marine bird population information (Wahl and Speich, 1984; Wahl and Speich, 1983) using the methods described in Wahl et al. (1981) and Manuwal et al. (1979). Marine bird population information was very sparse for the Washington outer coast at the time of schedule development, consequently vulnerability scores were based on expert judgement of the marine bird advisory committee participants. The pre-calculated zonal bird vulnerability score for the appropriate season is used in calculations of damages using the compensation schedule except as follows: for spills in which threatened or endangered marine bird species are documented to be exposed to oil, the marine bird vulnerability ranking score is multiplied by 1.5.

Marine Fisheries Vulnerability Ranking. The marine fisheries vulnerability ranking is a modification of a vulnerability ranking developed for marine birds (Wahl et al., 1981; Manuwal et al., 1979). The marine fish vulnerability ranking rates the vulnerability of 61 marine fish species and species groups harvested commercially, recreationally and for subsistence purposes to oil spills in each compensation schedule zone by season. The following factors are rated to establish species vulnerability to oil spills in a particular compensation schedule zone: presence and usual abundance (P), current stock condition (SC), importance to commercial fisheries (CI), importance to recreational fisheries (RI), importance as a prey or indicator species (PI), normal distributional range (PD), adult sensitivity (AS; as measured by depth of occurrence), larval sensitivity (LS; as measured by presence and depth of occurrence in a particular season), and egg sensitivity (ES; as measured by presence and depth of occurrence in a particular season). Each factor is rated on a 1-to-5 scale where a score of 5 represents the most vulnerable condition, and a score of 1 represents the least vulnerable condition. The following formula was developed by marine fisheries advisory committee participants to calculate species/species group vulnerability for a spill in a particular season and compensation schedule zone:

$$V_s = P * SC * (CI+RI+PI) * (PD+AS_s+ES_s+LS_s)$$

where:

V_s = marine fish vulnerability for a particular species and region; and

s = season.

V_s was then summed for each harvested marine fish species present in a region to derive the marine fish vulnerability score (MFVS) for a particular region and season. The results were then converted to a 1-to-5 scale to derived the final marine fish vulnerability score (MFVS) for each season and compensation schedule zone. The appropriate pre-calculated MFVS score is applied to a spill to calculate damages using the compensation schedule.

Shellfish Vulnerability Ranking. As with the marine fisheries vulnerability ranking, the shellfish vulnerability ranking rates the vulnerability of harvested species to oil spills and is based on a modified version of the marine bird vulnerability ranking (Wahl et al., 1981; Manuwal et al., 1979). The shellfish vulnerability ranking rates the vulnerability of 38 shellfish species and species groups harvested commercially, recreationally and for subsistence purposes and takes into account the following factors for the species present in a particular zone: five year average annual harvest (H), adult/juvenile habitat (AJH), location and presence of larvae (LH), location of eggs (LE), Washington population concentration (PC), length and timing of spawning period (SP), species distribution (SD), population size in Washington (PS), reproductive potential (RP), and age at sexual maturity (SM). Each factor was rated on a 1-to-5 scale where a score of 5 represents the most vulnerable condition, and a score of 1 represents the least vulnerable condition. The following formula developed by the shellfish advisory committee was used to calculate species/species group vulnerability for each season and compensation schedule zone:

$$V_s = H^*(.4AJH+.15LH_s+.15LE_s+.05PC+.05SP_s+.05SD+.05PS+.05RP+.05SM)$$

where:

V_s = shellfish vulnerability for a particular species and region; and

s = season.

Weighting of vulnerability factors was derived through consensus of the shellfish advisory committee participants. V_s was then summed for each of the harvested shellfish species present in a compensation schedule zone to derive the shellfish vulnerability score (SFVS) for a particular zone and season. The SFVS scores were scaled to a 1-to-5 ranking to facilitate comparison with the other resource vulnerability rankings. The appropriate pre-calculated SFVS for a particular season and compensation schedule zone is applied to a spill to calculate damages using the compensation schedule approach. For spills in which threatened or endangered species included in the shellfish vulnerability ranking are documented to be oiled, the shellfish vulnerability score is multiplied by 1.5.

Salmon Vulnerability Ranking. The salmon vulnerability ranking is a habitat-based approach developed by salmon advisory committee participants. The ranking is based on seasonal habitat preference of juveniles during outmigration and adults as they return to spawn, and whether spilled oil enters river mouths during the peak migration of a species. Vulnerability of the following species/age-classes are rated: Chinook (subyearling), Chinook (yearling), Coho, Pink, Chum and Sockeye. Pink salmon are only incorporated into the vulnerability ranking in years they are present in state waters. Vulnerability of each species/age-class in each habitat type is rated on a 1-to-5 scale where 5 represents the most vulnerable condition and 1 represents the least vulnerable condition. The vulnerability of a particular species/age-class over all habitat types exposed to a spill is determined by calculating the weighted species/age-class vulnerability score where weighting is defined as percent-coverage of the habitat type within the area of spill impact. Species vulnerability scores are then averaged to derive the salmon vulnerability score for a spill (the vulnerability scores for yearling and subyearling Chinook are averaged to determine the Chinook vulnerability score for a spill).

For spills in which threatened or endangered races and/or runs of salmon are exposed to spilled oil, the salmon vulnerability score (SAVS) is multiplied by a factor of 1.5. Because the salmon vulnerability ranking is based on habitat types affected by a spill and other spill-specific information, SAVS is calculated at the time of a spill.

Marine Mammal Vulnerability Ranking. The marine mammal vulnerability ranking rates the vulnerability of 15 marine mammal species commonly found in or migrating through Washington waters to oil spills. As with the marine fish and shellfish vulnerability rankings, the approach used is based on a modification of the marine bird vulnerability ranking (Wahl et al., 1981; Manuwal et al., 1979). The marine mammal vulnerability ranking takes into consideration the following factors for each species rated to account for vulnerability to oil spills: presence/abundance in a region or subregion (P), physiological vulnerability to presence of oil (PV), primary habitat (PH), vulnerability of breeding population (VB; where applicable), vulnerability of non-breeding population (NB; where applicable), likelihood of impact based on feeding behavior (FH), Washington population status (WA), and population status in the North Pacific (PS). Each factor is rated on a 1-to-5 scale where a score of 5 represents the most vulnerable condition, and a score of 1 represents the least vulnerable condition. The following formula was developed by marine mammal advisory committee participants to calculate vulnerability for each marine mammal species present in a particular zone during a particular season:

$$V_s = P^*(PV^2+PH^2+VB_s^2+NB_s+WA^2+NP+FH+PS)$$

where:

V_s = marine mammal vulnerability for a particular species and region; and

s = season.

V_s was then summed for each species present in a compensation schedule zone to derive the marine mammal vulnerability score (MVS) for a particular region and season. The MVS score was scaled to a 1-to-5 score to facilitate comparison with the other resource vulnerability rankings. The appropriate pre-calculated MVS for a particular season and compensation schedule zone is applied to a spill to calculate damages using the compensation schedule approach. MVS is multiplied by a factor of 1.5 when spilled oil comes into contact with threatened or endangered marine mammal species.

Recreation Vulnerability Ranking. The recreation vulnerability ranking rates the vulnerability of marine- and estuarine-related recreation to oil spills. Vulnerability for this ranking is based on number, size and attributes of public shore sites present in compensation schedule zones and seasonal use levels. All of the public shore sites bordering marine and estuarine waters of the state (excluding the Columbia River Estuary) as described in Scott and Reuling (1986) were evaluated by recreation advisory board participants over the following attributes: fish and wildlife values, water contact sports, boating use and aesthetic character. Attribute scores were summed and multiplied by shoreline length of the site to derive a site score. Sites were then aggregated by compensation schedule zone and site scores were summed to derive a zonal score. Proportion of recreational use in each season was then calculated from five years of Washington State Parks use data. The zonal score was then multiplied by the proportional use by season to derive a recreation vulnerability score (RVS) for each subregion by season. This score was then scaled to a 1-to-5 ranking to facilitate comparison with other resource vulnerability rankings. The appropriate pre-calculated RVS is used to calculate damages when using the compensation schedule.

The Oil Effects Rankings

The oil effects rankings rate the relative severity of spilled oils to cause the following three environmental effects: acute toxicity, mechanical injury, and environmental persistence. The rankings were developed by Leschine et al. (1991) and reviewed by an oil effects advisory committee. Some small modifications have been made to

Leschine et al.'s rankings based on comments received on the draft state regulations during the public comment period. The three effects were rated for the following crude oil and five oil products which comprise approximately 90 percent of the volume of oil shipped through Washington coastal waters: Prudhoe Bay crude oil, bunker C, no. 2 fuel oil, gasoline, kerosene and kerosene-type jet fuel. The following sections describe the criteria used to develop the oil effects rankings.

Acute Toxicity Ranking. Leschine et al. (1990) found that relative differences in acute toxicity effects among crude oils and petroleum products are best described by content, absolute toxicity and solubility of constituent 1-, 2- and 3-ring aromatic compounds. The following formula was developed to describe these relationships:

$$\text{Relative Acute Toxicity} = SOL_1{*}PCT\text{-}WT_1 + SOL_2{*}PCT\text{-}WT_2 + SOL_3{*}PCT\text{-}WT_3$$

where:

SOL_i = solubility in seawater of i-ring aromatic hydrocarbons;

$PCT\text{-}WT_i$ = percent-weight of i-ring aromatic hydrocarbons in crude oil or refined product; and

$i = 1, 2, 3.$

Solubilities and percent-weight composition of 1-, 2- and 3-ring aromatic hydrocarbon compounds of the crude oil and oil products were determined from existing information. Formula results were then scaled to a 0-to-5 ranking (where 0 represents the least harmful condition and 5 represents the most harmful condition). Because formula results did not adequately represent the acute toxicity for Bunker C, the acute toxicity ranking for this oil product was made equivalent to the ranking derived for No. 2 Fuel Oil. This decision was based on empirical information derived from oil toxicity studies by Anderson et al. (1974). The pre-calculated acute toxicity ranking scores provided below in Table 1 are used in determinations of damages when applying the compensation schedule.

Table 1. Relative acute toxicity rank for selected oils.

Crude Oil or Oil Product	**Relative Acute Toxicity Rank (OIL_{AT})**
Prudhoe Bay Crude Oil	0.9
Bunker C	2.3
No. 2 Fuel Oil	2.3
Gasoline	5.0
Kerosene	1.4
Jet Fuel	1.4

Mechanical Injury Ranking. Mechanical injury is primarily caused by the ability of some oils and oil products to coat or smother flora and fauna. Leschine et al. (1991) found that relative differences in an oil's propensity to cause mechanical injury are best described by differences in API gravity (another way to describe an oil's specific gravity or density). Leschine et al. (1991) used the following general relationship to describe an oil's propensity to cause mechanical injury: the lower an oil's API gravity (i.e., the higher the specific gravity or density), the greater the oil's propensity to cause mechanical injury. To rank mechanical injury on a relative scale, API gravity was first converted to specific gravity using the following formula:

$$\text{specific gravity} = 141.5/(\text{API}^0 + 131.5).$$

Linear interpolation was then used to scale specific gravity to a 1-to-5 scale where a score of 1 represents the least harmful condition, and a score of 5 represents the most harmful condition. Table 2 provides the API gravity of the selected crude oil and oil products, and the mechanical injury ranking score.

Table 2. API gravity and mechanical injury rank for selected oils.

Relative Mechanical		
Crude Oil or Oil Product	**API Gravity**	**Injury Rank**
Prudhoe Bay Crude Oil	27.8	3.6
Bunker C	13.0	5.0
No. 2 Fuel Oil	31.6	3.2
Kerosene	41.5	2.4
Gasoline	62.4	1.0
Jet Fuel	35.8-56.7	2.4

Persistence Ranking. Because limitations in the available data do not allow comparisons to be made between an oil's propensity to persist in the environment and specific classes of compounds comprising the oil, Leschine et al. (1991) used a judgmental approach to relatively rank the oils' propensity to persist in the environment. An oil's propensity to persist in the environment was classified into one of the five categories listed in Table 3.

Table 3. Oil persistence categories.

Relative Expected Oil Retention Time	**Persistence Ranking**
Five to ten years or more	5
Two to five years	4
One to two years	3
One month to one year	2
Days to weeks	1

Persistence ranking scores were assigned to the selected oils based on empirical information (Leschine et al., 1991). These scores are presented in Table 4.

Table 4. Persistence scores for selected oils.

Crude Oil or Oil Product	**Relative Persistence Rank**
Prudhoe Bay Crude Oil	5
Bunker C	5
No. 2 Fuel Oil	2
Gasoline	1
Kerosene	1
Kerosene-Type Jet Fuel	1

Damages Determination

Damages are derived under the compensation schedule by applying a formula which utilizes the resource vulnerability and oil effects rankings. The resource vulnerability scores determined using the methods described above are first combined into a single spill vulnerability score (SVS). Resource vulnerability scores for a spill are simply added together to derive a SVS for acute toxicity, mechanical injury and persistence as follows:

$$SVS_i = HVS_i + BVS + MFVS + SFVS + SAVS + MVS + RVS$$

where:

SVS_i = spill vulnerability score for oil effect i;
HVS_i = habitat vulnerability to oil's propensity to cause i;
BVS = marine bird vulnerability score;
MFVS = marine fisheries vulnerability score;
SFVS = shellfish vulnerability score;
SAVS = salmon vulnerability score;
MVS = marine mammal vulnerability score;
RVS = recreation vulnerability score; and
i = acute toxicity (AT), mechanical injury (MI), or persistence (PER).

The spill vulnerability scores (SVS_i), oil effect scores (OIL_i), and number of gallons spilled are then utilized in the following formula to derive damages:

$$\text{Damages (\$)} = \text{gallons spilled} * 0.1 * [(OIL_{AT}*SVS_{AT})+(OIL_{MI}*SVS_{MI})+(OIL_{PER}*SVS_{PER})]$$

where:

gallons spilled = the number of gallons of oil spilled;
SVS_i = spill vulnerability score for oil effect i;
OIL_i = oil effect score for oil effect i;
i = acute toxicity (AT), mechanical injury (MI), and persistence (PER) effects of oil; and
0.1 = multiplier to adjust the damages calculated to the \$1 - \$50 per gallon range.

The multiplier is inserted into the formula to adjust the dollar amount of damages calculated to the one to fifty dollar per gallon of spilled oil range. The compensation schedule also allows for reduction of damages based on actions taken by the party responsible for the spill. Actions resulting in a reduction in damages include protection of specific resource features (seal and sea lion haulouts, public recreation sites, marine fish spawning areas, salmon concentration areas, shellfish beds and seabird breeding colonies), resource restoration, rehabilitation or enhancement, and immediate containment and removal of oil from open water areas. The amount of the reduction in damages varies depending on the circumstances of a spill but cannot be reduced below one dollar per gallon of oil spilled.

Discussion

It is anticipated that adoption of the oil spill compensation schedule into Washington State regulations will significantly improve the state's ability to recover compensation for damages to public resources caused by oil spills. Not only will the compensation schedule provide a mechanism to assess damages where such assessment is not technically feasible, the schedule will also provide a mechanism to assess damages where the cost of assessment is anticipated to exceed damages. This is important not only for the moderate to large size spills, but also the smaller-sized spills which constitute the vast majority of Washington spills. No damage assessments were conducted on nearly 1,000 spills that occurred during a 21-month period. There are two main reasons why damages are not assessed, namely assessment costs are anticipated to greatly exceed damages that could be recovered and no responsible party can be identified. With the compensation schedule damage assessment is greatly simplified, substantially reducing cost of assessing damages. The result will be that damages are assessed on a much greater percentage of spills. Although the compensation schedule will not have an impact on spills of substances other than oil, or for cases in which no responsible party is identified, the schedule will undoubtedly improve the efficiency of the damage assessment process where it is applicable. The coming months will provide an opportunity to evaluate the success of the Washington Compensation Schedule.

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PREVENTING OIL SPILLS: WHAT'S 'BEST'?

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Abstract

In response to the many hard lessons learned from the *Exxon Valdez* oil spill, the federal government and many states have initiated oil spill prevention and response campaigns via new laws, regulations, and other activities. The Washington legislature recently passed the 1991 Oil Spill Prevention and Response Act, a comprehensive bill that recognized the benefits of prevention through requirements for vessel and facility prevention plans, facility operations guidelines and other measures. In drafting requirements for industry, the legislature used such terms as "best achievable protection" and "best achievable technology." The statutory definitions of both phrases directly involve environmental, technological and economic variables. Indirectly, shaping these terms in regulation will involve the political variable of public comment, which plays an important role in Washington's rulemaking process.

This paper examines the definition of "best" as it relates to prevention from the perspective of each of these four variables. Environmental protection factors include baseline exposure levels, past spills, worst-case scenarios, and natural resource damage assessment. Technology factors involve existing capabilities, current research and development efforts, safety, and engineering feasibility. Economic variables include commercial availability, capital expenditures, operating costs, and spill-related cost incentives. Finally, the political variable includes input from outside interests, including industry, environmental organizations, tribes, and local citizen concerns. The Washington Department of Ecology's efforts to coordinate with existing regulatory programs, and to work with industry, environmental groups and other interests through technical work groups, have provided a framework in which to define the variables involved in "best achievable protection." Ultimately, this effort will result in oil-handling operations and design performance standards, as well as prevention plan review guidelines, that can set effective expectations for facility oil spill prevention programs.

Introduction

Of the many truths emphasized by the aftermath of the *Exxon Valdez* tragedy, one of the most clear was that in the event of a catastrophic oil spill, spill response is not an adequate line of defense in protecting the environment and public from the impacts of oil. This concept, while not a new one, has also been the primary message of the many groups that have assembled in the past few years to study spills. In its 1990 final report, the States/British Columbia Oil Spill Task Force declared, "Since response efforts can not effectively reduce the impact of large oil spills, prevention of spills must be the prime strategy in developing solutions to this issue." Similarly, the primary recommendation from the Alaska Oil Spill Commission's 1990 final report on the *Exxon Valdez* spill was that "prevention of oil spills must be the fundamental policy of all parties in the maritime oil transportation system." Following this philosophy, the Washington legislature passed the Oil Spill

Prevention and Response Act (OSPRA) in 1991. While this statute amended a number of spill response-related laws, it established a broad array of requirements intended to reduce the likelihood of spills occurring in state waters. The Washington legislature clearly stated in the statute that: "The legislature finds that prevention is the best method to protect the unique and special marine environments in this state. The technology for containing and cleaning up a spill of oil or hazardous substances is in the early stages of development. Preventing spills is more protective of the environment and more cost effective when all the costs associated with responding to a spill are considered."

In the 1991 OSPRA, the legislature charged the Washington Department of Ecology with the regulatory responsibility of implementing these legislative spill prevention and response provisions with respect to onshore and offshore oil-handling facilities. The legislature created a new state agency, the Washington Office of Marine Safety, to develop such programs for tank ships and other vessels (while the scope of this paper does not include vessel spill prevention, much of the issues discussed are applicable). At this point, no offshore facilities exist in Washington, so the Department of Ecology is essentially focused on onshore facilities. An onshore facility is defined by statute as one that transfers oil in bulk to or from tank vessels or pipelines and is located on or near navigable waters of the state such that it could be reasonably expected to cause substantial harm to the environment by an oil discharge. The definition's lack of quantitative criteria, such as a minimum storage volume, and its use of ambiguous terms such as "reasonably expected to cause substantial harm" (a term federal agencies are currently analyzing with respect to its usage in the Oil Pollution Act of 1990), complicates the ability to identify regulated onshore facilities. However, the Department of Ecology has identified approximately 65 facilities in the state that appear to be covered by OSPRA requirements. While this number is primarily restricted by the condition regarding tank vessel/pipeline transfer, diverse facility types are covered, ranging from large refineries with major marine terminals and multi-million-gallon tanks to small distributors in the San Juan Islands that have only a few personnel involved in oil-handling operations. Among many new requirements under OSPRA, regulated onshore facilities must develop prevention plans that document those measures taken by the facility to provide "best achievable protection" from oil spills. Plans must be submitted to the Department of Ecology by Jan. 1, 1993, at which point they will be reviewed for adequacy. The primary statutory criterion for adequacy is that the plans provide "best achievable protection" from damages caused by the discharge of oil into Washington state waters. It is in the development of prevention plan standards by rule, and moreso during the review of prevention plans, that Department of Ecology staff must answer the question "what's best?"

The main guidance given by the Washington legislature to solve this puzzle takes the form of the definition of "best achievable protection," which is:

> The highest level of protection that can be achieved through the use of the best achievable technology and those staffing levels, training procedures, and operational methods that provide the greatest degree of protection available. The director's (of the Department of Ecology) determination of best achievable detection shall be guided by the critical need to protect the state's natural resources and waters, while considering the additional protection provided by

the measures, the technological achievability of the measures; and the cost of the measures.

A key term in this definition is "best achievable technology," which is defined in statute as:

> The technology that provides the greatest degree of protection, taking into consideration processes that are being developed, or could feasibly be developed, given overall reasonable expenditures on research and development, and processes that are currently in use. In determining what is best achievable technology, the director (of the Department of Ecology) shall consider the effectiveness, engineering feasibility, and commercial availability of the technology.

The "best achievable protection" concept is not unique to Washington, appearing in other oil spill legislation such as California's Lempert-Keene-Seastrand Oil Spill Prevention Act. The definitions of "best achievable protection" and the related "best achievable technology" together involve a number of factors that break down into three categories: environmental variables, technological variables and economic variables. Indirectly, shaping these terms in regulation will involve the political variable of public comment, which plays an important role in Washington's rulemaking process. The following sections discuss each of these variables in more detail.

Environmental Variables

Defining "best achievable protection" requires consideration of past and worst-case spills, baseline environmental exposure to oil, and environmental impacts—in other words, "what are the risks?" This question involves examining the probability of a spill's occurring, and then the potential impacts of that spill on the environment. Washington law, similar to federal law, focuses on the threat of a worst-case spill, which from an onshore facility is the "largest foreseeable spill in adverse weather conditions." Based on past spills and other existing regulations, the Department of Ecology has refined the definition by rule to involve the volume of the facility's largest aboveground tank. However, recent facility spills in Washington, such as Texaco's February 1991 spill in Anacortes, have involved significantly lesser volumes than the largest tank capacity and yet resulted in significant natural resource damages. Therefore, while Washington's rules may focus foremost on protection from catastrophic spill risks, they need to address smaller spills as well. In order to identify the ranges of oil spill risks present at a facility, the Department of Ecology will require prevention plans to include a detailed risk analysis prepared under the supervision of a licensed professional engineer. This risk analysis must analyze the oil transfer, production and storage systems in the facility, including tanks, pipes and associated equipment, to identify potential risks of structural failure, operation errors and other key spill causes. In addition, the facility must identify and evaluate the causes of past spills, particularly those greater than 25 barrels. The many types of regulated facilities dictate the need to examine these risks case by case, rather than applying a blanket list of common spill risks to each facility.

Environmental sensitivity is the second part of the equation; for a given level of spill risk, expectations for protection strategies will depend on the impacts of that spill to the environment. A prevention measure designed to reduce a particular spill risk at facilities will yield a greater benefit in areas where impacts will be to highly valuable environmental resources (e.g., salmon spawning areas) than areas of less environmental value (e.g., previously damaged urban bays). Therefore, it is important to develop thorough baseline information on vulnerable natural resources that may be affected by a discharge associated with identified facility risks. Knowing existing environmental sensitivity is necessary as well, particularly if past or ongoing oil damage from non-facility spill sources (e.g., stormwater runoff) limits the protection a facility's individual oil spill prevention measures can provide. The Department of Ecology has developed a series of maps that identify environmentally sensitive areas for a large portion of Washington's waters and coastlines. Under its Preassessment Screening and Oil Spill Compensation Schedule Rule (WAC 173-183), the Department of Ecology has ranked these areas on a 1 to 5 scale for damage assessment purposes, with 5 being highest in vulnerability due to habitat and other values. Efforts continue to add to this information base, which will be a key tool in evaluating best achievable protection.

Technological Variables

Washington's definition of best achievable technology is interesting because it requires the Department of Ecology to look not only at existing capabilities or even technology under development, but technology that could feasibly be developed. Nevertheless, the first step in this challenging exercise is to focus on facilities' existing prevention measures. While technology invokes images of circuitry and machinery, it captures operational techniques and other "non-hardware" aspects within its context in "best achievable protection." Facilities often have unique risks that have spawned different approaches to spill prevention. The range of regulated facility types in Washington adds to this variety. For example, while a major refinery may have installed a state-of-the-art electronic monitoring system to measure pipeline leaks, a small-terminal operator might be able to accomplish the same end by visual means. For this reason, the Department of Ecology has recognized the importance of visiting diverse facilities to identify these differences. Still, there are common practices that apply to most oil handling facilities; these are often delineated in industry guidelines by organizations such as the American Petroleum Institute. Reviewing these standards, as well as trade journals and other information sources, can provide insight into technology that has already proven useful in some arenas.

While existing measures often represent the best practices available, they also may represent a status quo that has not evolved due to a lack of incentive for improvement. Therefore, it is necessary to tap into research and development ideas and projects that may not have made it off the drafting room floor and onto the facility site. Research conference proceedings, journal articles and other sources provide limited glimpses into new technology. The Department of Ecology is also pursuing this information through its formation of a technical subcommittee composed of industry and non-industry representatives with specific engineering expertise in storage tank design, transfer operations and other areas where spill prevention is emphasized. One of the subcommittee's roles is to provide insight on new practices or technology which could reduce spill risks but are not currently in place in Washington facilities. For a similar function, the Department of Ecology has contracted with an engineering consulting firm based in western Canada to provide information on new and emerging oil spill prevention technology. The Department of Ecology is directing a significant part of the subcommittee's and consultant's focus toward pipeline leak detection and control; a technology that has not been intensively used at many onshore facilities in Washington. In fact, a contracted report on the potential application of leak detection and control methods for facility transfer pipelines is under development. Ultimately, the increasing costs of spills, as well as technological advances in other fields, will most likely promote expanded spill prevention capabilities in the future. The Department of Ecology and other regulatory agencies will need to keep one eye on these changes and allow their requirements to evolve with the technology itself.

In addition to keeping one eye on developing technology, Washington's OSPRA requires the Department of Ecology to keep a critical eye on feasibility as well. The consulting and subcommittee teams described above have an additional role to provide feedback on the limitations of new technology, based on the realities they have dealt with in running operations at an oil-handling facility. New accident-prevention concepts that work for one industry may not apply to the transfer or storage of oil. This evaluation is particularly important given the range of facility types involved in Washington. Safety is another basic consideration of feasibility; a new device that can improve corrosion detection capabilities is not providing "best achievable protection" if its use causes a significant risk to worker health. Overall, feasibility often overlaps with the economic aspect of defining "best achievable protection," as many oil spill prevention measures can be applied given enough expenditures on engineering.

Economic Variables

While much can be done to prevent oil spills at a less expensive price than that incurred when a spill occurs, spill-prevention technology and practices can involve significant capital expenditures and operating costs. There is a range of perspectives as to how economic variables should be factored into setting expectations for facility spill-prevention measures. Straight environmental economics might define "best achievable protection" as the point at which the marginal costs of preventing an oil spill equal the marginal cost of having a spill (Randall, 1987). Campaigns for "zero pollution tolerance" or "jobs first" might argue to shift that balance. However, simply for the need to develop spill-prevention priorities that involve the biggest "bang for the buck," it is important to compare the economic value of spill-prevention costs and benefits. On the cost end, capital expenditures will be likely where new equipment must be installed, such as tank overfill alarms. The capital costs may be less for new construction than for upgrades to existing features of the facility (e.g., redesign of tank farm berms). Most of these large capital expenses will be amortized over the lifespan of the measure. The Department of Ecology will need to be aware of implicit costs associated with a capital improvement (e.g., lost opportunities, lost revenues from operations down-time forced by installation). Secondly, prevention measures will involve long-term operations costs.

These costs may range from payment for extra hours by facility personnel performing additional inspections to decreased daily production (i.e., decreased revenues) because of switching to a more conservative oil-transfer practice. On the other side of the coin, a spill-prevention measure can be associated with savings from prevented spills. Estimating this savings depends first on the ability to quantify how much a particular measure has reduced the risk of an oil spill (e.g., a tank liner will minimize the chance of a spill of *x* gallons by *y* percent); that factor then can be multiplied by the cost of the avoided spill. The direct and indirect costs of a prevented spill both must be addressed. Direct costs of oil spills—oil removal, disposal, damage to commercial species—are typically straightforward and the traditional focus of oil spill assessments. Indirect costs involve non-market issues, such as damage to wildlife, habitat, recreational resources and quality of life; these costs can be estimated by a suite of methods (e.g., contingent valuation); each with their own challenges. The Department of Ecology's Preassessment Screening and Oil Spill Compensation Schedule Rule assigns regions of the state with damage compensation values that include non-market values; this information will be useful in determining the cost-benefit ratios for prevention measures at particular facilities.

A final economic aspect of the statutory definition of "best achievable protection" is commercial availability. While technological analysis of a spill-prevention measure may demonstrate that it is feasible, a particular facility may find difficulty in obtaining access to the measure if it lacks the resources to develop the measure independently, or if proprietary rights are involved. This can be a two-way street; a collective interest in a particular technology by industry could drive that technology to become commercially available on the market.

Political Variables

The political variable of best achievable protection is certainly not contained in the statutory definition, but it needs to be recognized as a force that shapes the expectations for best achievable protection that emerge from the Department of Ecology's consideration of the environmental, technological and economic variables. This political variable mainly involves the influence from outside interests, including industry, environmental organizations, tribes and local citizens, on developing regulations—in this case, on the definition of best achievable protection. In a vacuum, a regulatory agency may weigh in economic, technological, and environmental factors to the development of standards, and come up with one approach. However, in a political world, a very different standard may emerge based on different interpretations of how these variables interrelate, as well as on different priorities regarding which should predominate. Often compromise plays a large role in setting standards; middle grounds may prevail, particularly within a range of options for numerical standards. The Department of Ecology attempts to account for this variable as much as possible through its public involvement strategies. In addition to public workshops and hearings designed to solicit external input, the Department of Ecology has established a prevention work group composed of representatives from regulated facilities, environmental and citizen groups, tribes and other interest groups. This group is playing a key role in providing review and input while the Department of Ecology crafts the definition of best achievable protection.

Coordination with other state and federal agencies is a related external influence on defining best achievable protection. While oil spill prevention is a new arena for most states, it has been the subject of many federal regulations for years (e.g., U.S. Environmental Protection Agency's Spill Prevention, Countermeasure and Control regulations under Title 40, U.S. Code of Federal Regulations, Part 112). In some cases, federal regulations may actually preempt states from developing their own standards. For example, the federal Pipeline Safety Act contains language that keeps pipeline safety requirements for interstate pipelines primarily in the federal domain. For areas where federal preemption is not at issue, the state must consider the problems of defining best achievable protection that could conflict with federal standards or is groundlessly inconsistent with other states' programs. The Department of Ecology has benefitted greatly regarding this challenge through its involvement with the States/British Columbia Oil Spill Task Force, composed of the environmental agency representatives from California, Oregon, Washington, Alaska and British Columbia. One of the task force's primary missions is to promote consistency among the West Coast jurisdictions and with federal authorities.

Implementation Strategies

The above discussion addresses the variables that needed to be considered when defining best achievable protection. Separate from that issue lies the question of regulatory methods which the Department of Ecology may use to approach defining "what's best?" particularly for the review of facility spill-prevention plans. Three primary implementation strategies are planned. First, in addition to the prevention plan rule mentioned earlier, the Department of Ecology is required by OSPRA to develop an associated rule that sets operation standards for facilities. These standards will involve quantitative performance requirements and will be the Department of Ecology's most concrete and formal approach to defining best achievable protection. For example, in the realm of leak-detection from transfer pipelines (a deficiency exposed by recent Washington spills), the operations rule may require a regulated facility to possess a system of detecting leaks of a certain volume or percentage of flow within a specific time. As a performance standard, this requirement would allow flexibility and creative opportunities to achieve this goal through the most appropriate means. However, the rule would provide facility staff and Department of Ecology prevention plan reviewers with a well-defined benchmark to gauge whether the facility is providing best achievable protection with respect to leak detection. The administrative burden of having to revise the rule requirements to reflect changes in best achievable technology or other variables presents one key drawback to this approach.

While facility prevention plans must comprehensively address all applicable oil spill risks, the Department of Ecology most likely will not adopt specific performance standards by rule for certain prevention measures due to information limitations or complexities caused by the variety of regulated facilities. For example, it may be difficult to define exact performance standards by rule for methods to prevent vandalism. In such cases, the next layer of defining best achievable protection rests in development of Department of Ecology guidelines, primarily through some form of handbook. These guidelines would elaborate on the rule and provide technical information (e.g., strengths and weaknesses of facility lighting systems and other security measures). These guidelines would set direction for Department of Ecology prevention plan reviewers but would also be available to regulated facilities. This approach has been successfully used by the Department of Ecology for oil spill contingency plan review and other purposes, as well as by other states; it is more adaptable to change than a rule, but therefore is also more susceptible to ambiguity.

Finally, a certain amount of Department of Ecology decisions on what is best achievable protection involve direct interpretation of the rule provisions by a prevention plan reviewer using his or her best professional judgement. This discretion is necessary given the complex nature of oil spill prevention at facilities and the diversity of facilities involved. However, it requires constant attention among plan review staff to catch inconsistencies and keep aware of developments on the oil spill prevention horizon.

Conclusions

Although Washington's spill-prevention legislation and its focus on "best achievable protection" and "best achievable technology" are new, the challenge of defining what's best in the field of environmental regulation has always existed. Performance standards have been used to establish expectations for "what's best" in many arenas, from wastewater treatment requirements to air release allowances; and their application appears well suited for the sake of oil spill prevention as well. In setting its expectations for facility oil-spill-prevention programs, the Washington Department of Ecology will need to integrate environmental, technological and economic factors, shaped in part by external political forces. Where this process results in underlying expectations for all facilities, regulatory performance standards will be adopted; less pervasive conclusions will need to be applied case by case through general guidelines and best professional judgement. Evaluating oil spill risks requires a systems approach; a patchwork of regulatory band-aids developed in response to specific problems in particular spills rather than by looking at the entire facility oil-handling system will not provide best achievable protection when new problems arise. The Washington Department of Ecology's effort to apply the statutory concept of best achievable protection will generate a comprehensive set of decisions regarding how to balance the costs of oil spill risks inherent in oil consumption with the extent of industry strategies required to reduce these risks. Ideally, Washington's decisions regarding what's best for safeguarding its resources from facility oil spills can mesh with expectations of other state, federal and international authorities and provide a consistent blanket of overall protection.

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OIL SPILL INSIDE THE LAGOON OF VENICE: A SIMULATION

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Introduction

This presentation is one part of an ISMES research program commissioned by the Ministry of Environment on the risk of technological disaster in the main Italian ports and along the main routes of tankers. Within this general program our staff has focused its work on the study of an oil and/or chemical spill in the Adriatic Sea. The situation of this sea and its coastline has been analyzed, and some areas, which have both high environmental "sensibility" and high accident potential, have been investigated.

The first results for the Lagoon of Venice, one of the most representative areas from an environmental, artistic and industrial point of view, are presented in Figure 1. The whole lagoon system is dominantly water-based or water-related. Much of the lagoon outside the navigation channels is extremely shallow and the water movements are highly variable.

Geography and Hydrology

The Lagoon of Venice is located in the northern end of the Adriatic sea. It is about 50 km long, and its width varies between 10 km and 15 km. About 75 percent of its area is very shallow water, no deeper than 2 m. Between these shallow regions run narrow, deep channels whose depths reach from 20 m to a maximum of 50 m close to the inlets. In the eastern and northern parts exist wide areas of intertidal flats (Barene and Velme) that govern the dynamics of the region.

The three inlets, Chioggia, Malamocco and Lido, have a maximum width of 1 km and connect the lagoon to the open sea. The maximal astronomical tide at these inlets amounts to an amplitude of 50 cm. Extreme meteorological situations in which the city of Venice is flooded by the high water have not been taken into account.

Humans and the Venetian Environment

Thanks to its artistic treasures, unique features and location, Venice is one of the most famous cities of the world. In addition, Venice-Porto Marghera is an industrial center and a very important port (Table 1). Petroleum products for the petrochemical industries of Porto Marghera, raw material inputs to refineries and other chemicals are transported by big tankers crossing the lagoon to the port. In 1989, a total of 12 billion tons were transported through the port (AA. VV., 1989).

Table 1. Weights (in thousands of tons) of dry goods and petroleum products shipped through Porto Marghera in 1989. [Source: Provveditorato al porto di Venezia]

Solid Fuels	2,611
Minerals	1,180
Chemicals	2,227
Phosphates and fertilizers	1,601
Other goods	1,958
Crude mineral oils	4,865
Mineral oil derivatives	6,573

Many studies on the impact of the industrial zone and port on the environment have been carried out, but an exhaustive risk analysis of technological accidents is still underway, as well as application of an appropriate and advanced monitoring technology (Bruzzi and Marcelli, 1990). Protection and prevention plans are necessary for the safeguard of the lagoon environment. Less known than the historic city of Venice, it is one of the most beautiful wetlands of Europe for its landscapes and richness of flora and fauna.

The Ramstadt Convention ranked the Lagoon of Venice No. 1 for its value—especially for its recovering migratory birds—along with the mouths of the Danube, Guadalquivir and Rhone rivers.

A Simulated Oil Spill in the Lagoon

An accident was simulated along the main route of tankers into the channel of the Malamocco Inlet. In the simulation, one "particle" of oil is released every five seconds for four days (69,120 particles). Because this is not yet a true model of an oil spill's behavior, the amount of oil represented by one particle is arbitrary.

The simulation was done for two meteorological conditions: the northeastern "Bora" wind and southeastern wind "Scirocco." For both, a typical constant wind speed of 6 m/sec is used.

Circulation in the lagoon is controlled by the tide. The tide used at the inlet is a typical monochromatic M2 with an amplitude of 40 cm and a period of 12 hours. It carries about 90 percent of the signal and arrives in Venice in about an hour with no appreciable damping.

A two-dimensional model was used to study the problem. The hydrodynamic evolution of the basin was described using a finite elements model, and the spatial distribution of the "particles" in the field of motion was described by a Lagrangian model. The coupling of these models allows representation of dissolved or suspended matter that is transported in the field of motion.

The Finite Elements Method: Spatial Description

A finite elements method takes into account variations in horizontal parameters, such as coastline, bathymetry and physical phenomena, and in the vertical direction the number of levels that determines the degree of resolution of the model. Because not all the domain requires the same detail, it is possible to describe certain zones in the model more accurately than others. The use of this method allows for an accurate description of a front, i.e., a zone with a steep gradient. The finite differences method in this case would encounter the problem of choosing a grid fine enough to model the channels but coarse enough to keep the number of points reasonably small.

The domain of interest has been divided into triangles (elements) that may vary in form and size. In these elements all the parameters and unknowns are defined with the help of form functions that vary linearly over each element. A grid containing about 1,000 nodes and 6,500 elements has been set up (Figure 2) using digitalized bathymetry.

The Equations

The equations used are the continuity equations, the primitive momentum equations in conservative form with the Boussinesq approximation, the transport diffusion equations for salinity and temperature and the equation of state. A detailed discussion on the strategies applied for the solution can be found in Umgiesser and Bergamasco (1991).

Some important considerations are to be made in this case. In shallow water, the bottom friction term is several magnitudes greater than a horizontal eddy coefficient, so no turbulent viscosity is considered. The Coriolis term is ignored because the dimensions of the basin are small. Only one vertical level has been considered, because the water is well mixed due to tides, and no stratification occurs.

Consequently the transport process due to the baroclinic phenomena has been neglected, supposing the density is constant. As mentioned above the forcing term is the wind.

Results and Conclusions

A FORTRAN program runs the described numerical model on VAX/Digital. Finite elements have been chosen to cope with the "shallow water" theory. The following consideration have been made for the two runs:

Bora wind simulation. The diffusion of the spilled matter is slow but constant and dominates the advection. In this case, the spill will reach a large zone of flat lands important to wildlife and, within two days, some cultivated areas and fish farms. Figure 3 shows an example of a 4-day run.

Scirocco wind simulation. In this case, the advective term overrides the diffusive term. The propagation of the spilled matter will follow the rhythm of the tide as it drifts toward Venice. The industrial zone will be reached soon, and, after the third day the oil will enter Venice from the Grand Canal. Figure 4 shows an example for a 4-day run.

Further refinements to this model are planned. A detailed risk analysis is also planned for another important oil terminal, Trieste, and the northern Adriatic Sea. Other steps are yet to be completed, including the introduction of the Coriolis term, the density field and vertical layering.

At this stage the number of particles leaving the lagoon from the Malamocco Inlet has not been considered, but with expansion of the simulation to the Adriatic Sea, the model will also follow the behavior of the spilled matter outside the lagoon, because the number of particles gives information on the concentration of the spilled matter.

Moreover, the great importance of advection in the process is confirmed by the large number of particles reaching the channels.

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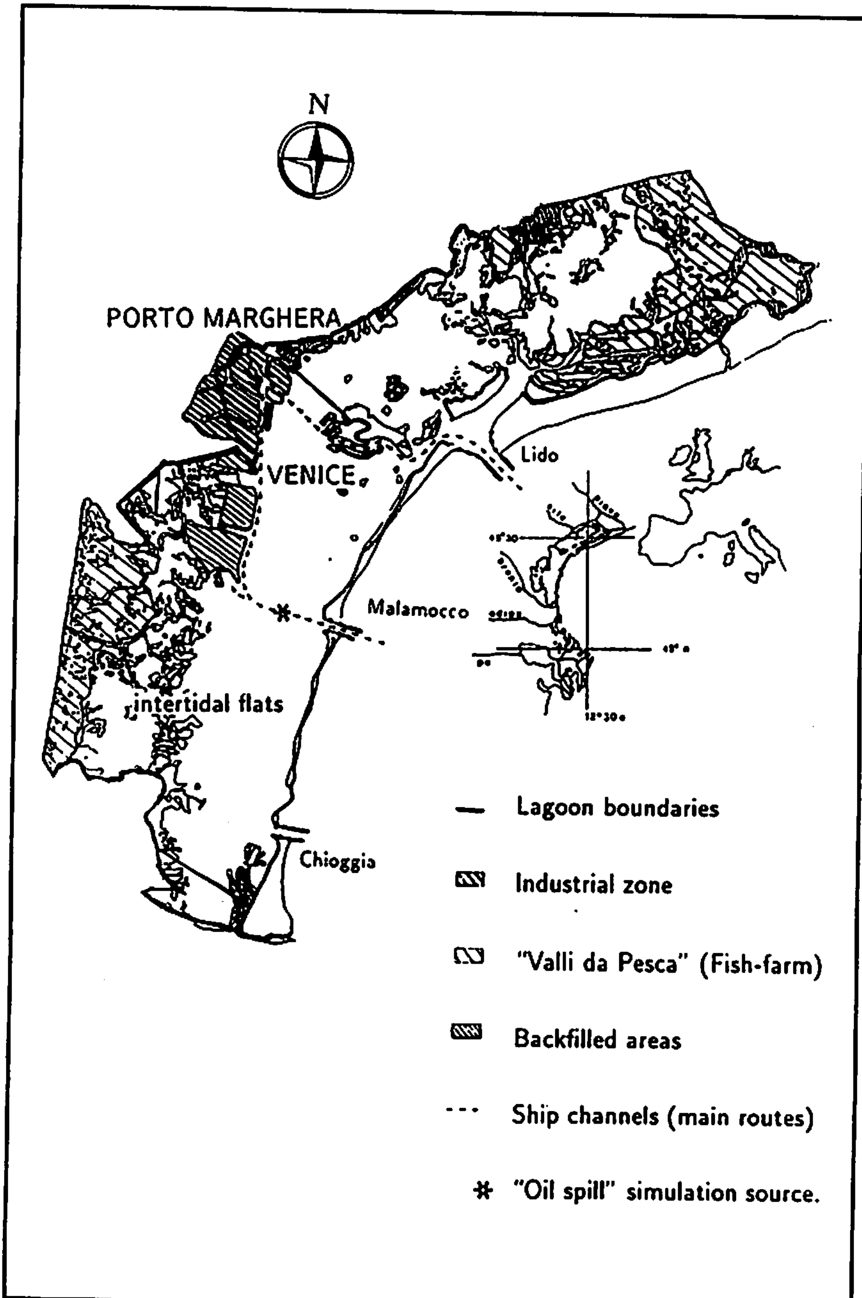

Figure 1. The Lagoon of Venice.

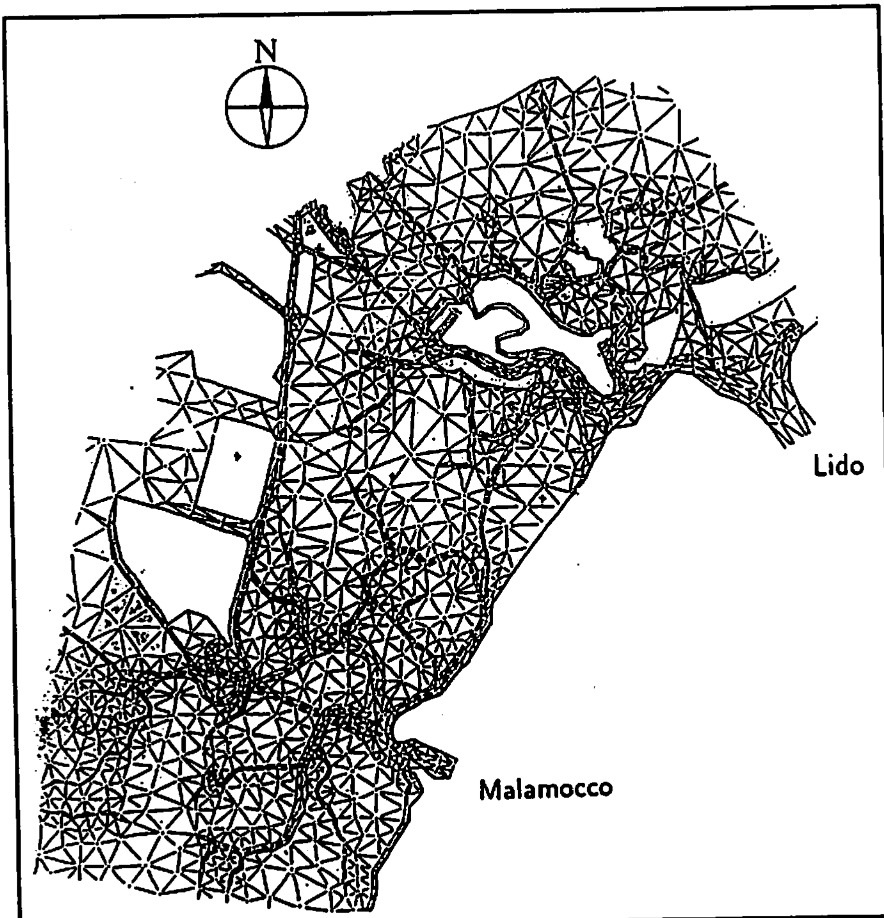

Figure 2. The grid used for the computer simulation.

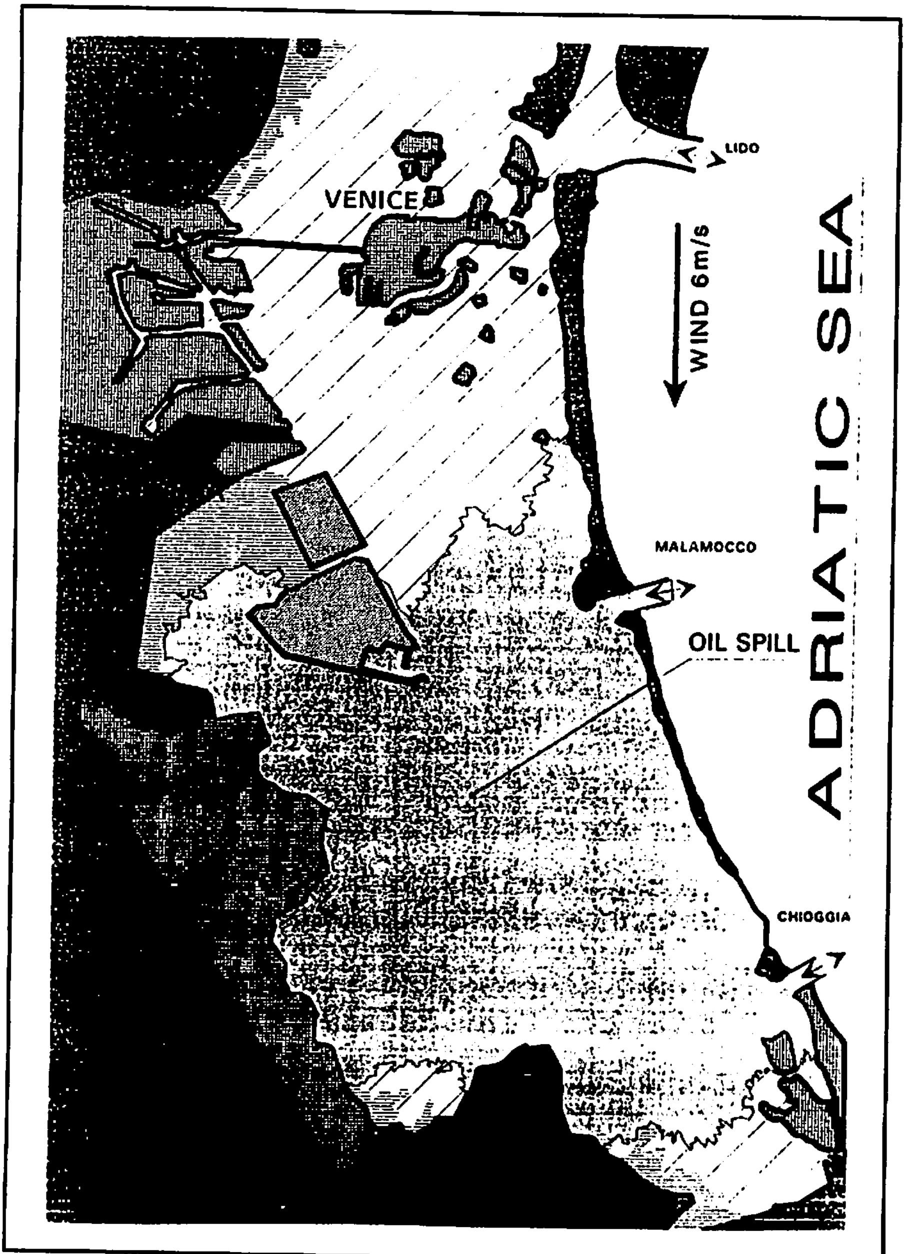

Figure 3. The Bora wind simulation: The situation after 96 hours.

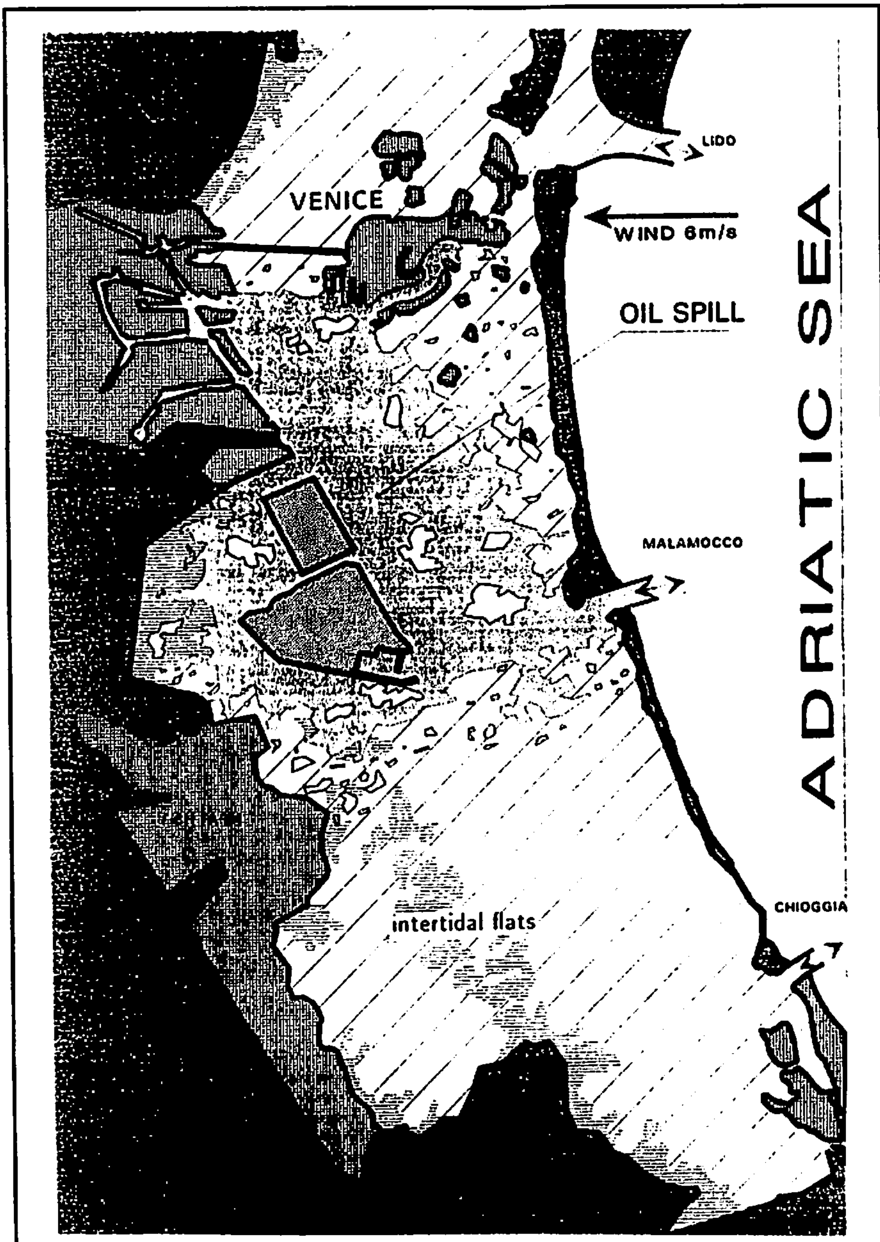

Figure 4. The Scirocco wind simulation: The situation after 96 hours.

A STUDENT'S OIL SPILL PREPAREDNESS EDUCATION PROGRAM

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Abstract

Following the *Exxon Valdez* incident, the Clean Seas oil spill cooperative received numerous requests from local educational institutions for additional information on oil spill response procedures. In response, Clean Seas undertook the development of an educational package which could be sent to schools. This package was designed to provide more information on Clean Seas, the causes of and how to prevent oil spills, and how the equipment used to recover oil is designed to work.

Introduction

The intense media coverage of the *Exxon Valdez* oil spill in Prince William Sound greatly increased public awareness and concerns regarding the potential environmental impacts associated with large marine oil spills. As a result, Clean Seas, a Southern California-based oil spill cooperative, received a large number of inquiries regarding the organization and its capabilities to respond to a similar event. Such inquiries were from government agencies, local media (newspapers and television), public interest groups and educational facilities.

Although active education and information exchange programs with government and private groups were in place, Clean Seas did not find itself well equipped to handle inquiries from educational groups. To meet this specialized need, Clean Seas initiated the development of the Student's Education Program. The goal of this new program was to develop a package of interactive materials that could be sent to a school or interested group that demonstrates the principles of oil spill cleanup and how Clean Seas is organized to respond to an oil spill in its area of responsibility.

Program Components

The Student's Education Program for Oil Spill Preparedness was designed to provide information on:

The Clean Seas oil spill cooperative organization;

The potential causes and risk of oil spills in the marine environment;

The techniques available to contain and clean up oil spills; and

The equipment and resource information available to Clean Seas.

The program was designed with the idea of maximum flexibility. This allows each teacher to customize a classroom presentation at the level he or she feels is appropriate for the students. The program requires that the teacher familiarize themselves with the materials presented in the teacher's handbook. However, if additional assistance or instruction is required, Clean Seas is available to provide a demonstration at the school or a tour of Clean Seas facilities.

The Clean Seas Student's Education Program for Oil Spill Preparedness consists of the following items:

Teacher's handbook
20-minute videotape, entitled "Sentinels of the Sea"
Materials for a wall display
Classroom demonstration materials
Student's workbook

Teacher's Handbook. The teacher's handbook was designed to provide a somewhat detailed look at the Clean Seas organization and the types of information and resources used to prepare for and respond to an oil spill. The material is not intended to be used directly by the students; however, the teacher can select the topic and the level of detail desired. The handbook includes descriptive text and graphics which cover the following topics:

Clean Seas background and resources
Risk and historical causes of oil spills in the marine environment
Response techniques
Shoreline sensitivity and response considerations

Sentinels of the Sea. The videotape titled "Sentinels of the Sea" lasts approximately 20 minutes and discusses the role of Clean Seas in protecting the South Central California marine environment from a possible oil spill. The videotape provides a pictorial overview of the types of equipment used by Clean Seas, as well as a closer look at some of the oil and gas facilities located in the Santa Barbara Channel.

Wall Display. To aid children's understanding of oil and gas operations in the local area and where Clean Seas equipment is positioned, a wall display is provided. The materials include a map of the Clean Seas area of responsibility (this map depicts the locations of platforms and Clean Seas equipment storage locations); photographs of major pieces of Clean Seas response equipment; and several tables and graphics describing oil spill sources and causes.

These materials may be displayed in any format. It is suggested that the map be on display during the showing of the videotape and during any discussion to help show the locations of the facilities or equipment being discussed.

Classroom Demonstration. The demonstration handbook discusses the principles of containment boom, skimmers and sorbent materials and includes simple classroom demonstrations of this equipment. These demonstration materials include a scale model of a containment boom, several simple skimming devices, sorbent materials and a dispersing agent. Consisting of a plastic demonstration tank and reusable plastic tools, the classroom demonstration is designed to show the wide range of options available to remove oil from the water's surface. Again, the demonstrations can be customized to the level of detail the teacher wishes. It is recommended that these demonstrations be conducted by the teacher.

Student's Workbook. The last item included in the Student's Education Program for Oil Spill Preparedness is a workbook designed for the students to take home. This workbook asks simple questions related to the material presented in the videotape, wall display and classroom demonstration. Pictures are provided to remind the children of what they have seen and which can be colored if the children wish.

Program Development and Implementation

Once the initial materials were assembled, the program was reviewed by several independent teachers, including the Channel Islands National Marine Sanctuary's Los Marineros program coordinator. Response to the program was extremely favorable due to its timing with current events. Some questions were raised as to the complexity of some of the materials, but only minor revisions were made in the original draft. It is Clean Seas' intention to make additional revisions as new materials become available and when there is a better understanding of the program needs and grade level of individuals using this program.

Once the materials were completed, 10 copies of the program were prepared and packed into self-contained shipping packages. These packaged programs could then be mailed or shipped directly to the school requesting the program. These programs were distributed to local schools which had made previous inquiries regarding Clean Seas. During the *American Trader* oil spill off Huntington Beach, Calif., additional programs were prepared and sent to a number of schools requesting more information.

Conclusion

Since its creation, the Clean Seas Student's Education Program for Oil Spill Preparedness has been requested by over 20 educational institutions, including local schools, Sea World, the Monterey Bay Aquarium, and the California State Parks system. The program continues to be improved and expanded as new information becomes available.

Clean Seas hopes that this program will provide students with some new insights into one aspect of the complex issues of environmental safety. If you have any questions regarding this program, please contact Clean Seas, 1180 Eugenia Place, Suite 204, Carpinteria, Calif. 93013, (805) 684-3838, fax, (805) 684-2650.

Coastal and Estuarine Governance

MANAGEMENT OF ESTUARIES AND THEIR WATERSHEDS IN A NATIONAL SEASHORE CONTEXT

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Introduction

A recent development in coastal management is the recognition that land uses in watersheds affect water quality in adjacent estuaries. Throughout the 1970s and 1980s primary emphasis was placed on the control of point sources or pipe discharges through requiring increasing levels of treatment. In the 1990s, techniques for control of pollution of estuaries will expand to incorporate the management of land uses. The difficulty of instituting these substantial changes should not be underestimated. First, they imply a change from managing pipe discharges to managing certain activities on the land. Second, they require that this management of the landscape must occur in areas that are remote from the estuary to be protected.

These enormous challenges, while new to national programs in water pollution control, are not new to governance of natural resources in other circumstances. The purpose of this paper is to indicate the parallel nature of the problem identified above with that of park or seashore management. A second objective is to identify the types of solutions that have been applied in a coastal park setting on Cape Cod.

Several terms provide a bridge between these two areas of investigation in natural resource management. Both park management and estuarine management contain cross-boundary problems. Thus, the ecosystem in question is affected by or extends into lands or waters outside a boundary of the protected area (Schonewald-Cox, 1992). In this setting, the protected area, whether park or estuary, requires additional levels of control in nearby geographic regions.

In park management, the undesirable land manipulation is termed an external threat and consists of problems due to activities outside of park boundaries on public and private lands that threaten to degrade park resources (Conservation Foundation, 1985). Land uses outside of the park that produce water pollution within it are one of several external threats. This water pollution connection is the one most germane to this study.

In the jargon of estuarine water quality protection, nonpoint sources include everything that is not an effluent from a pipe, and in impaired estuaries 45 percent of the problem has been attributed to nonpoint sources (Whittington, 1988). The reauthorization of the Coastal Zone Management Act (1990) added Section 6217 on protecting coastal waters. This section urges states with approved coastal programs to plan for control of nonpoint sources. Subsequent National Oceanic and Atmospheric Administration (NOAA) and Environmental Protection Agency (EPA) activities under that section have identified runoff from agriculture, silviculture and urban lands, in addition to hydromodification and erosion, as primary issues to be considered (EPA, 1991).

To summarize, an estuarine water quality problem is a type of external threat that may be caused by nonpoint sources. The cross-boundary nature of the problem means that its solution requires that action be taken on lands that are not under direct control of the management entity responsible for the water body being impacted.

The Cape Cod National Seashore

Controlling external threats has been an issue before the National Park Service for many years. For coastal units such as Cape Cod external threats are due in some instances to nonpoint sources of pollution. The seashore, a unit of the National Park system, includes the well-known ocean-facing outer beach of Cape Cod. In addition and less well known are the many fresh and estuarine waters. Marine waters within one-half mile of the coast are also included, thereby extending management into nearby coastal waters (Cape Cod National Seashore, 1961). Thus, the protection of estuarine waters and their biota has been within the purview of the National Park Service for many years.

However, in most instances the seashore does not include all the land within watersheds that affect water quality in estuaries. Furthermore, even when a watershed is substantially encompassed by seashore boundaries, there may still be a number of inholdings or privately owned lands within the protected zone. Thus, external threats to water quality may be generated on private lands within park boundaries or from private lands within the watershed but outside of park boundaries.

The nature of the water quality issues in five estuarine systems in or adjacent to the seashore has recently been summarized (Burroughs and Lee, 1991). The major external threats to aquatic areas may be noted in a few categories. A primary threat to most of the systems is the lack of saline flows into what were formerly marsh areas. The Park Service does not control tide gates and must therefore negotiate with adjacent landowners, primarily state and local government, prior to changing these flows. In every instance, enhancement of the estuarine environment depends upon reaching an agreement about saline flows.

A second concern is eutrophication. The surface, groundwater, and/or atmospheric inputs of nutrients may be a factor in estuarine decline. In many instances, land use practices in or adjacent to the park have been identified. These practices include housing developments, solid or sewage waste disposal sites, and runoff, among other factors. A third category includes potential problems derived from marine or land spills of oil or other materials. Thus, the situation at the Cape Cod National Seashore embodies a variety of cross-boundary issues, including nonpoint source problems. Fortunately, in the establishment of the seashore a number of mechanisms were created that may address these kinds of problems.

Techniques for Managing Cross-Boundary Problems on Cape Cod

The National Seashore on Cape Cod was established through substantial purchase of private land. In this context the "Cape Cod formula" suspended the secretary's authority to condemn improved property in areas of a town covered by a zoning bylaw which had been approved by the secretary (Cape Cod National Seashore, 1961, Section 4 (b)(2)). In theory, some cross-boundary issues would be settled, not through federal purchase of adjacent land, but rather through local control of land uses in such a manner that the uses remained compatible with the protected status of the seashore. Its success in the park and seashore context is such that many units established after 1961 adopted similar provisions at their inception.

A second approach is the Advisory Commission (Cape Cod National Seashore 1961, Section 8). Composed of 10 members, the group had representatives from town, county, state and federal governments. Through the commission, the secretary consults about commercial, industrial and recreational land use within the seashore. Thus, activities within the protected area that might affect adjacent environments are discussed with regional representatives.

Many of the participants in the commission found it to be quite successful (Foster, 1985). The membership consisted of seashore supporters as well as opponents. In addition, representatives were drawn from towns, regional and state governmental entities. Eventually the Park Service developed a cooperative attitude toward the group, and local residents recognizing the seashore's inevitability chose to become actively involved in advisory activities.

Finally, groups interested in the goals of the seashore often participate as "friends." As such, citizens from the area may act constructively as advocates for the seashore and/or provide services for its operation.

The mechanisms outlined above created a way to address cross-boundary problems. Some could be resolved through condemnation or zoning while others might be approached through advisory mechanisms. These tools should be evaluated for their relevance to the design of institutional mechanisms for nonpoint source control in coastal areas. Furthermore, Park Service experience with the application of these tools in a variety of locations may be examined to ascertain their utility for nonpoint source control.

Conclusions

A recent analysis of external threats to Cape Cod National Seashore estuaries has demonstrated that water quality may be jeopardized by nonpoint sources. Frequently, these nonpoint sources are cross-boundary in origin. Thus, the land on which the pollution threat originates is not owned by the Park Service. It may be a private inholding within the seashore boundary or land adjacent to the seashore. As a result, effective management of estuarine water quality within the park may require coordination with land owners and users outside of the seashore boundary.

Revisions of the Coastal Zone Management Act calling for increased control of nonpoint sources from lands outside of the legally defined coastal zone in many states require federal and state governments to develop solutions to external threats similar to those confronted by the Park Service. A nonpoint source outside of the seashore boundary that affects water quality in estuaries within the boundary is analogous to the problem faced in implementing successful programs under the CZMA revisions. Numerous tools have been developed in the park/seashore setting to meet external threats. The tools used on Cape Cod include: condemnation, the Cape Cod formula, an Advisory Commission, and friends. Each should be evaluated for applicability and effectiveness in meeting nonpoint source control problems in the estuarine environment.

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A WETLAND/UPLAND LAND COVER CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSORS

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Abstract

A land cover classification system for wetlands, submerged ecosystems and uplands has been developed to satisfy the immediate needs of the National Oceanic and Atmospheric Administration Coastwatch Change Analysis Program (C-CAP) and several components of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). The classification system has the following attributes:

It is hierarchial with special consideration for unique characteristics of remote sensors and GIS;

It is a hybrid of the Anderson and Cowardin systems, minimizing the need to define new classes;

It emphasizes wetland, deepwater habitat and upland categories to meet special requirements of the C-CAP and EMAP programs;

The classes are defined in terms of land cover, avoiding land-use terms, to eliminate confusion and improve reliability of detection;

It is designed for use with satellite (TM, SPOT) data, yet capable of incorporating aircraft and field data at lower levels;

It is compatible with the National Wetlands Inventory (NWI), and other programs.

The system has been modified for more general land cover classification during meetings with representatives from U.S. Geological Survey, U.S. Fish and Wildlife Service, NOAA, EPA and other government agencies. Also, comments from

five NOAA regional workshops were incorporated into the classification development process.

Introduction

Coastal wetlands with emergent and submergent vegetation (saltmarshes, mangroves, macroalgae and submerged aquatic vegetation) support most marine finfish and shellfish resources in the coastal United States. Yet coastal wetlands are being destroyed by dredge-and-fill operations, impoundments, toxic pollutants, eutrophication, and, for submergents, excessive turbidity. Continued loss of these wetlands may lead to a collapse of coastal ecosystems and associated fisheries. Documenting losses and gains in coastal wetlands is critical to their conservation and to effective management of marine fisheries (Haddad and McGarry, 1989; Haddad and Ekberg, 1987). Such information is necessary to respond to the president's call for "no net loss of wetlands."

Current projections for U.S. population growth in the coastal zone suggest accelerating losses of wetlands and adjacent habitats, as waste loads and competition for limited space and resources increase (U.S. Congress, 1989). Agencies responsible for coastal management must be kept current with regard to extent and status of wetlands and adjacent uplands. Therefore, timely quantification of wetland area, location and rate and cause of loss is needed now (Kean et al., 1988). Management decisions can then be proactive and based on fact rather than supposition of the effects of coastal development on coastal wetlands and wetland-dependent fisheries.

Changes in wetlands are occurring too fast and too pervasively to be monitored only once a decade, as is presently being done by key federal and state programs. Therefore, the National Oceanic and Atmospheric Administration, within its Coastal Ocean Program, has initiated a cooperative interagency and state-federal effort to map coastal wetland and adjacent upland cover and change in the coastal region of the United States every two to five years and to monitor annually areas of significant change. The program is called the NOAA Coastwatch Change Analysis Program (C-CAP). Remote sensing (from satellites and aircraft) and other techniques will be used to quantify and map coastal wetlands and adjacent uplands. The first cycle will document status and change (retroactively). The database, increasing with each monitoring cycle will be an invaluable resource for research; evaluation of local, state and federal wetland management strategies; and construction of predictive models.

In the first year, the NOAA C-CAP program concentrated on protocol development and prototype studies in the Chesapeake Bay and coastal North Carolina. Through a series of workshops and working group meetings, a documented standard protocol for classifying and mapping habitat location, abundance and change in the U.S. coastal zone is being developed. A critical part of the protocol is the selection of a land cover classification system for wetlands and uplands that meets the needs of this and other programs.

Unfortunately, there is a multitude of classification schemes being used by federal, state and county agencies to inventory wetland and deepwater habitat. Some of these classification schemes differ to the point of making it impossible to cross-reference and exchange data between them. Also, the need for more frequent updates of wetland and deepwater habitat inventories is forcing mapping and change detection programs to make more efficient use of satellite and aircraft remote sensing data. Therefore, we have attempted to design a land cover classification system for use with remote-sensing data that would meet the needs of most wetland and deepwater habitat mapping programs.

Need for a Revised Classification System

Since the development and widespread use of remote sensing techniques, the Anderson land-use and land cover classification system (Anderson et al., 1976), or modified versions of it, have been used in numerous land-use mapping projects. This classification system includes only the more generalized first and second levels. The system satisfies the three major attributes of the classification process as outlined by Grigg (1965): it gives names to categories by simply using accepted terminology; it enables information to be transmitted; and it allows inductive generalizations to be made. The classification system is capable of further refinement on the basis of more extended and varied use. At the more generalized levels it meets the principal objective of providing a land-use and land cover classification system for use in land-use planning and management activities. Despite improvements resulting from widespread use of the system, the objective of providing a standardized system of land-use and land cover classification for national and regional studies has still not been attained.

A good overview of the historical development of wetlands classification systems can be obtained from Cowardin (1977). In 1974 the U.S. Fish and Wildlife Service began planning for a new National Wetland Inventory and after examination of the existing classifications decided to design a new one. The FWS's wetland classification system (Cowardin et al., 1979) was developed by a team of wetland ecologists with the assistance of local, state and federal agencies. After major revisions and extensive field testing, the Cowardin Classification System was officially adopted by FWS in 1980 (Wilen, 1990).

The structure used in the Cowardin Classification (Cowardin et al., 1979) is hierarchical and progresses from *provinces* at the most general level, to major *ecological systems* and *subsystems*, to *habitat classes*, *subclasses* and *orders*, and finally to the *habitat type*, which is formed by adding modifiers for water regime and water chemistry to the order. Where no orders have been defined, these same modifiers may be applied to classes or subclasses. Within each of the five ecological systems, the same parameters are not always used at the same level. Although consistency is conceptually appealing, it is not always ecologically meaningful or, in some cases, even possible. For example, marine and estuarine systems are subdivided on the basis of tidal inundation, whereas the riverine system is subdivided first on the basis of stream gradient, water velocity, stream bed composition and presence or absence of a floodplain.

Some county, state and federal programs map uplands using the Anderson classification system and use the Cowardin system for the wetlands. Modifying and combining classification systems for special applications has been quite common, particularly at the state and local levels. A good example is Florida, which has at least half-a-dozen different schemes used by its counties and other agencies. As a result, much time and money are wasted in duplicate data collection efforts.

Proposed Classification System

The proposed wetland and land cover classification system for use with remote sensing data is shown in Table 1. The system is a hybrid of the Anderson and Cowardin classification systems with some modifications to accommodate remote sensing data and the unique requirements of the C-CAP and EMAP programs. Since these programs concentrate on wetlands, submerged ecosystems and adjacent uplands, we divided the hierarchial system at the top into three superlevel (Level 0) categories. These are shown in Table 1 as *uplands*, *wetlands*, and *water and submerged land*. All remote sensors can discriminate these three categories.

Level 1 classes were chosen to be similar to the Level 1 classes in Anderson et al., 1976. At Levels 2 and 3 the *upland* classes still resemble the Anderson system with some significant modifications, including an emphasis on land cover instead of land use. The Level 2 and 3 classes for *wetlands* and *water and submerged lands* are based on the Cowardin scheme, which is more ecologically oriented.

Although land-use data obtained at any level should not be restricted to any particular user groups nor to any particular scale of presentation, information at Levels 1 and 2 in general would be of interest to users who desire data on a nationwide, interstate or statewide basis. More detailed land-use and land cover data, such as those categorized at Levels 3 and 4, usually will be used more frequently by those who need local information at the intrastate, regional, county or municipal level. At this time we decided not to develop a more detailed breakdown of classes beyond Level 3. At Levels 4 and 5, each program is likely to have its own unique needs, and attempting to make a universally acceptable breakdown of classes at those levels would be doomed to failure.

Uplands

The Level 1 classes for *upland* are similar to the Level 1 classes in the Anderson system, except that land-use terms were excluded (e.g., *agricultural land*, *rangeland*, etc.) and replaced by land cover designations (Anderson et al., 1976). *Rangeland* was replaced by *grassland* to ensure that no shrub-brushlands were included. A new category, *woody*, was formed to include both trees and shrubs. This was done in part to alleviate the problem of separating various sizes of trees and shrubs with satellite remote sensors and allowing that separation to be done at a lower level where *forest* (*treeland*) and *shrub* (*shrubland*) are shown as separate categories that can be distinguished by airborne remote sensors.

The *developed* and *exposed land* Level 1 categories are somewhat similar to the Anderson *urban or built-up land* and *barren land* classes, respectively. For instance, *exposed land* is land of limited ability to support life and in which less than one-third of the area has vegetation or other cover. In general, it is an area of thin soil, sand or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the *shrub* category. Unusual conditions, such as a heavy rainfall, occasionally result in growth of a short-lived, more luxuriant plant cover. Wet, nonvegetated exposed lands are included in the wetland categories.

Land may appear barren because of human activity. When it may reasonably be inferred from the data source that the land will be returned to its former use, it is not included in the *exposed* category but classified on the basis of its site and situation. Cultivated land, for example, may be temporarily without vegetative cover because of cropping season or tillage practices. Similarly, industrial land may have waste and tailing dumps, and areas of intensively managed forest land may have clearcut blocks evident. When neither the former nor the future use can be discerned and the area is obviously in a state of land-use transition, it is considered to be *exposed land*, in order to avoid inferential errors.

Some of the Level 2 classes differ so significantly from those of the Anderson system, that brief definitions will be provided here. *High intensity developed land* refers to heavily built-up urban centers. Concrete and asphalt with significant land area covered by very little vegetation occur in these areas. *Low intensity developed land* refers mainly to single family housing areas that contain landscaped and vegetated areas around the buildings.

Unmanaged grassland encompasses lands dominated by naturally occurring grasses and forbs. *Managed grasslands* are areas in which human activity has an influence in maintaining the area. Examples of these areas are yards, golf courses, forest or shrub areas converted to grassland, or areas of permanent grassland in which man has changed the natural species composition. This category includes pastures that contain vegetation that grows as fallow. Pastures are used for grazing activities, such as farmland maintained as grassland, or are used for growing and harvesting of hay, straw and kept fallow for future animal feeding. Detailed definitions of all classes and subclasses in Table 1 are being prepared by the authors in a separate document.

Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water (Cowardin et al., 1979).

The upland limit of wetland is designated as: the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover; the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or in the case of wetlands without vegetation or soil, the boundary between land that is flooded or saturated at some time during the growing season each year and land that is not.

The wetlands breakdown at Levels 2 and 3 is closely related to the Cowardin system (Cowardin et al., 1979). Level 2 includes Cowardin's five major systems, i.e. marine, estuarine, riverine, lacustrine and palustrine (Table 1). However, we have used Cowardin's subsystem designators (e.g., intertidal, tidal, etc.) as modifiers of our Level 2 categories. The main reason why we used Cowardin's subsystem designators (intertidal, tidal, etc.) as modifiers rather than using them as a separate level (e.g., Level 3) was that we did not want to relegate the classes describing the bottom and vegetation types to Level 4. Cowardin's subsystem layers are also nearly impossible to detect by remote sensing.

Furthermore, all vegetated or bare surfaces that are subtidal or have a continuously submerged substrate have been moved into the *water and submerged* *land* superclass (Level 0). As a result, the Level 2 categories for "wetlands" become *marine (intertidal), estuarine (intertidal), riverine (tidal, lower perennial, upper perennial, intermittent, and unknown perennial), lacustrine (littoral)* and *palustrine (wetland)*. At Level 3 we differentiate the various bottom, shore and wetland types following closely the scheme proposed by Cowardin at his "class" level. Thus *estuarine (intertidal)* breaks down at Level 3 into *aquatic bed, reef, streambed, rocky shore, unconsolidated shore, emergent wetland, scrub/shrub wetland,* and *forested wetland.*

The definition of Level 3 classes is identical to those in Cowardin et al. (1979). Six classes are based on substrate and flooding regime: *rock bottom* with a substrate of bedrock, boulders, or stones; *unconsolidated bottom* with a substrate of cobbles, gravel, sand, mud, or organic material; *rocky shore* with the same substrates as *rock bottom*; *unconsolidated shore* with the same substrates as *unconsolidated bottom*; *streambed* with any of the substrates; and *reef* with a substrate composed of the living and dead remains of invertebrates (corals, mollusks or worms). The bottom classes are flooded all or most of the time and the shore classes are exposed most of the time. The class *streambed* is restricted to channels of intermittent streams and tidal channels that are dewatered at low tide. The life form of the dominant vegetation defines the five classes based on vegetative form: *aquatic bed,* dominated by plants that grow principally on or below the surface of the water; *moss-lichen wetland,* dominated by mosses or lichens; *emergent wetland,* dominated by emergent herbaceous angiosperms; *scrub-shrub wetland,* dominated by shrubs or small trees; and *forested wetland,* dominated by large trees.

Water and Submerged Land

Traditionally, the concept of wetland had not included the ocean or the deeper areas of lakes, rivers and estuaries. These places, however, are ecologically inseparable from the typical shallow wetlands that border them. The Cowardin classification defines subtidal coastal areas as deep-water habitats.

The boundary between wetland and deepwater habitat in the marine and estuarine systems coincides with the elevation of the extreme low water of spring tide; permanently flooded areas are considered deepwater habitats in these systems. The boundary between wetland and deepwater habitat in the riverine and lacustrine systems lies at a depth of 2 m (6.6 feet) below low water; however, if emergents, shrubs or trees grow beyond this depth at any time, their deepwater edge is the boundary. The 2-m lower limit for inland wetlands was selected because it represents the maximum depth to which emergent plants normally grow.

At first we attempted to separate *water and submerged land* into two Level 0 superclasses. However, it seemed to be more logical and intellectually satisfying to lump the two classes together at Level 0, especially since the cover in each case is water (Table 1). Also, strictly speaking, there is no such thing as bottomless water.

At Levels 2 and 3 we again relied heavily on the Cowardin system. The Level 2 classes consist of Cowardin's "system" categories with their appropriate modifiers. They include *marine (subtidal), estuarine (subtidal), riverine (tidal), riverine (lower perennial), riverine (upper perennial), riverine (unknown perennial)* and *lacustrine (limnetic)*. As shown in Table 1, at Level 3 we use Cowardin's class categories. Thus for *estuarine (subtidal)* the Level 3 breakdown consists of *rock bottom, unconsolidated bottom, aquatic bed, reef* and *open water.*

At first glance, the close adherence to the Cowardin scheme seems to introduce much repetition, e.g., there are four Level 2 *riverine* classes under *water and submerged land*, causing the same Level 3 categories to be repeated four times. This apparent repetition is, however, the price we must pay if we wish to use map data from other programs, such as the NWI, which are based on the Cowardin system. At a minimum, we have to be able to crosswalk between different programs.

Conclusions

A land cover classification system for wetlands, submerged ecosystems and uplands has been developed which has the following attributes:

It is hierarchial with special consideration for unique characteristics of remote sensors and geographic information systems (GIS);

It is a hybrid of the Anderson and Cowardin systems, minimizing the need to define new classes;

It emphasizes wetland, deepwater habitat and uplands categories to meet special requirements of the C-CAP and EMAP programs;

The classes are defined in terms of land cover, avoiding land use terms, to eliminate confusion and improve reliability of detection;

It is designed for use with satellite (TM, SPOT) data, yet capable of incorporating aircraft and field data at lower levels;

It is compatible with the National Wetlands Inventory (NWI), and other programs.

The proposed classification system was designed to be useful to resource managers and researchers for studying and inventorying primarily wetlands, deepwater habitats and adjacent uplands. Therefore, at the top the entire system is divided into *uplands, wetlands* and *water and submerged lands.* Most of the *uplands* categories are identical or similar to the ones used and defined in Anderson et al. (1976). On the other hand, the *wetland* and *water and submerged land* categories are similar to those defined by Cowardin et al. (1979). All classes in the proposed classification system are uniquely defined and the system as a whole meets most of the classification criteria outlined by Anderson et al. (1976). A report containing definitions of all classes and subclasses used in the proposed system is being prepared by the authors.

We fully realize that the breakdown of the *upland* classes may not be detailed enough for other, non-wetland-oriented programs. Therefore we hope to modify our uplands classification scheme in the future to accommodate the needs of land use and land cover mapping programs being conducted by the U.S. Forest Service, the U.S. Soil Conservation Service, the Bureau of Land Management, and other programs concerned with arid lands, grasslands, etc. Specifically, we plan to test our ability to "crosswalk" from our land cover categories to those contained in systems used by other programs such as the U.S. Fish and Wildlife Service Gap Analysis Program, the Natural Resources Inventory, and the State Natural Heritage Programs. We will also determine our compatibility with global classification systems being developed by United Nations agencies.

The classification system was developed during joint meetings with representatives from various government agencies, including USGS, EPA, NOAA, USFWS, etc. Also, comments from five regional workshops were incorporated into the classification development process. We believe that as a result of these workshops and planning meetings, we have produced a practical classification system for inventorying and studying changes in wetlands, deepwater habitats and adjacent uplands not only for NOAA's C-CAP and EPA's EMAP programs but also for other programs at the national and state level.

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Table 1. Modified wetland/upland land cover classification system for use with remote sensor data.

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Upland	1.0 Developed (solid cover)	1.1 High intensity	1.11 Residential
			1.12 Commercial
			1.13 Industrial
			1.14 Transportation, communications and utilities
		1.2 Low intensity	1.21 Residential
			1.22 Commercial
			1.23 Industrial
			1.24 Transportation, communications and utilities
			1.25 Rural development
	2.0 Cultivated land	2.1 Woody	2.11 Orchards/groves
			2.12 Vine/bush
		2.2 Herbaceous	2.21 Cropland
	3.0 Grassland (herbaceous)	3.1 Herbaceous	3.11 Unmanaged
			3.12 Pasture
			3.13 Groomed
	4.0 Woody	4.1 Deciduous	4.11 Forest
			4.12 Shrub
		4.2 Evergreen	4.21 Forest
			4.22 Shrub
		4.3 Mixed	4.31 Forest
			4.32 Shrub

Table 1 (continued). Modified wetland/upland land cover classification system for use with remote sensor data.

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Upland, cont.	5.0 Exposed land	5.1 Soil	5.11 Transitional developed
		5.2 Sand	5.21 Beach/dune complex
			5.22 Sandy, other than beach/dune complex
			5.23 Extraction pits
		5.3 Rock	5.31 Outcrops
			5.32 Quarries/mines
			5.33 Unconsolidated
		5.4 Evaporite deposits	5.41 Dry salt flats
	6.0 Snow and ice	6.1 Snow and ice	6.11 Perennial snowfields
			6.12 Glaciers
Wetland	7.0 Wetland (intertidal)	7.1 Marine	7.11 Aquatic bed
			7.12 Reef
			7.13 Rocky shore
			7.14 Unconsolidated shore
		7.2 Estuarine (intertidal)	7.21 Aquatic bed
			7.22 Reef
			7.23 Streambed
			7.24 Rocky shore
		7.2 Estuarine (intertidal),cont.	7.25 Unconsolidated shore
			7.26 Emergent wetland
			7.27 Scrub/shrub wetland
			7.28 Forested wetland

Table 1 (continued). Modified wetland/upland land cover classification system for use with remote sensor data.

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Wetland, cont.	7.0 Wetland (intertidal),cont.	7.3 Riverine (tidal)	7.31 Rock bottom
			7.32 Unconsolidated bottom
			7.33 Streambed
			7.34 Aquatic bed
			7.35 Rocky shore
			7.36 Unconsolidated shore
			7.37 Emergent wetland
			7.38 Open water
		7.4 Riverine (lower perennial)	7.41 Rock bottom
			7.42 Unconsolidated bottom
			7.43 Aquatic bed
			7.44 Rocky shore
			7.45 Unconsolidated shore
			7.46 Emergent wetland
			7.47 Open water
		7.5 Riverine (upper perennial)	7.51 Rock bottom
			7.52 Unconsolidated bottom
			7.53 Aquatic bed
			7.54 Rocky shore
			7.55 Unconsolidated shore
			7.56 Open water
		7.6 Riverine (intermittent)	7.61 Streambed

Table 1 (continued). Modified wetland/upland land cover classification system for use with remote sensor data.

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Wetland, cont.	7.0 Wetland (intertidal), cont.	7.7 Riverine (unknown perennial)	7.71 Rocky
			7.72 Unconsolidated bottom
			7.73 Aquatic bed
			7.74 Rocky shore
			7.75 Unconsolidated shore
			7.76 Emergent
			7.77 Open water
		7.8 Lacustrine (littoral)	7.81 Rock bottom
			7.82 Unconsolidated bottom
			7.83 Aquatic bed
			7.84 Rocky shore
			7.85 Unconsolidated shore
			7.86 Emergent
			7.87 Open water
		7.9 Palustrine (wetland)	7.91 Rock bottom
			7.92 Unconsolidated bottom
			7.93 Aquatic bed
			7.94 Unconsolidated shore
			7.95 Moss-lichen
			7.96 Emergent
			7.97 Scrub/shrub
			7.98 Forested
			7.99 Open water

Table 1 (concluded). Modified wetland/upland land cover classification system for use with remote sensor data

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Water and submerged land	8.0 Water and submerged land	8.1 Marine (subtidal)	8.11 Rock bottom
			8.12 Unconsolidated bottom
			8.13 Aquatic bed
			8.14 Reef
			8.15 Open water
		8.2 Estuarine (subtidal)	8.21 Rock bottom
			8.22 Unconsolidated bottom
			8.23 Aquatic bed
			8.24 Reef
			8.25 Open water
		8.3 Riverine (tidal)	8.31 Rock bottom
			8.32 Unconsolidated bottom
			8.33 Aquatic bed
			8.34 Open water
		8.4 Riverine (lower perennial)	8.41 Rock bottom
			8.42 Unconsolidated bottom
			8.43 Aquatic bed
			8.44 Open water
		8.5 Riverine (upper perennial)	8.51 Rock bottom
			8.52 Unconsolidated bottom
			8.53 Aquatic bed
			8.54 Open water
		8.6 Riverine (unknown perennial)	8.61 Rock bottom
			8.62 Unconsolidated bottom
			8.63 Aquatic bed
			8.64 Open water

Table 1 (concluded). Modified wetland/upland land cover classification system for use with remote sensor data

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Water and submerged land, cont. Open water	8.0 Water and submerged land, cont.	8.7 Lacustrine (limnetic)	8.71 Rock bottom 8.72 Unconsolidated bottom 8.73 Aquatic bed 8.74

THE COASTAL WETLANDS PLANNING, PROTECTION AND RESTORATION ACT

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Introduction

Across the nation coastlines are in trouble. This is true on the East Coast, the West Coast, and the Gulf Coast, but nowhere is it more true than along the Louisiana coast. It is in Louisiana that 80 percent of the annual national loss of coastal wetlands is occurring. Each year 31 square miles of Louisiana's coastal wetlands convert to open water. Unless something is done, it is estimated that over the next 50 years one-half of this unique ecosystem will disappear.

Loss of these wetlands imposes an immense environmental and economic hardship on the coastal area. The bounty produced by these wetlands, some 30 percent of the nation's total harvest of commercial seafood, has a value annually of $850 million. Louisiana produces more wild fur and hides than any other state in the nation with an estimated current value of $19 million per year. Louisiana's coastal wetlands are located at the southern end of the great Mississippi Flyway. Annually 4 million ducks and geese, some 66 percent of the waterfowl that use that flyway, spend the winter in the Louisiana coastal marshes. Over 3 million man-days of hunting, valued at over $10 million, is directly attributable to these wetlands. In addition to this direct economic loss, the loss of Louisiana's coastal wetlands threatens a way of life and a culture unique to this area, but important to the world.

Why are these wetlands disappearing? No one cause can be singled out as the culprit. Coastal processes are far too complex to permit such an easy answer. Each force, both natural and human induced, acts synergistically with the other forces intensifying and accelerating the affects. Some causes which are natural—sea level rise, subsidence, compaction, salt water intrusion, and erosion have caused significant changes in the relative land and water surface elevations. While these natural forces are important, man's actions have played and continue to play a major role in causing the loss of Louisiana's coastal wetlands. Flood control works such as leveeing of the Mississippi River and cutting off this source of sediments for the coastal area have had a major role as have activities relative to the production, exploration, and development of the oil and gas industry in the area. These economic development activities interact with and intensify the natural processes resulting in the continuation of the coastal wetland losses. As these wetlands are lost the Gulf of Mexico estuarine dependent fishery will decline. Over the next 50 years it is expected that the recreational and commercial fish and wildlife harvest will be down about 70 percent. The impact on the economy will be a $274 million annual loss. Over that same time period an estimated $300 million in wetlands real estate would erode into the Gulf of Mexico. Navigation canals, hurricane protection levees, Federal and state highways, railroads, pipelines, utility and telephone lines would all have to be relocated. These would add many millions of dollars to the already devastating economic effects caused by the erosion of Louisiana's coast.

Attempted Solutions

While there has not yet been a well-coordinated plan for the preservation of Louisiana's coastal marshes, there have been numerous attempts by both the private and the public sectors. These have met with limited success in some cases, great success in other cases, and no success in still others. On the private side oil companies have had success in armoring some of the barrier islands and in preventing erosion along some oil field canals. In the agricultural sector, mixed results been obtained through the development of numerous marsh management plans. In the public sector, the Corps of Engineers has had several projects that deal directly with coastal erosion. The Corps has developed a fresh water diversion plan to move fresh water from the Mississippi River to the adjoining coastal marshes that have been cut off from their source of fresh water by the Mississippi River levees. These projects consist of diversion structures through levees and outfall canals to convey the water to where it's needed. Three structures, one at Bonnet Carré, one at Davis Pond, and one at Caernarvon, form the nucleus of this plan. The Caernarvon structure is completed and is operating successfully. The structures at Bonnet Carré and Davis Pond are in the final stages of design and are expected to come on line in the not too distant future. Creating new wetlands is another technique that the Corps has used to offset coastal wetland losses. Two methods are used to create wetlands, strategically placing dredged material and diverting riverine sediments. In conjunction with the Corps' navigation projects, over 3,000 acres of wetlands have been created. In addition, riverine sediments have been diverted in a number of small locations along the distributaries of the Mississippi River to create mini-deltas. Through the Corps Section 404 permitting process, attempts are made to minimize the impact of private development on the coastal wetlands. All of the efforts, however, pale in comparison to the overall wetland loss problem.

A New Approach

The lack of a comprehensive plan has been a major hindrance to making any real progress in the problem of coastal wetlands losses and clearly a new strategy is needed. The Coastal Wetlands Planning, Protection and Restoration Act signed into law on November 29, 1990, is that new strategy. The purpose of this act is to ensure the long-term conservation of coastal wetlands throughout the nation. Special emphasis, however, is placed on Louisiana's coastal wetlands because of their rapid and extensive loss and their value to the nation as a whole. The Act is expected to provide approximately $175 million in federal funds within coastal Louisiana between October 1991 and October 1996. The Act establishes the Louisiana Coastal Wetlands Conservation and Restoration Task Force which consists of six members: the secretary of the Army, the administrator of the Environmental Protection Agency, the governor of Louisiana, the Secretary of the Interior, the Secretary of Agriculture, and the Secretary of Commerce. The task force is chaired by the Secretary of the Army and is responsible for the planning and implementation of a comprehensive array of coastal wetland restoration projects in Louisiana. By November 28, 1993, the task force is to prepare a comprehensive coastal wetlands restoration plan for Louisiana. That plan will consist of a list of wetland projects ranked by cost effectiveness and wetland quality. Recognizing the severity of the problem and the need for immediate action, the Act includes a provision for the preparation of a list of priority projects. The construction of these projects is to be started as soon as possible and the projects must be essentially complete within five years. These projects must also fit in well with the long-term restoration plan that is to be completed at the end of the third year of activity under the bill. The Act provides that cost-sharing for the restoration plan shall be 75 percent federal and 25 percent local. If however the state prepares a conservation plan to further regulate coastal wetlands usage, the cost-sharing under the Act would change to 85 percent federal and 15 percent local. Thus far the state of Louisiana has not initiated work on that conservation plan.

The Act further provides matching grants to develop wetland conservation projects in states other than Louisiana. These projects would generally follow the same criteria as applied to those projects in the Louisiana portion of the bill. The Act is funded by monies collected in the Small Engine Gasoline Tax Fund. This fund is administered by the Department of the Interior. It is currently estimated that approximately $35 million per year will be available. Funding in the act is set for five years total. Of the roughly $35 million available each year, $5 million is to be used for planning and development of the projects and the remaining money for the construction and operation of the projects. Seventy percent of the funds collected is to be used for projects in the Louisiana coastal wetlands area, 15 percent is to be used for projects in the other states, and the remaining 15 percent is to be used to further the North American Wetlands Conservation Act. Including state funds, it is estimated that the Act will provide well over $40 million per year for the construction and operation of coastal wetlands projects in Louisiana.

Organization

As stated earlier, the Act is administered by a task force with representatives from the five federal agencies and the state. This task force is the policy-making group and provides overall leadership and guidance in development of the program. Day-to-day activities are conducted under the auspices of a Technical Committee, again chaired by a representative of the Corps of Engineers with representatives from each of the other federal and the state agencies. This committee's mandate is to ensure that the projects are developed on schedule and within budget. Subordinate to the Technical Committee are several other working groups that are specialized in nature. The Planning and Evaluation Group is responsible for the actual detailed development and evaluation of the projects. That group plans the overall concepts of the projects and develops the economics, both the costs and the benefits, that would be attributable to each. There is a Monitoring Group whose purpose is to develop monitoring techniques to comply with that section of the Act that requires that each project be evaluated every three years to see that it is in fact performing as it is designed. This is a very important feature of the Act, because many of the projects are at the edges of the state of the art in coastal work. Many of the projects that will be built, particularly in the early stages, will be experimental in nature and will be investigating ways to better and more economically preserve coastal marshes. There is also an Engineering Work Group whose job it is to do the engineering design of the projects and to ensure consistency across the various types of projects that are developed by the several agencies involved. An Environmental Work Group has been tasked to develop the environmental impacts of the projects and to develop the National Environmental Protection Act compliance documents. Our intent is to prepare a programmatic environmental impact statement covering the entire process and then to supplement that for each individual project with an environmental assessment and a finding of no significant impact.

Also included in the organization plan is a Citizens Participation Group. This group has as its membership representatives of all of the user groups, environmental groups and resource groups interested in the coastal area. One of the principal reasons that prior attempts at saving the coastal marshes have not always succeeded is that comprehensive citizen involvement has been lacking. It is the intent of this Act to ensure that every interest group and every individual who has an idea that could be developed into projects to preserve the coastal area is heard and to afford everyone the opportunity to be a participant in this process. Clearly, all of the expertise in coastal engineering and coastal preservation does not rest in the federal and state agencies involved. The Citizens Participation Group has been very active, and they continue to provide a valuable service that is not available through any other forum. While not directly a part of the organization plan, the organization includes a mechanism for involving the scientific community in the projects. Again one of the major shortcomings of prior attempts at comprehensive looks at coastal preservation was a lack of real scientific involvement. Louisiana is blessed with having several great universities, all of which are deeply involved in research dealing with coastal preservation. Through a contractual arrangement with the Environmental Protection Agency, a scientific advisor-coordinator has been hired whose job it is to work with the universities in the state to coordinate research and to find and develop means of applying that research to the projects undertaken. This shows great possibility for having a payoff well beyond its cost.

First Year's Priority List

On November 28, 1991, Senator John Breaux, the major sponsor of the bill, held a press conference to announce the results of the first year's work. The task force recommended 14 projects for immediate implementation. Table 1 shows the ranking of the projects based on their cost per habitat unit. It also gives a ranking of the projects by type, showing the lead task force member, the cost per habitat unit, and the fully funded cost over the life of the project which includes construction as well as future operation and maintenance, and monitoring. These projects include marsh building through sediment diversion, water management plans, marsh building with dredged sediments, structural shoreline erosion control, restoration work on barrier islands, and vegetative planting demonstration projects. The projects were all evaluated on a cost per habitat unit basis. The costs used were life cycle costs and include the construction cost, the interest during construction, the annual operations and maintenance cost, and the monitoring cost. All of these costs were put on a present worth basis and amortized over the 20-year anticipated life of the project. On the benefit side, to determine the amount of habitat units that would be affected so that a cost per habitat unit could be developed, a modification of the U.S. Fish and Wildlife Service's habitat evaluation procedure (HEP) was used. This evaluation process has been designated the Wetland Value Assessment. The Wetland Value

Assessment operates under the assumption that optimal conditions for coastal wetlands can be characterized and that any existing or predicted conditions can be compared to that optimum to provide an index of wetland quality. The quality component of a wetland is expressed through the use of a mathematical model developed specifically for each wetland type. Models were developed for fresh marsh, brackish marsh and saline marsh. Each model consists of: a list of variables that are considered important in characterizing the particular wetland type; a suitability index graph for each variable which defines the assumed relationship between wetland quality and that variable; and a mathematical formula that combines the quality value, known as a suitability index, for each variable into a single overall value for wetland quality. That single value is referred to as the habitat suitability index. An example of a habitat suitability index for a fresh marsh, as well as a definition of the variables involved, is given in Figure 1.

This first priority list illustrates an interesting combination of projects resulting from an even more interesting combination of agencies and individuals involved in their development. The construction agencies involved—the Corps of Engineers and Soil Conservation Service—tended to be very practical in their approach, very pragmatic in developing projects using fairly proven technology and rather simplistic construction techniques. The nonconstruction agencies were less constrained in developing projects and tended to be a little more experimental in nature, such as the barrier island proposal by the Environmental Protection Agency and the proposals by the National Marine Fishery Service. The final result was a combination of projects varying from the interesting to the mundane, from the inexpensive to the very expensive, and from the proven technology to the experimental. Therein lies one of the strengths of this bill: it combines both the practical engineering capabilities of the construction agencies with the free thinking approach of those agencies who are more interested in results with rather than how to accomplish them. This approach which will continue throughout the operation of this Act will likely be proven to be one of the strengths that was clearly built in by the crafters of this bill.

Current Operations

While all of the participants recognized that there would be, over the years, a changing of the guard in all of the federal and state agencies, an unanticipated event occurred early on that had a major impact on the development of the plans. Louisiana had an election. Historically in Louisiana, it has been almost impossible to defeat an incumbent governor. This year's election had three major players: the existing governor, Buddy Roemer, a Democrat recently converted to the Republican party; a former governor, Edwin Edwards, who has a history of colorful involvement in state government including several indictments, but no convictions; and finally David Duke, former leader of the Ku Klux Klan, who was running on a very conservative approach to government. Louisiana has an open primary system where all candidates run regardless of party in the same primary and then the top two vote-getters face each other in the run-off. While Gov. Roemer was not the most popular governor Louisiana has ever had, conventional wisdom anticipated that the final run-off would include Gov. Roemer and one of the other two candidates. After the first primary it became a choice of former Gov. Edwards or David Duke. What this meant to the Wetlands Act was that an entirely new slate of players would likely be involved from the state's side after the election. Former Gov. Edwin Edwards was elected in the second primary and became governor in January of this year. He immediately appointed an entirely new slate of state secretaries to various departments including the Department of Natural Resources, a major player in this Act. He also appointed a new governor's assistant for environmental affairs who represents the state of Louisiana on the task force. Fortunately, he chose someone who had been involved to some extent with the program prior to the election. So what could have been a real disaster for the program was averted.

Currently, the second year priority list is being prepared concurrently with the development of the restoration plan. The coastal area has been subdivided into nine individual hydrologic basins and separate plans are being developed for each of those subbasins. A basin captain has been selected for each basin. His duty will be to draw together the plan for that basin. These captains have come from the various federal and state agencies involved and they will work closely with the Engineering and Environmental Work Groups as well as the Planning and Evaluation Subcommittee to develop plans for each basin that will be complimentary in forming the restoration plan for the entire coastal area. Work is being closely coordinated with the Louisiana legislature since that body has to approve state participation in each of the projects. It is also being closely coordinated with the public through the Citizen Participation Group. The importance of both of these coordination efforts cannot be overemphasized. If a program is going to be developed to have a major impact on the future of Louisiana's coastal marshes, that program is going to have to enjoy the support of the elected officials of the state as well as the people in the affected areas.

The Future

Where do we go from here? In the short term the Act will provide five years of funding to develop the plan, and to build and operate projects to restore and preserve Louisiana's coastal marshes. The restoration plan which is being developed will likely have a four-tiered approach: first, it will include projects that can be built immediately; secondly, projects that have been evaluated and found to be good projects, but that need further detailed design; third, it will list projects that appear to be meritorious but that need additional study. These will be recommended for further study to possibly be developed at a later date. Finally, the fourth phase will be projects that are purely conceptual at this time. There is little chance that a program of five years duration will reverse the trends that are occurring in the coastal Louisiana marshes. It is going to take a much longer-term program and a far greater commitment of resources to bring about major changes. This program, this restoration plan, will include a vision for the future describing in very general terms what that commitment has to be. While it is recognized that major strides will be made in the next five years, it is also recognized that if the marshes of coastal Louisiana are important to this nation and are important to the world then a commitment must be made for their permanent restoration. It is anticipated that a program will be recommended, through continued funding, that will do just that. It is a big project; it is an important project. It is the first time that the resource agencies and the construction agencies have worked so closely in Louisiana toward a common goal. This Act is just the beginning.

Table 1. Ranking of projects by type.

Priority	Task Force Ranking	Lead per Member*	Cost ($) Cost AAHU**	Fully Funded ($1,000s)
Marsh Building with Sediment Diversion				
West Bay sediment diversion	8	AR	305	8,517
Water Management (Hydrologic Restoration)				
Fourchon	1	CO	21	252
BA-2 (GIWW to Clovelly)	2	AG	68	8,142
Cameron Creole Watershed	3	IN	128	502
Bayou Sauvage Refuge	4	IN	180	1,105
Lower Bayou La Cache	10	CO	837	1,254
Marsh Building with Dredged Sediments				
Barataria Bay Waterway	9	AR	518	1,625
Bayou La Branche	11	AR	2,369	4,327
Shoreline Erosion Control with Structures				
Turtle Cove	5	IN/LA	194	386
Sabine Refuge	6	IN	253	4,844
Cameron Prairie Refuge	12	IN	3,171	1,111
Vermilion River Cutoff	13	AR/LA	6,196	1,523
Barrier Island Restoration with Dredged Sediments				
Eastern Isle Derniers	16	EPA	13,949	6,345
Demonstration Project				
Vegetative plantings	7	AF	282	848

* The lead task force member (federal sponsor) for the project, represented by the following acronyms: *CO*, U.S. Department of Commerce; *LA*, State of Louisiana; *AG*, U.S. Department of Agriculture; *AR*, U.S. Department of the Army; *IN*, U.S. Dept. of the Interior; *EPA*, Environmental Protection Agency.

** Average annual habitat units.

Figure 1. Wetland value assessment community model for a fresh marsh.

Vegetation

Variable V_1 — Percent of wetland area covered by emergent vegetation (≥10% canopy cover).

Variable V_2 — Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.

Interspersion

Variable V_3 — Marsh edge and interspersion.

Water Depth and Duration

Variable V_4 — Water duration in relation to marsh surface.

Variable V_5 — Open water depth in relation to marsh surface.

Water Quality

Variable V_6 — Mean high salinity during the growing season (March through November).

Aquatic Organism Access

Variable V_7 — Aquatic organism access.

HSI Calculation

$HSI = (SI_{V1}^{3} \times SI_{V2}^{2} \times SI_{V3} \times SI_{V4} \times SI_{V5} \times SI_{V6} \times SI_{V7})^{1/10}$

The National Estuary Program: A Success Story in the Making

DEVELOPING A COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN: A CASE STUDY OF SARASOTA BAY

Mark Alderson
Sarasota Bay National Estuary

Introduction

From the few fishermen who populated the coastline 200 years ago, today's Sarasota Bay community has increased to almost a half-million people.
The comfortable climate, relatively low cost of living, absence of a state income tax and low property tax rate in most parts of the state compared to elsewhere in the nation attract an estimated 900 new residents to Florida each day. The Sarasota Bay basin has been one of the fastest growing regions in one of the fastest growing states in the nation—an estimated 32 people per day have moved into the bay area each year since 1980.

The total population of the bay area (Manatee and Sarasota counties) is currently estimated at 425,400 (187,400 in Manatee County and 238,000 in Sarasota County). By 2000 that combined population is expected to increase by approximately 25 percent, to 513,900 (209,000 in Manatee County, 304,900 in Sarasota County). Predictions of population growth into the next century point to continued increases, with accompanying increases in demand for the area's services and potential stresses on Sarasota Bay's resources.

Physical Description of the Bay

Sarasota Bay is located in southwest Florida, south of Tampa and north of Venice. Flanked by a chain of barrier islands, the bay is approximately 56 miles long, with widths ranging from 300 feet in the southern portion of the bay near Venice, to 4.5 miles north of Sarasota. The watershed is small (approximately 500 sq. miles). The bay has a mean depth of 6 feet with a maximum depth of 27 feet. Over 65 percent of the bay is less than 3 feet deep, making the bay optimal for seagrasses and related sport fishing.

The average tidal range is 2.1 feet with average wave heights of less than 1 foot. The bay is flushed by four inlets (Longboat Pass, New Pass, Big Pass and Venice Inlet) with Midnight Pass currently closed. The closure of Midnight Pass by bulldozers in 1984 significantly changed the ecology of southern Sarasota Bay (Little Sarasota Bay) between Sarasota and Venice. Sarasota Bay joins Tampa Bay to the north.

Bay Issues and Problems

Population growth, related development and associated dredging activity primarily during the 1950s and 1960s created many of the issues and problems impacting bay ecology. Large dredge-and-fill projects were constructed throughout the area. Bay bottom was dredged and filled behind bulkheads creating artificial islands, coastal "canal front type" communities and deep holes in the bay now suffering from anoxia. As a result of dredge-and-fill activity, less than 22 percent of the natural bay shoreline remains and shoreline length increased by 65 percent.

Natural species were replaced by less desirable exotic species, such as Australian pine and Brazilian pepper. Water circulation throughout the bay changed significantly.

These large-scale development projects and the dredging of the intercoastal waterway changed bay circulation patterns and destroyed or disturbed living resources.

Overall water quality throughout the bay can be rated from "poor to good." Water quality is typically "good" near passes and inlets and is rated "poor" in many tributaries, canals and in areas of poor flushing. A general decline in water clarity has been identified as a key issue in the bay, with nutrient enrichment identified as a potential cause. Inadequately treated wastewater and stormwater have been implicated as the sources of nutrients. Wastewater treatment also varies throughout the watershed, with secondary treatment and land application in the northern areas; advanced waste treatment with land application and intermittent direct discharge in the central bay; and a complex mix of septic systems and 71 small package treatment plants to the south. Stormwater has been determined to contribute approximately 50 percent of nutrients to the bay and an unknown quantity of toxic substances and suspended sediment.

Since 1960, seagrass losses have been paralleled by losses of scallop, hard-clam and oyster harvests. The loss of these commercial harvests is believed to be related to diminished seagrass beds, contamination by sewage-effluent discharge resulting in closure of approved shellfish areas and past overharvesting practices. Serious decreases in commercial landings of blue crabs, spotted sea trout, red drum and mullet have occurred, whereas landings of stone-crab claws have increased, possibly due to greater demand.

Program Background

Sarasota Bay was named in the Water Quality Act of 1987 as an area to receive priority consideration by the National Estuary Program. The state of Florida entered into a five-year agreement with the U.S. Environmental Protection Agency on June 26, 1989, to develop and implement a comprehensive restoration and protection plan for Sarasota Bay. Shortly thereafter, the program formed a Citizen, Technical, Management and Policy Committee to oversee plan development. The Citizen Advisory Committee contains 30 members appointed by the Policy Committee; the Technical Advisory Committee contains 75 members from the community; the Management Committee contains 10 members, primarily high level officials, from federal, state and local governments; and the Policy Committee contains six members including three elected officials from the bi-county area, the Regional Administrator of EPA, the State Department of Environmental Regulation Secretary and the Chairman of the local Water Board.

The five-year agreement contains four major phases: Planning, Characterization, Plan Development and Implementation. The program began the planning phase in January 1989 and completed this element in October 1989 resulting in approval of a technical study plan by the Technical Advisory Committee. During FY90 and FY91, the program focused on Phases II and III, i.e., characterizing the environmental quality of Sarasota Bay and development of management recommendations.

The five-year agreement calls for specific documents to be produced, including:

State of the Bay Report, completed January 1990. This document synthesizes information on the bay and presents a program workplan in a format readily understood by the public;

Framework for Action, due August 1992. This document will synthesize the results of the technical, public outreach and early action projects underway and present management options;

Comprehensive Conservation Management Plan (CCMP), due June 1994. This document will be the final comprehensive plan and is to include financing alternatives.

The five-year agreement (workplan) was developed using seven goals focusing the attention of scientists, elected officials and the public at large. These goals are to:

Improve water transparency in the Sarasota Bay study area to the maximum allowable by Gulf of Mexico and local weather conditions;

Reduce the quantity and improve the quality of stormwater runoff to Sarasota Bay;

Eliminate further losses of seagrasses and shoreline habitats and restore lost habitats;

Coordinate beach/inlet/channel creation and maintenance activities to reduce dredging, eliminate conflicts and enhance the bay;

Provide increased levels of managed access to Sarasota Bay and its resources;

Establish a vertically integrated management system for Sarasota Bay; and

Restore and sustain fish and other living resources in Sarasota Bay.

Improving Bay Management

The Sarasota Bay Program is building networks among bay area scientists, managers and citizens to support bay restoration actions. Moreover, the program is using lessons learned from other areas of the country and applying them to improve bay management in Sarasota Bay. For instance, in the Great Lakes, Chesapeake Bay, Tillamook Bay, Potomac River (Maryland) and other areas of the country where successes have occurred, several key factors emerge. There was:

Strong public and political support to make a difference;

A strong and effective governing body overseeing implementation;

Financial support of appropriate federal, state and local agencies; and

Clear and straightforward technical justification for action.

To develop these key ingredients for success, the Sarasota Bay National Estuary Program has taken several steps:

The program created a governing body (Policy Committee) capable of bringing financial support from local, state and federal organizations. During the first two years, each member of the Policy Committee has assisted in securing cash resources for the program (Table 1).

The program established a management committee comprising high-level officials from state and local governments (second highest level), who have dedicated significant staff support to the program. This includes support in the production of program reports, meeting attendance and in data collection.

The Sarasota Bay Project's Technical Advisory Committee includes scientists, planners and managers. Thus, the Sarasota Bay technical workplan includes information that will be useful to local governments in decisionmaking. The technical workplan focuses on:

Water column analysis (nutrients and light), sediment chemistry and circulation;

Living resources status and trends (wetlands, fish, shellfish and bottom habitats);

Sources of pollution (stormwater and wastewater septic systems and others).

The program has also developed a strong public education and outreach component focusing on real needs in the community:

Media and films (bay issues);

Action plan (series of issue workshops and projects); and

Public school curriculum enhancement.

The program has developed an action component, i.e., "moving dirt." The program has seven habitat enhancement projects funded and under construction and one stormwater demonstration project underway.

Finally, the program is assisting local government in achieving improved programs while the plan is under development. For instance, the National Estuary Program has supported the stormwater utility development in the bi-county area (each residential and commercial establishment in the basin pays a fee for stormwater management) and intervened on proposed marina and development projects.

During 1992, the program will complete numerous technical, public outreach and early action projects. The findings of each piece of work will be synthesized into a "Framework for Action" report and released with management recommendations to the Citizen and Technical Advisory Committee for input in summer 1992. The document will be drafted by staff and principal investigators and given to the Technical and Citizen Advisory Committee for comments; reconstructed for Agency and public review; and ultimately approved by the Policy Committee for release in January 1993. Subsequent to its public release, a series of town and public meetings are planned for additional citizen input.

The management recommendations resulting from this process will be provided by:

General public
NEP Principal Investigators (scientists)
Citizen Advisory Committee members
Technical Advisory Committee members
Environmental Protection Agency staff
Elected officials
National Estuary Program staff
Environmental managers from the community

The recommendations will be pooled and refined based on community consensus. This process will result in improved information exchange between scientists, managers and citizens.

The process of combining public education and outreach, technical and early action projects to effectively develop a restoration plan over a three-year period improves on past efforts by the Great Lakes, Chesapeake Bay, Buzzard's Bay, Narragansett Bay, and others. The program is attempting to produce a implementable management plan within a 3-year period. The cash commitments made on behalf of the local governments continue to show strong support for the program and, it is hoped, will result in success. The management recommendations under development will be simple, straightforward and implementable.

Program Accomplishments

During the first two years (1989-1991), the program with community support has:

Implemented the most spatially intensive water quality monitoring program in the United States supported by state, local and private personnel and respective laboratories;

Contracted to produce one of the most extensive environmental data bases on any bay and watershed in the United States;

Produced and released the "State of the Bay" report, 1990, synthesizing existing information on the bay and presenting the Sarasota Bay Program workplan;

Participated in publishing the "Bay Repair Kit," an award winning homeowner's guide for bay protection;

Monitored ongoing local government actions that have improved water quality in the bay;

Launched an aggressive public education and outreach program in cooperation with the local school systems, Florida State University, Mote Marine Laboratory, Florida Sea Grant College, and community organizations;

Conducted workshops and events to improve community understanding of bay issues;

Analyzed data collected by the program, using the program computer system, to more definitely characterize bay problems and develop solutions;

Secured funding to increase linear intertidal habitat by approximately 10 to 15 percent baywide. These restoration projects have received national recognition for innovation and have been visited by environmental managers throughout the country;

Began to develop a list of practical management options for community review;

Initiated production of the "Framework for Action" report scheduled for release in August 1992. The report will present a synthesis of technical information and present preliminary management options.

Governance

Using the Sarasota Bay Project database to support program recommendation, the public outreach and education programs to develop community support and early action projects to show results, the program is rapidly approaching release of the preliminary management plan in 1992. The program is also presently developing options for program implementation beyond 1994 and recently completed a study in which environmental managers throughout the community were interviewed to evaluate program progress and address future governance with the following conclusions:

Sarasota Bay National Estuary Program has been successful in focusing attention among the multitude of local jurisdictions on the environmental conditions and problems of Sarasota Bay;

There is strong general support to develop and implement a comprehensive restoration plan for Sarasota Bay among government agencies and public;

There is a need to continue a formal institutional structure for the program beyond the five-year planning phase to ensure cohesive implementation of the recommended actions and to recruit funding for long-term restoration and remediation activities;

A potential role for program staff would be to recruit funds, focus public attention on key issues, and coordinate the review of major environmental activities threatening or proposed to improve the bay; and

Facilitate bay clean-up.

Sarasota Bay Restoration Themes

The program is also attempting to build its plan by enhancing and integrating existing programs. For instance, given the water shortages and 60-foot reduction in the aquifer in southwest Florida, the program may:

Promote changes in public policy to look at wastewater as a water source rather than a pollutant, thus reducing pollutant load;

Promote water conservation and reduced pollutant load through alternative landscapes (via Xeriscape, Eco-neighborhoods and Florida Yard); and

Focus attention on nutrient reduction through decreased fertilization usage and reduced runoff through increases in biomass of plant material on the watershed.

Table 1. Funding provided for the first two years of the Sarasota Bay program. (Figures are rounded to the nearest $50,000.)

State of Florida	$ 850,000
Manatee County	$ 150,000
Sarasota Count	$ 150,000
City of Sarasota	$ 100,000
Federal EPA	$2,300,000
Southwest Florida Water Management District	$ 450,000
Other (federal/state/private sources)	$ 800,000
Total	$4,800,000

The Work of NOAA's U.S. Coast and Geodetic Survey

THE NATIONAL GEODETIC REFERENCE SYSTEM

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Introduction

One of the primary concerns of government (federal, state, and local) must be to protect the coastal environment while maximizing the use of coastal resources. This is becoming even more important today with increasing population pressure upon the fragile coastal environment. Essential to the protection process are such activities as mapping and charting of the coastal zone; development and use of geographic information systems (GIS) to display, analyze and model the interactions between environmental and cultural parameters; definition of legal boundaries; development of safe and effective means of navigation; and monitoring of changes in the land/sea boundary. All of these activities require accurate horizontal positioning or determination of elevation. Positions or elevations determined and used by different agencies be compatible. The primary mission of the National Geodetic Survey (NGS), a division of the National Oceanic and Atmospheric Administration (NOAA), is to provide a means for everyone performing horizontal, vertical or gravity measurements to use the same coordinate system, thereby making all measurements compatible. We refer to the positional framework that makes this possible as the National Geodetic Reference System (NGRS). This paper describes NGRS, its applications in the coastal zone, and the products and services of NGS.

NGRS

Geodesy is the earth science used to determine the size and shape of the earth; exact positions/elevations of points on its surface; and its gravity field. NGS uses geodetic surveying techniques to develop and maintain NGRS, which is composed primarily of the nation's three geodetic control networks horizontal (270,000 stations), vertical (585,000 stations), and gravity (2,100,000 stations). Points defined by these networks are the basic geographic location and elevation starting positions for land surveys, cartography, engineering, construction, environmental control measures, and earth science studies. The primary value of NGRS is universal compatibility of spatial products. Simply put, this means that data whose geographic positions are determined through reference to NGRS are compatible with all other data whose geographic positions have been determined relative to NGRS—no costly transformations will be required to make the two data sets compatible.

To create NGRS, NGS defined both vertical and horizontal reference systems and provided users with a means to determine positions and elevations relative to these coordinate systems. The reference systems are the North American Vertical Datum of 1988 (NAVD 88) and the North American Datum of 1983 (NAD 83), respectively.

An essential element of NGRS is a large network of monumented points whose horizontal positions and/or elevations are known relative to NAD 83 or NAVD 88. The user can determine the geographic positions or elevations of unknown points by beginning at one of the monumented points and performing differential measurements to the unknown points. In the past, ground based measurement techniques required only the position or elevation of the monumented points to differentially determine the position or elevation of new points. Today, techniques that make use of the Global Positioning System (GPS) of satellites are revolutionizing the determination of horizontal and vertical positions. With GPS techniques, differential positioning (Figure 1) between a point of known geographic location and a point whose geographic coordinates are to be determined requires placing one GPS instrument at the known point, another at the unknown point, and making simultaneous observations of radio signals from several GPS satellites. However, GPS positioning technology requires accurate knowledge of the position of the satellites as a function of time, i.e., accurate satellite ephemeris (or orbital) information. Thus, in the GPS era another component of NGRS is the orbits of the GPS satellites.

GPS technology has introduced another component into NGRS. GPS positioning is three-dimensional—it provides not only horizontal position, but also elevation. However, the elevations provided by GPS are relative to a different reference figure than the NAVD 88 elevations obtained by conventional leveling methods. NAVD 88 (or orthometric height) elevations are required by most users. To convert an elevation obtained by GPS (ellipsoidal height) to an NAVD 88 elevation requires knowledge of the geoid height (geoid undulation) at the point (Figure 2). Thus another component of NGRS is a set of geoid heights as a function of position.

NGRS and Coastal Mapping, Charting and Land Use

The original reason for establishing a geodetic surveying capability in the United States was to provide horizontal control to support coastal mapping and charting needed for safe navigation of our coastal waters. This continues to be an important application of NGRS today. All hydrographic surveys by NOAA are performed relative to NGRS through positioning of hydrographic vessels based on points with NAD 83 positions.

GPS is changing the way in which ships are navigated and positioned. NOAA is cooperating with the U.S. Coast Guard (USCG) in a USCG program that will allow ships using GPS to navigate and position themselves more accurately. USCG will establish a network of continuously operating land-based reference stations that will broadcast GPS corrector information. Use of these correctors will neutralize the intentional degrading of GPS signals by the Department of Defense for reasons of national security. This approach is expected to be implemented nationwide during the next few years. Use of this technique will reduce the possibility that ships will ground and the subsequent destruction of the environment. It will also increase the efficiency and accuracy of mapping and charting, again contributing to safe navigation and increasing our knowledge of the coastal and near-coastal environment. These continuously operating GPS reference stations will be tied to NGRS to ensure that they are positioned properly to each other and to the nautical charts. NGS has begun to determine the positions of these continuously operating stations along the Atlantic and Gulf coasts.

Aerial photography of coastal areas is used extensively for coastal mapping, in addition to assessment, monitoring, and management of natural resources. Aerial photography also has been used to define boundaries between states or between a state and the federal government. Proper determination of these boundaries is critical in the management of natural resources. However, aerial photographs are of little value unless they can be related accurately to each other, to other photographic projects, and to known geographic positions. In the past, this relationship was been provided by identifying and marking (with paint or plastic panels, so that they can be seen in the photograph) points on the ground whose NGRS positions were known. This allows all the photographs to be related to a common framework and to each other.

Unfortunately, identifying and marking these points is very expensive. GPS technology is changing this. The aircraft, the photo center, and ground features shown in the photograph can be positioned accurately relative to a GPS reference station located at some distance from the survey area by placing a GPS receiver in the aircraft. If the reference station has been positioned accurately relative to NGRS, then the location of all ground features in the photograph will be positioned accurately relative to NGRS. This method largely eliminates the need to identify and mark points of known horizontal and vertical position, increasing efficiency and accuracy of photogrammetric operations. This method of photogrammetric mapping is of particular importance in coastal areas where it is often difficult and expensive to mark points that can be identified in the photographs.

For ship positioning, aircraft positioning, or positioning of points on the ground, continuously operating GPS base stations will be of increasing importance. These base stations will be positioned relative to the NGRS coordinate system and will themselves become a component of NGRS.

Horizontal and vertical information provided by NGRS is also essential to the control of coastal development. Following the destructive effects of Hurricane Hugo in 1990, NGS was called on to replace NGRS horizontal and vertical reference monuments along the South Carolina coast. This monumentation provides South Carolina with information to control construction along the coast—all new structures must be located to meet specified setback and elevation criteria, as specified by state law, relative to NGRS.

NGRS and Coastal Vertical Motions

The location of the shoreline is of fundamental importance in the development of coastal areas. The impact of shoreline movement is substantial. We usually think of shoreline movement in terms of land erosion. However, the cause of some shoreline movement is the vertical motion of the land itself. This vertical motion can have several origins: subsidence due to fluid removal from buried sediments; slow uplift and subsidence due to internal forces associated with removal of ice loads or the collision of the tectonic plates that make up the earth's surface; and large, nearly instantaneous, vertical motions associated with major earthquakes. NGRS network vertical reference stations in coastal areas provide the primary means for detecting and monitoring vertical motions of the land.

Subsidence due to fluid withdrawal has led to flooding problems at a number of locations along the Gulf and Pacific coasts. One of the most seriously effected is the Houston/Galveston area of Texas. Subsidence resulting from groundwater extraction has exceeded 10 feet in some areas. For a number of years

NGS has supported the Harris-Galveston Coastal Subsidence District by establishing and monitoring a dense network of level lines and vertical reference stations.

Based on the information from NGS studies, the subsidence district reduced groundwater extraction in some areas. Further studies by NGS have shown that subsidence has nearly ceased where pumping was reduced (Figure 3) while continuing in those areas where it was not reduced (Figure 4). NGS expects to continue this work using GPS to perform future monitoring.

NGS has also monitored subsidence due to fluid removal in Louisiana. An important question to answer in the Louisiana study is the amount of subsidence due to fluid withdrawal by human activity and the amount due to natural effects.

Not all vertical movements in coastal areas are due to fluid withdrawal. Studies referencing NGRS vertical reference monuments have determined that such movements in Oregon, Washington and British Columbia are caused by horizontal movement of the large tectonic plates that make up the Earth's surface. The Juan de Fuca plate, on which the Pacific Ocean rests, is moving toward the North American plate, on which most of the North American continent lies, and is being forced under it. These vertical motions are of interest, not only because of the information that they give on shoreline migration, but also because they provide information to aid in determination of the potential for major earthquakes due to the collision of tectonic plates.

The Alaskan earthquake of 1964 resulted in significant vertical as well as horizontal displacements. In some areas the vertical movement was as much as 30 feet. Leveling surveys since 1964 have provided important information on the vertical movements since the earthquake. These vertical motions provide important clues for use in determination of the mechanisms associated with earthquakes in southern Alaska.

NGRS and Pilot MPLIS Projects

NGS also participates in the development of Multi-Purpose Land Information Systems (MPLIS) and GIS through a grant procedure. One of NGS' primary interests in such projects is that the GIS be referenced to NGRS to ensure compatibility of spatial information. NGS administers grants appropriated by congress and provides assistance to the states and technical review and monitoring of the results from the projects. Of particular interest are projects in South Carolina and Louisiana.

The South Carolina Water Resources Commission is conducting a five-year project under an NGS grant to use MPLIS/GIS techniques and public policy procedures to develop a natural resources decision support system. The objectives of this project are to:

Determine data collection requirements to support decisionmaking;

Develop procedures to identify public interest in natural resources;

Develop procedures to classify and prioritize natural resources and sites by relative value;

Develop procedures to balance compensation to private landowners with the exercise of regulatory police powers;

Establish a GIS to provide products and services to support natural resource management at the parcel level; and

Use GIS technology for cumulative environmental impact assessment.

NGS administers congressionally appropriated grants to three parishes in Louisiana to develop GISs based on accurate parcel mapping relative to NGRS. These systems will be used for land management with particular reference to subsidence problems in Orleans and Jefferson parishes.

NGS also coordinates the Federal Geodetic Control Subcommittee effort to publish *Multi-Purpose Land Information Systems: The Guidebook.* This book focuses on local government's role in developing an MPLIS. It provides technical and policy standards for states, counties, cities and regional planning bodies designing an MPLIS or GIS.

Technology Transfer

NGS maintains an active technology transfer program. This technology transfer is not directed solely to the coastal states, but to the entire United States. However, the technology transferred has universal applicability. In addition, members of our technical staff not only answer questions from the general public but work with personnel from other government agencies and provide training through cooperative agreements.

NGS maintains a small field force of approximately 45 highly trained geodetic surveyors who augment and upgrade NGRS through GPS, leveling and calibration baseline surveys. A large percentage of these surveys are conducted under cooperative agreements with other federal, state or local government agencies and provide not only upgrades to NGRS, but also training for local personnel.

Under NOAA's Geodetic Advisor Program, NGS provides geodetic surveyors to provide technical assistance and training to states under a cooperative 50-50 cost-sharing program with individual states. Geodetic advisers assist states with their geodesy and surveying programs, suggest and coordinate NGRS maintenance functions, ensure that surveys performed by the states meet federal standards and specifications, and provide training in the areas of classical and GPS geodetic surveying, GIS, and various other surveying-related topics.

NGS also conducts a series of workshops to provide guidance on the application of new technology to properly use NGRS. These workshops are often co-sponsored by local government agencies or surveying associations.

A Look to the Future

The introduction of three-dimensional GPS measurement technology is revolutionizing positioning and navigation and bringing them closer together. NGS is upgrading NGRS to meet the reference system needs of the GPS era. Two components—accurate satellite orbits and accurate geoid heights—have been added to NGRS.

NGS produces GPS satellite orbital information in conjunction with NOAA's Office of Ocean and Earth Sciences (OES). OES and NGS expect to improve the accuracy of these orbits in the near future as data from additional permanent GPS tracking stations around the world are incorporated into orbit computations. A result of these more accurate orbits will be the increased accuracy of GPS positioning. Also, it will be possible to use continuously operating GPS reference stations at much greater distances than is now possible. Very soon all aircraft performing remote sensing in coastal areas, as well as ships performing hydrographic or research measurements, will probably be positioned relative to a small number of continuously operating GPS reference stations. The positions of these stations, together with the observational data taken by them, will become an integral part of NGRS. NGS is working with other federal agencies, state agencies and local groups to ensure that all relevant continuously operating GPS reference stations have compatible three-dimensional positions relative to the NGRS coordinate system. NGS is also working to ensure that data from a sufficient number of these reference stations are made available to multiple users and archived for future use.

GPS surveying technology is becoming accurate enough to monitor vertical motions in coastal areas. Because of large cost savings, GPS can be expected in many cases to replace conventional leveling for vertical motion monitoring, particularly where long distances or access problems are involved. To provide continuity and a longer time history for vertical motions, it will be necessary to combine conventional leveling determinations of orthometric height with GPS determinations of ellipsoid height. This will require high-accuracy geoid heights. NGS has already produced a high-accuracy geoid height model, designated GEOID90. A campaign is underway to obtain additional gravity and terrain data to produce an improved geoid in 1995. The ultimate aim is to permit ellipsoid height to orthometric height conversion with an accuracy of 1 to 2 cm. This will be a special challenge in coastal areas because of lack of gravity data in shallow water and in inaccessible coastal swamps.

NGS is providing high-accuracy regional upgrades to NAD 83 to allow surveyors and navigators to take full advantage of GPS. These upgrades consist of networks of stations having a spacing of 25 to 100 km and differential horizontal accuracies of 1 to 3 cm. These monumented stations are tied into and used to upgrade the absolute accuracy of the NAD 83 coordinates of existing NGRS horizontal reference monuments. Such networks are already in place in Washington, Oregon, Florida, Tennessee, Wisconsin, Maryland and Delaware. Observations have been completed and networks will be available over the next few months in Alaska, California, Louisiana and Alabama. These upgrades have been conducted as cooperative efforts with the aforementioned states.

NGRS Products

NGS provides the information needed to make use of NGRS through its National Geodetic Information Center (NGIC). This information consists of listings containing the horizontal positions, vertical elevations, and other data about the monumented points of NGRS, in addition to descriptions on how to locate these monuments. This information is available in print form or on diskette in a variety of geographic ranges.

Weekly GPS ephemeris (orbital) information is available on diskette from either NGIC or by modem from the U.S. Coast Guard Information Center bulletin board. GEOID90, the high-accuracy geoid model for the United States, and its associated vertical deflection model, DEFLEC90, also are available from NGIC on diskette.

NGS provides a range of computer software for solving geodetic surveying problems. These programs are available for mainframe and personal computers, as well as for HP-41CV programmable calculators. Also available from NGS is a series of publications, including the *MPLIS Guidebook*. For further information on these products contact the National Geodetic Information Center, N/CG174; Rockwall Bldg; Room 26, NOAA, National Geodetic Survey, 11400 Rockville Pike, Rockville, Md. 20852, (301) 443-8631, fax: (301) 881-0390.

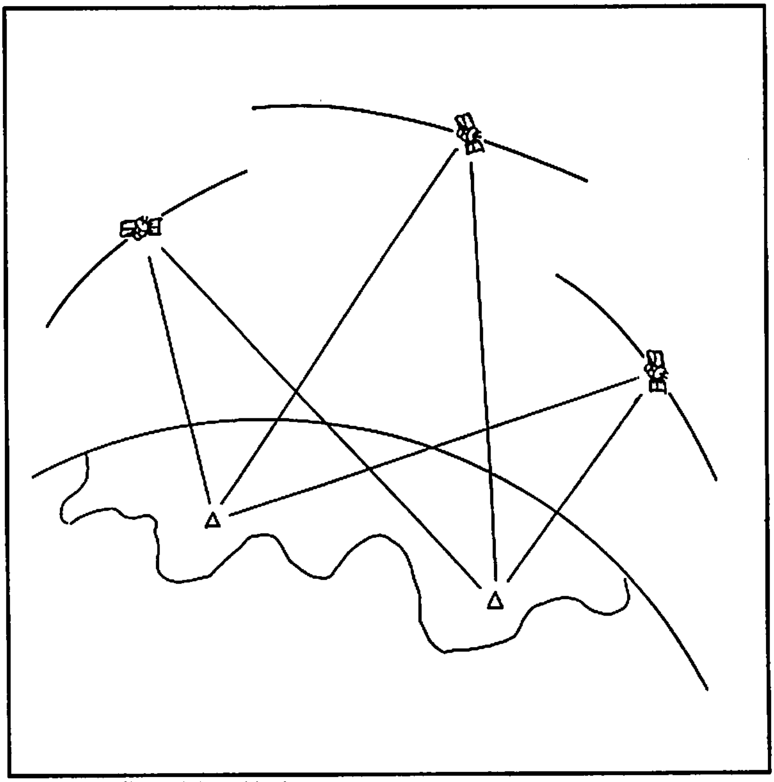

Figure 1. Differential positioning.

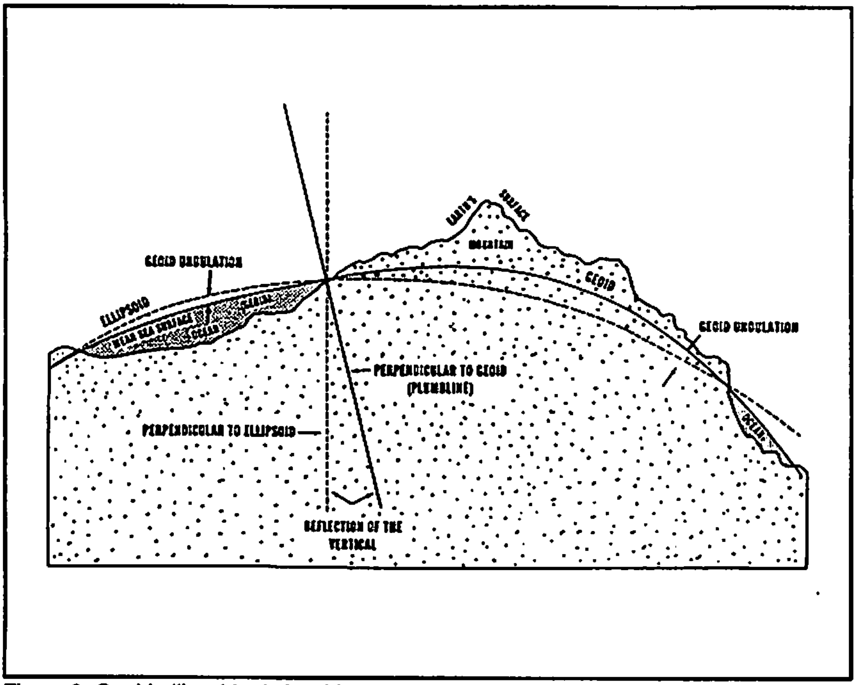

Figure 2. Geoid-ellipsoid relationships.

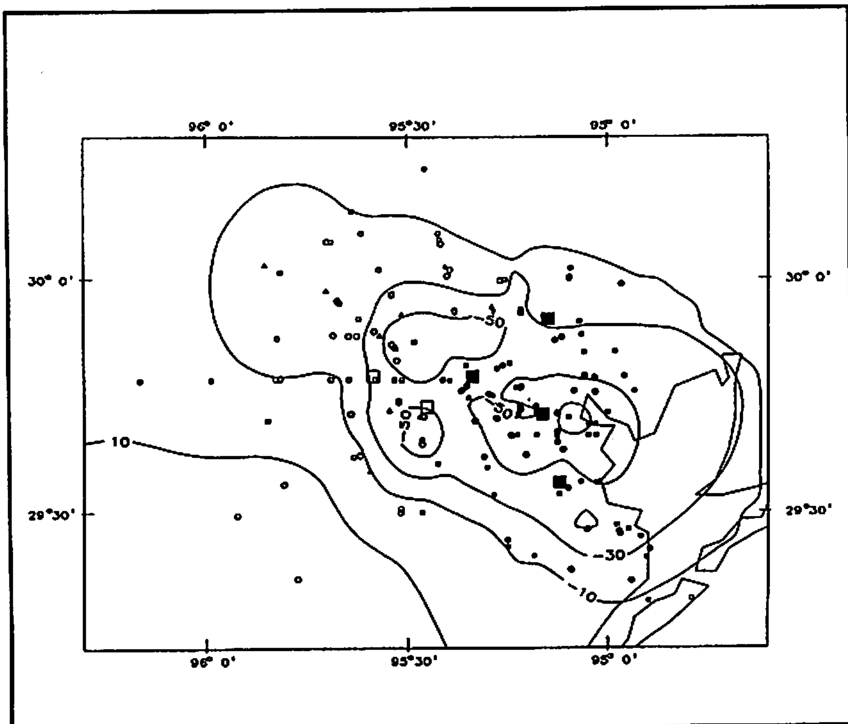

Figure 3. Houston-Galveston 1973 subsidence rates, mm/year.

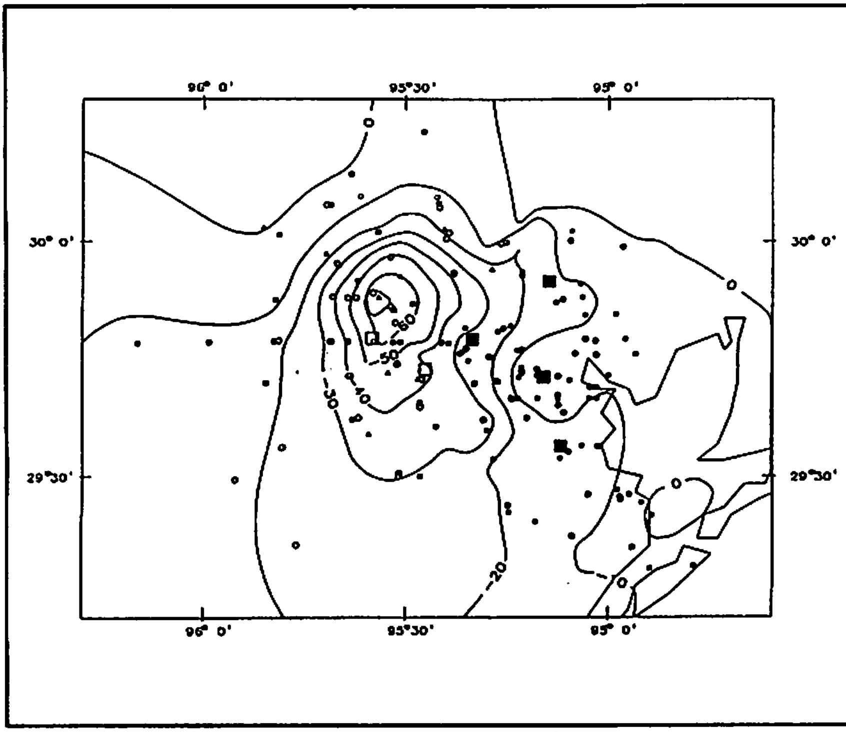

Figure 4. Houston-Galveston 1987 subsicence rates, mm/year.

SHORELINE SURVEYS: PAST AND PRESENT

Victor E. McNeel
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ABSTRACT

Current shoreline surveys in the Coast and Geodetic Survey (C&GS) result in the production of shoreline maps and associated data. Also included in the survey process is the collection of high-resolution, metric-quality aerial photographs. Shoreline maps (base maps), associated data and photographs are considered by some to be merely byproducts of the nautical charting program. However, they are also complete products in their own right and are available to the public. They should be of particular interest to those who are working in the coastal environment, since modern tide-coordinated surveys provide a starting point for many scientific studies of the coast. In addition, coastline data from the early 19th century to the present offer insight concerning types and rates of change in coastal areas. The purpose of this presentation is to provide information about these products.

INTRODUCTION

A shoreline survey is the process of establishing the location of the shoreline in a selected area. The shoreline shown on C&GS charts and maps represents the line of contact between the land and a selected water elevation. In areas affected by tidal fluctuations, this line of contact is the mean high water line. In confined coastal waters of diminished tidal influence, the mean water line may be represented. In non-tidal waters, the shoreline represented is the land-water interface at the time of the photography. In areas of marsh grass, cypress or other similar marine vegetation, the shoreline is often obscured. In these areas an apparent shoreline is mapped at the point where the line of vegetation is a definite line above the shoreline datum. Because this is the line that appears to a navigator as the shoreline, it is delineated as such and is located in lieu of the actual high water datum line.

SHORELINE MAPS

Shoreline maps result from the shoreline survey process. They are special-use planimetric or topographic maps that usually cover a relatively narrow zone along the shoreline and portray selected features. (Planimetric maps depict the horizontal placement of natural and manmade features; in addition to these features, topographic maps depict form, usually showing relief as contour lines.)

Shoreline maps are graphic representations derived from plane table and photogrammetric surveys. The maps contain data relating to the shoreline, alongshore natural and man-made features, and usually a narrow zone of natural and man-made features inland of the shoreline. This zone may vary, however, from several hundred meters to an area covering the entire map.

When obtainable, shoreline maps depict the low water line within the limits of the survey. The accurate location of the low water line is extremely valuable for charting because it may be used as the base line from which offshore boundaries are determined and it eliminates the need for the hydrographer to develop the zero depth curve.

Shoreline maps produced by C&GS may be grouped into three approximate eras, each of which has certain common characteristics, the most prominent of which is the data source.

Early Era Shoreline Maps (1834-1929)

The framework in the form of triangulation for the first topographic survey began in 1816. After a brief period, congressional action caused a break in operations until 1832 when work was resumed (Shalowitz, 1964). The topographic survey was completed in 1834 and is registered as C&GS's first topographic map. That map and subsequent ones of the era were the graphic recordings of field topographic surveys. The topographic shoreline surveys and the shoreline maps were essentially the same for these early surveys, since the maps consisted entirely of direct survey recordings made primarily with the use of a plane table and alidade. The plane table was considered by C&GS's authority on topographic surveying, O.W. Swainson (1928), to be "one of the best instruments for topographic surveying, as with it the map is actually drawn in the field where and when the features can be seen and where the amount of detail to be mapped and the accuracy required can be judged to best advantage." For most of the earliest shoreline maps, no supplemental information for the interpretation of the topographic maps was prepared apart from the map itself. Later maps in this era were accompanied by descriptive reports that supplemented the maps with interpretive information not readily shown on the maps themselves. Descriptive reports were included as early as 1863 and were officially mandated in 1887 (Shalowitz, 1964).

Intermediate Era Shoreline Maps (1930-1979)

Most shoreline maps produced in this period included the combined graphic representation of data that originated from aerial photography and field surveys. These maps were field-checked, had supplemental data applied to them if necessary, and were edited prior to registration to ensure that all critical nearshore hazards were represented and that the features depicted were accurately described and positioned.

Photogrammetric Surveys. During this era the application of photogrammetry was recognized by C&GS as a cost-effective method to survey the shoreline. Photogrammetry is the science of determining the physical dimensions of objects from measurements of photograph images. An investigation into the feasibility of using aerial photography in compiling coastal maps was started June 10, 1919 (Smith, 1979). From that time through 1926 experimentation included various aircraft and camera lens configurations. By 1927, the full potential of photogrammetry as an aid to the production of charts and maps was recognized by C&GS (Smith, 1979). In 1930, the director of C&GS stated: "The Coast and Geodetic Survey is convinced that it is time for the airplane to take its proper place and be officially recognized in the Bureau's mapping program" (Smith, 1979). After that, photogrammetric methods were consistently used in support of the coastal mapping program and also in providing surveys of the coast for the establishment of marine boundaries. In 1971, this capability was officially recognized and its use stipulated for the survey of the coast (DOC Organization Order 25-5B, July 11, 1971). In areas where adequate tidal datums were available, photogrammetric methods were often used to develop the low water line.

Aerotriangulation. Ground control for traditional photogrammetric mapping required a network of photo-identifiable points on the ground for which values, referred to horizontal and vertical datums, had been established. Aerotriangulation is a method of increasing the density of photo-control, relative to the specified horizontal and vertical datums, for photogrammetric use. Aerotriangulation is defined as the process for the extension of horizontal and/or vertical control whereby the measurement of angles and/or distances on overlapping aerial photographs are related into a spatial solution using the perspective principles of the photograph (American Society of Photogrammetry, 1980). Specifications for photogrammetric surveys required that the network of photo-control be established relative to geodetic and tidal/water level datums established by the National Ocean Service (NOS). For the majority of projects, this requirement was met using a combination of field surveying and aerotriangulation methods. The typical practice was to establish and premark available reference control stations throughout the project area using ground survey methods and then establish the full complement of photo-control by aerotriangulation methods.

Aerial Photography. In coastal surveys, the spectral reflectance characteristics of water, land, and sea or lake bed were considered and used to advantage. Different films are sensitive to particular ranges of the light spectrum. Infrared light, for example, is reflected by dry land and almost completely absorbed by water. For this reason, since about 1970, tide-coordinated black-and-white infrared photography has been used when distinct definition of the low and high water lines have been required. Light in the visible range will penetrate clear water, so low-altitude color photography has been used for feature investigations and photobathymetry.

Modern Era Shoreline Maps (1980 to present)

Since 1980, aerial photographs have been the sole source used for shoreline mapping. Final maps produced now provide the graphic representation of detail interpreted and extracted from the photographs. This method allows the adequate delineation of the shoreline, coastline structures, interior detail, and, when applicable, the low water line. Limiting factors, however, may affect the adequate representation and portrayal of open-water features. Open-water features on these maps represent only photo-identifiable objects that can be located using photogrammetric disciplines.

Although graphic data from field surveys are not used for compiling these maps, field operations provide an important role in support of photogrammetric mapping. Supporting field functions may consist of any or all of the following operations: recovering or establishing ground control, placing targets on control stations prior to aerial photography, observing tides in support of tide-coordinated photography, and conducting feature investigations that use field surveying techniques to supplement or verify photogrammetric data.

With Global Positioning System (GPS) technology, the task of establishing photo-identifiable geodetic control points on the ground has become less labor- and time-intensive than in the past. Prior to the availability of GPS, flight lines and photographic coverage were often compromised to accommodate existing horizontal control. With GPS receivers, geodetic control is placed wherever needed for maximum photographic coverage and mapping accuracy, including areas previously considered too remote for cost-effective ground survey.

RECENT DEVELOPMENTS

Analytical digital compilation has all but replaced conventional analog stereo plotter technology. In addition, photogrammetric operations are benefiting from new technology that includes photogrammetric surveys using kinematic GPS, a modern flight management system, and digital data.

Analytical Digital Compilation

Shoreline map compilation in C&GS has shifted from analog to analytical methods. The type of compilation can be identified by the registration prefix *T*, *TP* or *DM*. All registered maps compiled by analog methods have the prefix *T* or *TP*. These maps are stable-base copies of the original compilations. Registered maps with the prefix *DM* are computer-generated using a validated digital data set resulting from analytical compilation. This type of compilation is performed with the aid of analytical stereoscopic measuring instruments that differ from the traditional analog instruments in several important aspects. In analog instruments, the photographs are oriented to the same physical relationship that existed at the time of exposure. While compiling the map, the operator continually adjusts the mechanical projection system, and images of the shoreline are traced at scale by a pantograph. In analytic instruments, manual adjustment is replaced by a computer with an electro-servo interface. It continually adjusts the optical projection system by solving a system of equations. The imagery appears in stereo at all times as the operator moves the measuring mark throughout the stereo model. Instead of creating a graphic product, the computer displays and stores digital coordinates in the desired geodetic reference system. The shoreline map is created from the digital data, but the digital data are independent of the specific map. They can be used for a variety of final products.

Photogrammetric Surveys Using Kinematic GPS

During photogrammetric surveys using airborne kinematic GPS, the exposure station of the camera, as well as the targeted control, is positioned by GPS methods. Beginning in 1985, the National Oceanic and Atmospheric Administration (NOAA) Charting Research and Development Laboratory (Lucas, 1987) developed an aerotriangulation simulation model that suggested that positioning the aerial camera exposure station to an accuracy of one meter would eliminate the need for geodetic control for coastal mapping without compromising shoreline accuracy (Lapine, 1991a). Subsequently, various practical tests have been conducted by NOAA to confirm these findings. Lapine (1990) demonstrated that ground control points can be positioned from aerial photography to an accuracy of five centimeters from an altitude of 6,000 feet above the ground at a speed of 200 mph (1990). On Oct. 5, 1990, the Photogrammetry Branch conducted photogrammetric operations over Albemarle Sound, N.C., which demonstrated the practical application of GPS-controlled photogrammetry. The photo mission was flown at 24,000 feet and at speeds reaching 345 mph. Differential phase observations from an onboard GPS receiver significantly reduced the cost of shoreline mapping by eliminating the need for densely spaced and signalized ground control points. An analysis of the subsequent aerotriangulation process showed virtually no difference between the solution using signalized point positions determined by GPS-controlled aerotriangulation and true (surveyed) values within 1.0 meter in horizontal and 2.1 meters in vertical (Lapine, 1991b). This technology is being used to map the Florida Keys National Marine Sanctuary, where conditions preclude the use of extensive ground controlled photography.

Modern Flight Management System

A new flight management system within C&GS is based on very precise near-real-time GPS pseudo-ranging, a CD-ROM digital map file, and modern electronic camera technology. It enables precise navigation of the aircraft over preplanned nearshore and offshore flight lines. This should bring greater efficiency to aerial photograph operations and result in maintaining mapping accuracy of offshore areas.

Digital Data

The new generation analytical photogrammetric systems allow base mapping to be conducted in a totally digital environment. A benefit of this new technology is that a database of high-resolution seamless shoreline data is collected and can be used for multiple purposes by extracting a portion or all as needed. Any digital data set includes information about the integrity of the data it contains.

Recordkeeping and product retrieval are also advancing into the digital arena. The geographic positions of approximately 380,000 aerial photographs contained in the C&GS Photogrammetry Branch's film library have been digitized from photo indexes and correlated with supplemental information. These data are in the correction and testing phase and will soon be available through interactive computer query. Direct additions to this database will be forwarded from the flight management system on digital media.

A shoreline survey inventory database is currently being loaded with the coordinates and supplemental data relative to each registered shoreline map C&GS has produced to date. This will allow a quick categorical search of inventory via interactive computer query. In addition to this, plans are being developed to convert the historic registered maps to digital form. Each shoreline map will be scanned and the data stored in both raster and vector form for comparison, retrieval, and plotting purposes. Associated reports and records will be scanned and stored along with the digital map data. Ultimately private and commercial users should be able to access these data directly via computer modem.

COOPERATIVE SHORELINE MAPPING PROJECTS

There have been a number of cooperative projects in which C&GS has contributed its shoreline surveying expertise. The latest was to obtain high-precision base mapping for the Florida Keys National Marine Sanctuary. It was sponsored jointly by the National Ocean Service Office of Ocean Resources Conservation and Assessment and Office of Ocean and Coastal Resource Management; the National Marine Fisheries Service Southeast Fisheries Laboratory; the State of Florida's Department of Natural Resources; and Monroe County, Fla.

USES OF COASTAL SURVEY DATA

Coastal survey data not only serve as the database of shoreline and topography used in NOS nautical chart production but also provide an accurate geographic framework for management purposes, many published data, and environmental studies. For example, the National Marine Fisheries Service uses shoreline survey data and aerial photographs to classify, inventory, and map submerged aquatic vegetation. Elements of the NOAA Coastal Ocean Program use these data to evaluate the effects of physical impacts to coastline regions and for estuarine habitat studies. Historical data resulting from these surveys are often used in litigation to determine property ownership and to enforce regulatory mandates. Recently, a litigation settlement involving the states of Georgia and South Carolina resulted in the establishment of the states' boundary by using historical NOS coastal survey data as the basis of its determination.

AVAILABILITY

Shoreline Maps

Final shoreline and photobathymetric maps are registered and permanently archived in the NOS vault. A registered map is a stable base copy of the original manuscript. This copy is registered instead of the original because of its superior durability over time. Associated data, identified as descriptive reports or completion reports, are bound in a single volume and are also registered. They consist of all pertinent reports, records, and listings of production data associated with the shoreline survey and individual maps, beginning with register number T-979, archived in 1863. The shoreline maps are available to the public as stable base or bromide (paper) copies. Copies of the maps and reports may be obtained from the Archives of the National Ocean Service by contacting Data Control Section/NCG243, Nation Ocean Service, NOAA, Rockville, Md. 20852, (301) 443-8408.

Digital Shoreline Data

High-resolution seamless shoreline data will be maintained on file in vector form by the Photogrammetry Branch. For updated information, contact the Support Section, Photogrammetry Branch, (301) 443-8601.

Aerial Photographs

C&GS metric-quality photographs consist of natural-color, false-color, black-and-white (panchromatic), and black-and-white infrared photographs. The majority of available photographs range in scales from 1:20,000 to 1:60,000. Copies of these photographs in nominal 23cm x 23cm (9" x 9") contact size are available as prints, and as film negatives or positives. Paper prints are also available as enlargements ranging through 4.44 times the contact size.

To obtain aerial photographs contact Support Section, Photogrammetry Branch N/CG236, Coast and Geodetic Survey, NOS, NOAA, 6001 Executive Blvd., Room 719, Rockville, Md. 20852, (301) 443-8601.

Cooperative Mapping Projects

To obtain information about possible cooperative base mapping projects contact Photogrammetry Branch N/CG23x1; Coast and Geodetic Survey, NOS, NOAA, 6001 Executive Blvd., Rockville, Md. 20852, (301) 443-8006.

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HYDROGRAPHIC SURVEYS OF U.S. COASTAL WATERS

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Introduction

A stated goal of The Coastal Society is to provide an opportunity and forum to promote the exchange of ideas, techniques and experience in the use and management of coastal resources. This paper is intended to provide information pertaining to the availability of copies of National Ocean Service (NOS) hydrographic surveys and thus further the exchange and sharing of research and information.

It is important to note that this paper addresses hydrographic surveys as a product rather than hydrography, which is the professional surveying activity. Hydrography deals with the measurement and description of the physical features of bodies of water and their littoral land areas. In hydrography, emphasis is usually placed on the elements that affect safe navigation and on the publication of such information in a suitable form for use in navigation. The resultant "... information in a suitable form for use ..." is the hydrographic survey.

Hydrographic surveys are a principal source of information necessary to the compilation of nautical charts. Perhaps the NOS hydrographic surveys will serve as an invaluable resource for applications in the coastal and marine environments.

Historical Perspective

In the early days of this republic, the conduct of commerce by means of land transportation presented many difficulties. The difficulties of land transport along with the need for foreign trade, predominantly dependent on coastal shipping, fostered reliance on safe maritime commerce. The responsibility for such safe maritime commerce was recognized as an inherently governmental responsibility. On Feb. 10, 1807, this national obligation was formally recognized when Congress, acting on the recommendation of President Jefferson, adopted a resolution for a "Survey of the Coast." This resolution had its roots in various reports, circa 1795-97, which recognized the lack of accurate coastal surveys and the need for accurate charts of the "Atlantic coast of the United States, including the bays, sounds, harbors, and inlets thereof as have been made from actual observations and surveys. ..."

In implementing the Act of 1807 scientists were invited to propose a plan for carrying out the monumental and precedent setting task of surveying. Respondents included Swiss geodesist and scientist Ferdinand R. Hassler. Hassler's plan was accepted and he was selected to guide the early organization of the survey. His plan called for the division of the task into the three primary branches of geodetic, topographic and hydrographic operations.

The establishment of acceptable field procedures, training of surveying personnel, provision for the preparation of charts and maps, and the design and acquisition of precise survey instruments, as well as the War of 1812, combined to delay survey work until 1816. The first field work, accomplished in 1816, consisted of reconnaissance for the purpose of establishing two geodetic baselines; one in the vicinity of Englewood, N.J. and the second on Long Island, N.Y. However, due to circumstances familiar to today's administrators, i.e., lack of adequate funding, it was necessary to suspend the fledgling surveying undertaking. In the early 1830s Congress revived the original act and survey efforts resumed. The first topographic and hydrographic surveys were completed in 1834 and covered the area of Great South Bay, Long Island.

For early inshore hydrographic surveys, depths between 10 and 15 feet were measured with a graduated sounding pole; deepers waters, to 15 fathoms, were measured by a handlead and marked line. The development and implementation of echo sounding technology during the 1920s greatly increased the efficiency and accuracy of hydrographic surveying.

Hydrographic Survey Types

Basic Hydrographic Survey. The principal purpose of the hydrographic survey safe navigation. A hydrographic survey may include the determination of one or several of the following classes of data: depth of water; configuration and nature of the bottom; velocity of currents; heights and times of tides and water stages; location of aids and dangers for navigation and survey purposes; configuration of marginal land areas; and determination of magnetic declination and anomalies for navigating by magnetic compass. Information on geographic names and harbor facilities is also often documented. Most NOS hydrographic data are now collected by computer-supported systems.

Following field work, hydrographic survey data are forwarded to be processed and plotted on smooth sheets. The smooth sheet is plotted from verified and corrected data and constitutes the final, neatly drafted accurate plot of a hydrographic survey. The hydrographic survey smooth sheet serves as a primary source for data used in compiling a nautical chart (Figure 1).

Hydrographic survey smooth sheets are usually plotted at a scale of 1:10,000. The criteria for scale selection are based on the area to be covered and the amount of hydrographic detail necessary to depict adequately the bottom topography and portray the least depths over critical features. The standard size for hydrographic survey sheets, whether manually or machine plotted, is 91 cm by 136 cm. Accurate vertical control of hydrographic surveys is tied to tidal observation; other pertinent corrections are tied to the raw soundings, according to the type of sounding equipment utilized. Depths on most hydrographic surveys are reduced to true depths below an accepted datum plane, e.g., mean lower low water.

Wire Drag Survey. Wire drag denotes a specialized surveying technique using an apparatus for determining the maximum clearance depth over a bottom feature. It also is used for the detection of isolated dangers to navigation that might escape detection by ordinary sounding methods, e.g., rocks, pinnacles, ledges, boulders and coral reefs. It consists of a horizontal bottom wire supported at intervals ranging from 300 to 600 feet (91 to 183 meters) by adjustable upright cables suspended from buoys on the surface and towed at the desired depth by two ships or launches (Figure 2). The uprights can be lengthened or shortened for various required depths. They are kept in a nearly vertical position by means of weights attached to their lower ends. The end weights and buoys are larger than the intermediate weights and buoys and the towing gear is attached to them.

Wire drag surveys are considered to be of limited use for general purposes other than NOS nautical chart compilation due to the complex overlapping plots of the individual drag strips on the smooth sheet and the depiction of only cleared areas shown on the accompanying "area-and-depth" (A&D) sheet. Figures 3 and 4 illustrate a typical wire drag survey smooth sheet and A&D sheet respectively. **Field Examination (FE).** The FE is a special purpose NOS hydrographic, wire drag, or side scan sonar survey of very limited area. A survey is customarily assigned an FE registry number when it addresses the investigation of an individual item or several scattered items. In most cases, each investigation is smooth-plotted on an 8½- by 11-inch sheet that can be inserted in the descriptive report. Each item is subjected to sufficient investigation to resolve the status of the item in question and support a specific recommendation concerning the charting disposition of the item (Figure 5).

Navigable Area Survey. This is a basic hydrographic survey with restricted coverage. The coverage is reduced by omitting requirements for development of the zero-foot depth curve and foul, nearshore areas not considered navigable; and a complete field edit of the survey area. Navigable Area Surveys may also be restricted to the main navigable channel or corridor. By restricting the area of coverage while retaining the basic hydrography concept within surveyed waters, a more rapid progression of field work is realized.

Hydrographic Survey Products Available

Copies of survey indexes are available on 8½- by 11-inch sheets. For areas where the page-sized indexes are not current, copies of relevant master diagrams may be provided. Such indexes and diagrams will be furnished on request.

Photographic reproductions of surveys are usually made on paper and are rendered as positives (black lines and figures on white background) called "bromides." Photographic reproductions are also available on film-positive, stable base media (SBM) at a slightly higher cost. There is a charge for bromide and SBM film-positive copies. Fee quotes will be furnished upon request.

Negatives are not routinely generated for FE surveys. Accordingly, copies of FE surveys are only available as electronic (photocopy-type) copies of the descriptive report and accompanying page-sized plots of the individual developed survey areas. Charges are made on a per-page plus base fee basis, which depends upon the number of pages and plotted sheets included in the descriptive report.

Digital Hydrographic Survey Data. Approximately 4,324 digital hydrographic survey data sets are available. This covers the majority of surveys conducted since approximately 1930. These data sets are of two types, those conducted manually and later digitized and those acquired digitially (Figure 6).

The digitized datasets consist of 3,204 surveys conducted from 1930 to 1965. The digitally acquired hydrographic survey data consist of approximately 1,120 surveys and continue to grow as new surveys are registered.

Descriptive Reports. A descriptive report is written for each hydrographic survey conducted by the National Ocean Service. However, descriptive reports are not available for older hydrographic surveys in the Great Lakes conducted by the now-defunct Lake Survey Center.

The descriptive report comprises a narrative document that describes the conditions under which the survey was performed. It addresses important factors affecting the adequacy and accuracy of the survey to facilitate survey processing and provide additional information for consideration during the compilation of the nautical chart. In most cases, a copy of the hydrographic survey smooth sheet will be sufficient to meet the needs of the general user public, obviating the additional expense associated with obtaining a copy of the descriptive report. Nevertheless, copies of descriptive reports are available subject to a charge based on a per-page plus base fee basis. The cost varies depending on the total number of pages included in the descriptive report.

Automated Wreck and Obstruction Information System (AWOIS). The Automated Wreck and Obstruction Information System (AWOIS) is a personal computer database, using dBASE III Plus software. The AWOIS, developed by the Coast and Geodetic Survey, Nautical Charting Division, Hydrographic Surveys Branch, contains over 8,800 records on wrecks and obstructions reported in U.S. coastal waters. The database was designed primarily as an automated research tool to assist the Coast and Geodetic hydrographic survey program. It also has been useful to marine archaeologists and historians, fisherman, divers, salvage operators and other users in the marine environment.

Each record in the database has a repetitive format that has information on vessel name, position (latitude/longitude), positional accuracy, survey status, large-scale chart number, project number, survey requirements, history, and description.

Submission of Requests for Products

Requests for photographically reproduced copies of hydrographic surveys, topographic surveys, and photocopy-type copies of descriptive reports are processed upon receipt of payment. The request should be addressed to NOAA, National Ocean Service, HSB, Data Control Section, N/CG243, WSC1, Room 404, 6001 Executive Blvd., Rockville, MD 20852. Make checks payable to U.S. Department of Commerce, NOAA, N/CG243.

The AWOIS data base is maintained by the Hydrographic Surveys Branch, Operations Section, N/CG241. AWOIS computer listings and digital data on diskette are available to anyone for a fee. For further information about AWOIS, please contact Mark J. Friese, National Ocean Service, Hydrographic Surveys Branch (N/CG241), 6001 Executive Boulevard, Rockville, Md. 20852, (301) 443-8752.

Digital Hydrographic Survey Data. NOAA's National Geophysical Data Center (NGDC) is the designated distributor of all NOS digital hydrographic survey data. Copies of all NOS digital hydrographic surveys are sent to NGDC where they are archived. From this archival dataset NGDC has created and maintains the National Ocean Service Hydrographic Data Base (NOSHDB). The NOSHDB incorporates over 40 million uniformly formatted, 40-character survey records. The data are stored as one-degree-square area files on magnetic tape.

NGDC has created a second database that grids the NOSHDB depth records into 15-second cells. The depth assigned to the center of each cell is an arithmetic mean of all depths located within the cell, computed without regard to their spatial distribution. This database is used to generate data density plots that show data coverage for each one-degree-square area.

All inquiries regarding NOS digital hydrographic survey data should be directed to National Geophysical Data Center, NOAA, NESDIS, E/GC3, 325 Broadway, Boulder, Colo. 80303-3328, (303) 497-6338.

Conclusion

Requests for copies of hydrographic surveys, field examination surveys, topographic surveys, and descriptive reports have been received from private sector consultants, attorneys, surveyors, various federal, state and local government agencies, universities and various private individuals. Perhaps some of these products will prove useful for your particular research endeavors.

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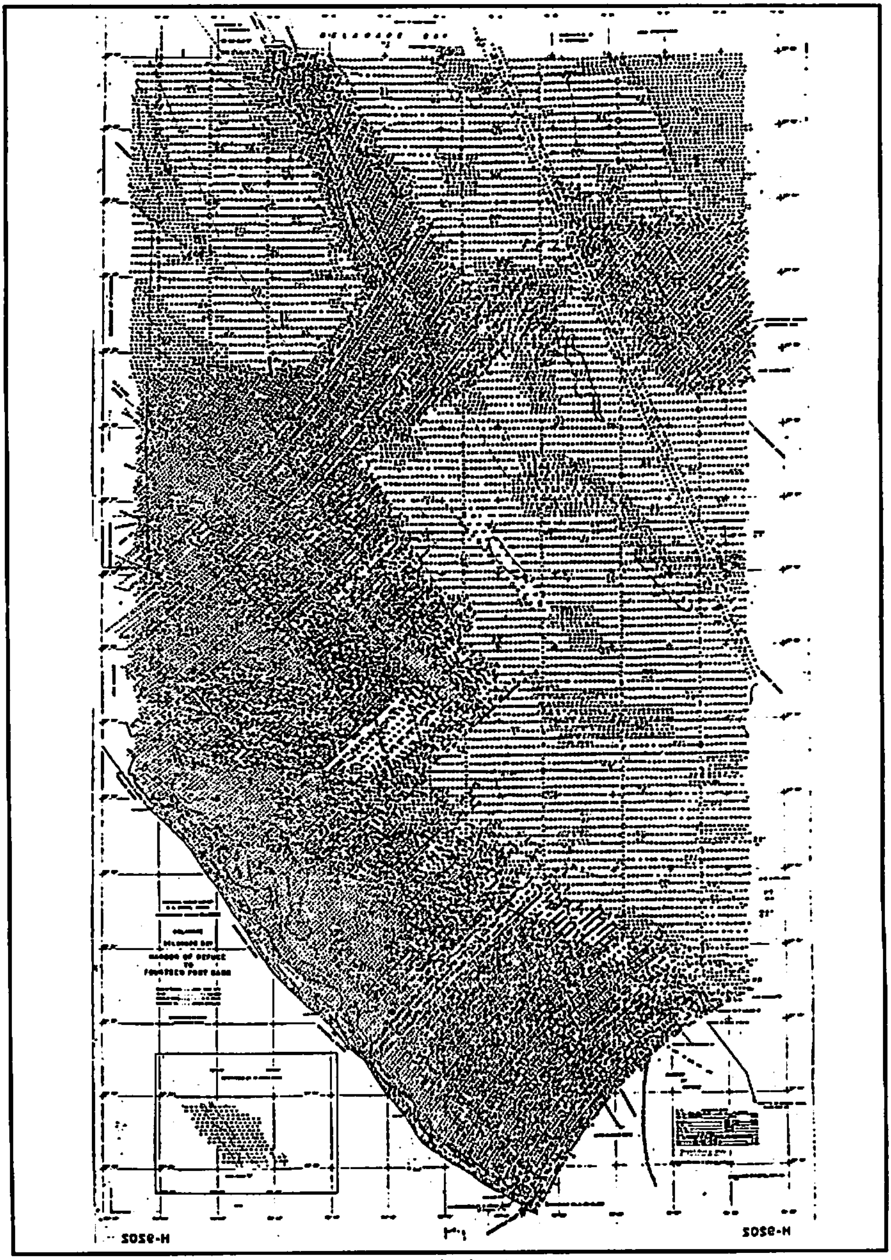

Figure 1. Sample hydrographic survey smooth sheet.

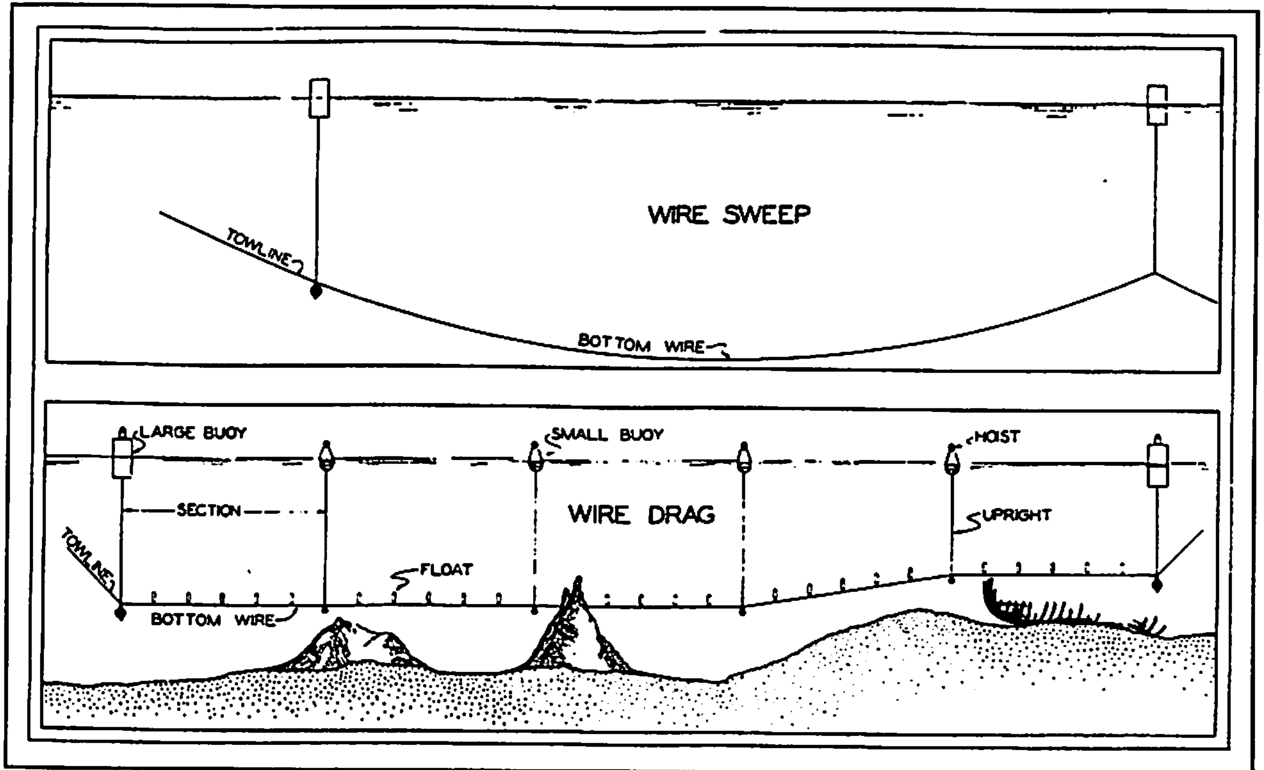

Figure 2. Wire drag and weep construction diagram.

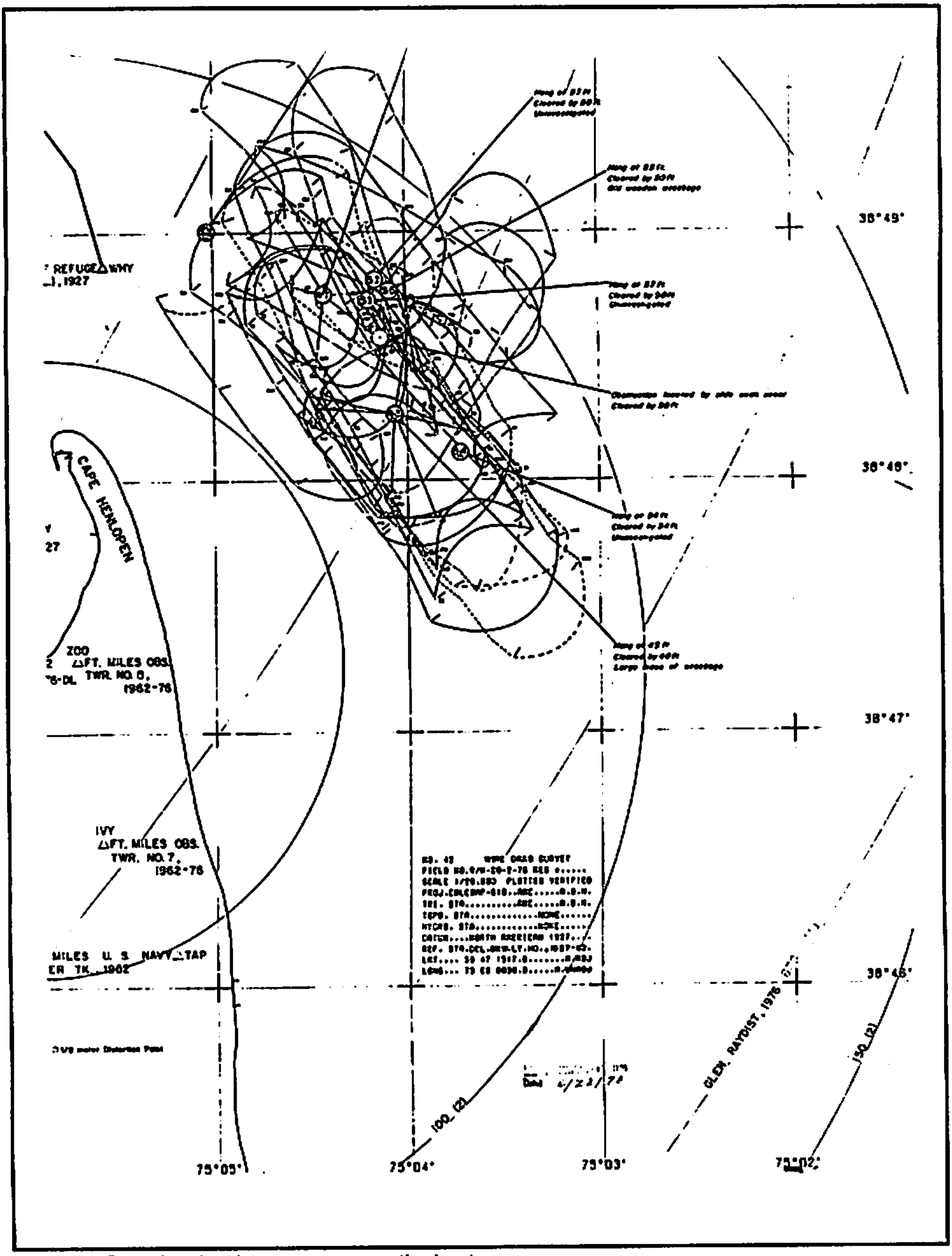

Figure 3. Sample wire drag survey smooth sheet.

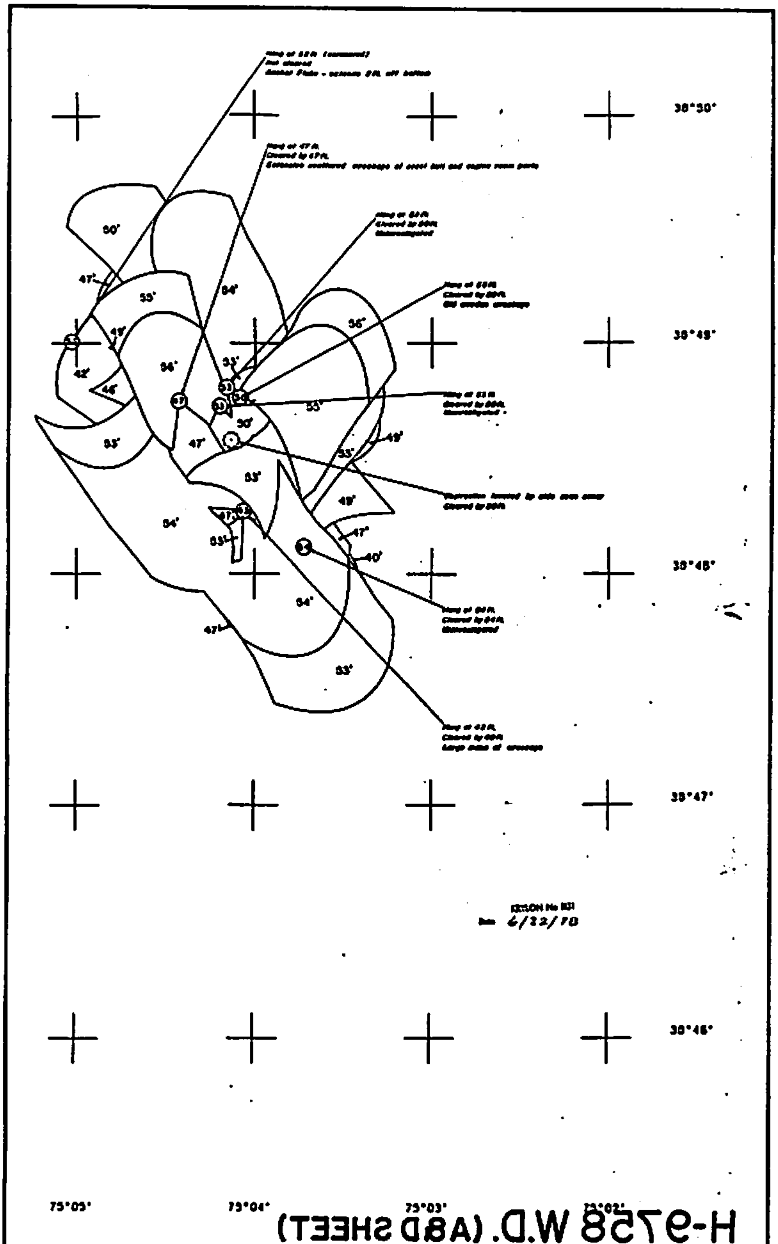

Figure 4. Sample wire drag area and depth (A&D) sheet.

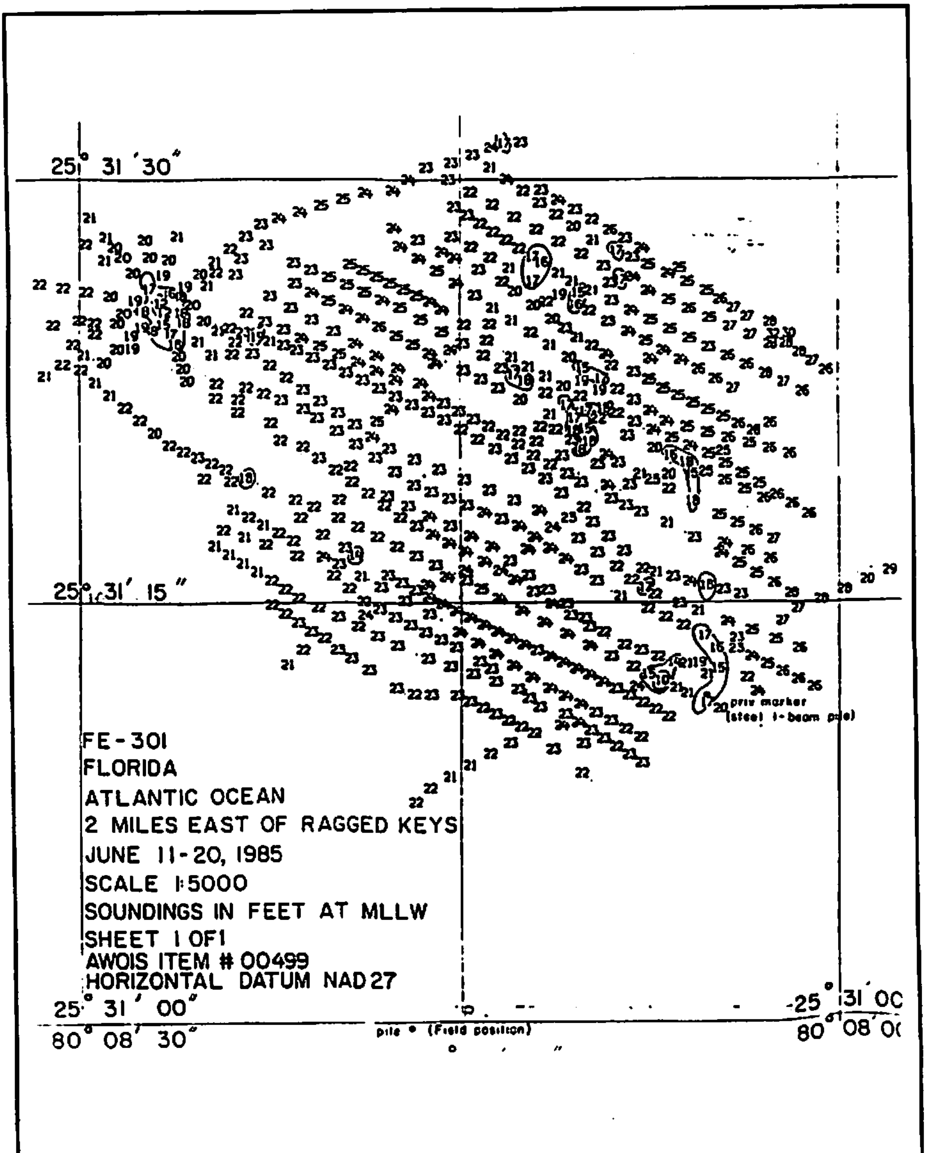

Figure 5. Sample hydrographic field examination (FE) smooth plot.

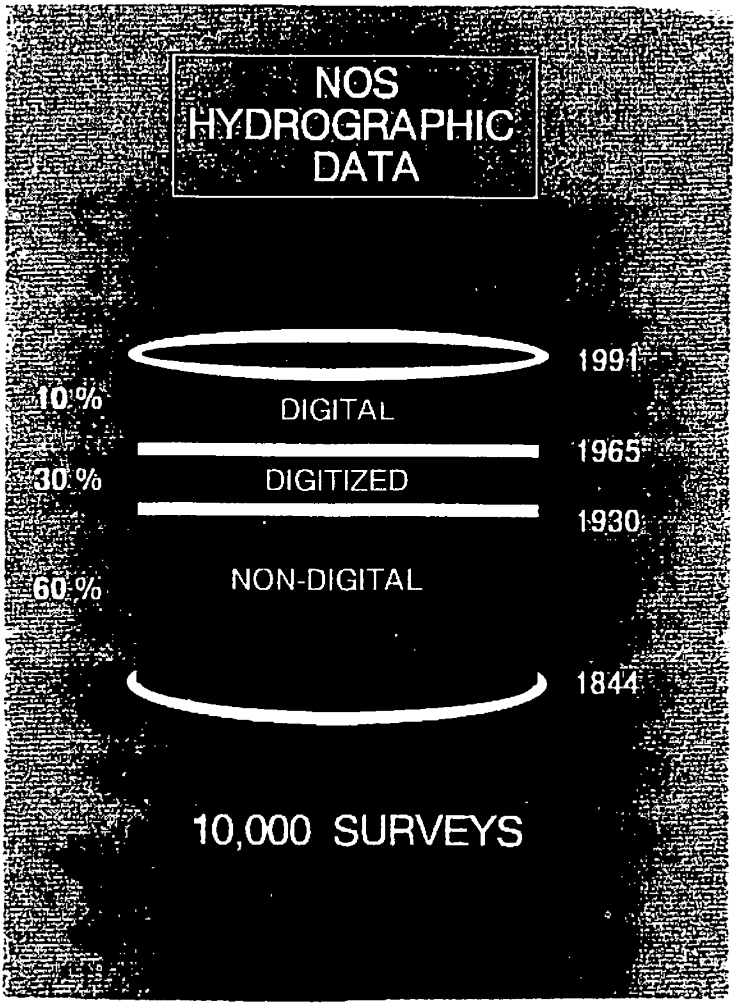

Figure 6. NOS hydrographic data.

NOAA'S PROGRAM TO MAP THE U.S. EXCLUSIVE ECONOMIC ZONE AND THE AVAILABILITY OF RESULTING BATHYMETRIC DATA

Paul J. Grim
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Abstract

In response to a 1983 presidential proclamation, NOAA's Coast and Geodetic Survey began surveying with multibeam sounding techniques the U.S. Exclusive Economic Zone, extending seaward for 200 nautical miles from the coastline. The resulting maps and data are needed in this largely unexplored area for the conservation and management of living and non-living resources as well as for various types of planning. To date, 71 bathymetric maps have been made, each having a scale of 1:100,000 and generally measuring 1° in longitude by 0.5° in latitude. The basic data are in a digital format. These include full-resolution data (all soundings collected which typically number 5-10 million per map area) and two types of grids derived from these full-resolution data. NOAA is making all maps and digital data available to the public. Gridded data for a single map area are disseminated on diskette in ASCII format for use on PC desktop computers. Full-resolution data are disseminated on magnetic tape.

Introduction

In March 1983, President Reagan signed a proclamation establishing the U.S. Exclusive Economic Zone (EEZ). This zone (Figure 1) extends seaward for 200 nautical miles from the coastline of the United States, its overseas territories and possessions, and the commonwealths of Puerto Rico and the Northern Mariana Islands. As a result of this proclamation, the United States has sovereign rights, in accordance with the rules of international law, over all living and non-living resources in the EEZ. The area of the EEZ is about 1.7 times greater than the combined areas of the above-mentioned land masses. Although the undersea topography and mineral resources of only small parts of this enormous area have been surveyed and are relatively well known, systematic mapping of the EEZ, until recently, has not been done. Such surveys of the seafloor, through the resulting maps and digital data, are expected to yield vast amounts of information that can be used for diverse purposes, including interpretation of geologic features, planning of scientific and environmental studies, wise management of living and non-living resources, and education of students at many levels of study.

This paper describes NOAA's EEZ program and the nature of the resulting data, as well as formats, products, and the availability of both maps and digital data. Numerous publications give technical details on the multibeam systems used by NOAA (Farr, 1980; Renard and Allenou, 1979). A description of how NOAA manages and processes the data, as well as details of how soundings are used to produce maps, is given by Herlihy et al. (1988). A bibliography concerning the policy and science of EEZ mapping has been prepared by NOAA (1989). This bibliography includes numerous references to the complementary GLORIA sidescan data collected by the U.S. Geological Survey in the EEZ. Also, see papers given in the recent EEZ Symposium held in Portland, Ore. (Mills and Perry, 1991; Matula, 1991; Grim, 1991).

Because of the wealth of bathymetric detail revealed by NOAA's EEZ multibeam program, the dissemination of data was stringently controlled by the U.S. Navy prior to the spring of 1989. At that time the Navy removed all restrictions on data dissemination with the exception of two areas: the EEZ in the Pacific, north of 46°N (essentially the entire EEZ off the coast of Washington); and the Atlantic EEZ extending from Cape Romain, S.C. to Fort Pierce, Fla. The data collected in these two areas from NOAA's EEZ multibeam program (but not from university multibeam research cruises) remain classified.

Thus, it has only been about three years that these data have been advertised and disseminated to the general public. Because of this small time period, the nature and availability of these multibeam data remain unknown to many potential data users.

One measure of the usefulness of the data is shown by scientific publications using the data to interpret geologic features on the seafloor (Greene et al. 1989; Jackson et al., 1990; Bryant et al., 1991).

Map Areas in Depths Less than 150 M.

It is important to understand, especially when NOAA EEZ maps are used in coastal areas, that the sounding data used in making maps in depths less than 150 m have not been collected by the highly accurate multibeam techniques described in this paper. Instead, these shallow soundings have been obtained from single-beam hydrographic surveys, some of which were made as long ago as the early 1930s. Sounding data from such hydrographic surveys are not as dense or as accurate (in positioning or depth) as soundings obtained by the adjacent multibeam surveys, which are generally conducted in water deeper than 150 m.

Status of Map Production

Every year since 1984, NOAA has conducted EEZ mapping operations with multibeam techniques. Five vessels have been involved in data collection. Off the East Coast and in the Gulf of Mexico, the work has been carried out by NOAA ships *Mt. Mitchell* and *Whiting*. Surveying along the West Coast, and in Hawaiian and Alaskan waters has been conducted by NOAA ships *Davidson, Surveyor* and *Discoverer*. Seventy-one 1:100,000 EEZ maps are available in either a published, multicolored format or as black-and-white copies of preliminary maps. The numerical breakdown according to geographic region, to date, is as follows: Central and Northern California (13), Oregon (16), Alaska (4), Hawaii (7), East Coast (2), Gulf of Mexico (29). The exact locations of these maps are shown in a series of index maps (periodically updated) provided free to the public at the address given below.

General Characteristics of EEZ Soundings

Much interest has been expressed about the full-resolution multibeam data, which are collected as follows. A multibeam ship collects data from a swath of soundings along the sea floor. This swath is normal to the ship's heading. Typically

15 or 16 soundings are obtained. A depth and a position are determined for each sounding. An example, showing results from a single swath where 15 soundings are collected, is shown in Figure 2. For NOAA's SeaBeam system, in this water depth, the two outermost soundings (1,234 m and 1,301 m) are both about 440 m from the ship in a horizontal direction, thus giving a total swath width of about 880 m. (The boxed-off depth, 1,273 m, directly beneath the ship, is the only depth that would be recorded with a single-beam system).

A second swath of data is collected from the seafloor several seconds later (five or six seconds is typical—the actual time between swaths depends mainly on water depth). This second swath produces a similar group of soundings that are offset from the soundings of the first swath, in a direction along the trackline of the ship. All soundings collected in this manner, for a complete bathymetric survey, make up a full-resolution dataset. The maps and gridded data described in this paper are based on only a small subset (selected soundings) of these full-resolution data.

NOAA uses both deep and intermediate-depth multibeam systems for EEZ mapping. Two types of intermediate-depth water systems have been used. The first, no longer used, is the Bathymetric Swath Survey System (BSSS), which measured depths between 150 and 600 m. Currently HYDROCHART II is used in depths from 150 m to 1,000 m, although depths as shallow as 15 m have been measured. Both systems operate at 36 KHz and generate a swath on the seafloor with a nominal length of about 2.5 times the water depth.

The SeaBeam system is the only deepwater system used by NOAA. (SeaBeam and the two systems cited above are products of SeaBeam Instruments Inc.). The SeaBeam system is used in depths from the deepest parts of the U.S. EEZ to 1,000 m or 600 m, depending on which of the two intermediate depth systems is used in adjacent shallower waters. SeaBeam operates at 12 KHz and generates a swath measuring about 0.7 times water depth.

At present, the only intermediate depth system used in the Pacific has been BSSS, and the only system used in the Atlantic and Gulf has been HYDROCHART II, although it is anticipated that an intermediate-depth system will be used in the Pacific in the future.

In general, multibeam sounding data are not collected in water shallower than 150 m due to the efficiencies of the systems. In order to complete a map containing such shallow water, NOAA hydrographic survey data, of varying quality, are used (Matula, 1991).

Most EEZ map areas measure 1° in longitude by 0.5° in latitude. In Alaskan waters the east-west dimension is 1.5° of longitude. However, there are exceptions to these standard map limits. These may occur when a map area is close to land and it is judged that certain land features should be included in the map (the map limits would be expanded to include these features). It is also possible that in the future, maps that are close to or include the EEZ boundary may not have these standard map limits. In some cases a seafloor feature, judged to be especially important environmentally or geologically, extends outside the U.S. EEZ boundary into international waters. In such cases NOAA will enlarge its survey area to include the feature. This has been done in the Gulf where NOAA has surveyed parts of the Sigsbee Escarpment extending seaward of the EEZ limit.

The coverage of the seafloor using multibeam systems is 100 percent. The prevalent trend of the topography is known before a survey starts and ship tracklines (mainscheme lines) usually run parallel or subparallel to this trend. Swaths from adjacent, parallel mainscheme lines overlap by 10 percent or more. Crosslines, which generate about 5 percent of the total data collected, are run normal to the mainscheme lines and are used to verify soundings collected on the mainscheme lines.

Sound velocity profiles are developed from conductivity, temperature and depth (CTD) data collected prior to surveying. These results are used to apply velocity corrections to the raw sounding data. Daily expendable bathythermograph (XBT) data are used to see if significant temperature changes have occurred in the water column. If so, new CTD data are collected and used to derive a new sound velocity profile, which is applied to the sounding data.

Positions have been determined by satellite systems (e.g., STARFIX of John Chance Inc. and differential GPS) and shore-based systems, such as ARGO and RAYDIST. LORAN-C positioning is not used because of its limited accuracy (about 0.25 nautical miles or 463 m). All surveys are based on the 1983 North American Datum (NAD83).

The accuracy of the depths and positions are judged to be well within the International Hydrographic Organization (IHO) standards of: (1) one percent of actual depth (we believe that in most cases our depths are better than 0.5 percent of true depth); and (2) within 50 m (based on the scale of our 1:100,000 scale maps) of true position.

Preliminary and Published Maps

NOAA disseminates both printed (i.e., published) maps and preliminary maps (black-and-white photocopies of maps not yet published). Both show identical bathymetric contours except for shallow areas (less than 150 m) where, in general, there are no contours on the preliminary maps. The purpose of disseminating preliminary maps is to make the data available to the public before the map is published. Once a map is published, the preliminary map is no longer used.

The 250-m grids and resulting contours for both types of maps are made using commercial software (Radian Corporation's CPS-1 contouring program) running on a DEC minicomputer. CPS-1 is also used to create the physiographic plots described below.

Both types of maps have the following characteristics: the scale is 1:100,000; contours are in corrected meters; the contour interval is 20 m; the projection is Universal Transverse Mercator; and LORAN-C lines (rates) are shown.

The published maps differ from the preliminary maps as follows: the preliminary maps generally do not show contours in water depths less than 150 m, and published maps may also omit contours in such shallow depths when future maps are published if the hydrographic data, from which these shallow contours are derived, are judged inadequate; the published maps show, where available, labeled lease block outlines provided by the Minerals Management Service; the published showing depth ranges; the published maps include at least one relatively small three-dimensional view of the whole map area (this 3D view is derived from the same 250-m grid (described below) used to generate the map contours); the published maps label both established names of seafloor features and in many cases new names proposed by NOS or others for relatively large and distinctive features (i.e., features newly discovered or precisely defined for the first time as a result of NOAA's EEZ multibeam surveying. All names shown on the published maps have been approved by the U.S. Board on Geographic Names).

Physiographic Maps

A new product is a multicolored physiographic map consisting of a three-dimensional fishnet plot overlain by a generalized contour map with major seafloor features labeled. This type of map will commonly be made by combining the 250-m grids of six adjacent maps (e.g., 2 across and 3 down giving dimensions of 2° of longitude by 1.5° of latitude) into one large grid. To date, NOAA has published two of these physiographic maps: one in the Gulf of Mexico and one off central California. A third, off northern Oregon, is currently in preparation.

Gridded Data

Gridded data for a map area are produced from a small subset of the full-resolution data. Typically, the number of full-resolution soundings for a map area is about 5 million to 10 million (the actual number being a function of water depth). The subset used for gridding purposes is generally about 350,000 to 400,000 soundings with each sounding having an associated latitude and longitude. The subset (generally referenced as "selected soundings") are randomly or almost randomly distributed over the map area. These are used to produce a 250-m grid usually having 80,000 to 100,000 grid points. A typical grid might have 400 columns and 230 rows. This grid is linked to the UTM map projection with coordinates of all X and Y UTM grid points being evenly divisible by 250.

This 250-m UTM grid is used to automatically produce the contours shown on the preliminary and published maps. This grid is also used to produce a geographic grid with a grid spacing of 15' in both latitude and longitude directions. The geographic grid consists of 241 columns and 121 rows for the standard map area. It is more conveniently manipulated by microcomputers since the number of grid points (29,161) is about one-third the number of points in the 250-m grid. For example, we are able to fit an entire geographic grid into SURFER software (Golden Software Inc.), but the 250-m grid for a complete map is too large for SURFER.

Gridded data are disseminated for a single map area on a diskette, each containing both the 250-m grid and the geographic grid and a parameter file for each. The parameter files give information needed to interpret the grid files. In addition a READ.ME file is included. All five files are provided in ASCII format. No software is provided.

Full-Resolution Data

The full-resolution data for a single map area typically total about 5 to 10 million soundings. The actual number is determined mainly from the water depth, but also from the latitude of the map, the average speed of the ship, and several other factors.

These soundings, each of which is defined by a latitude, longitude and depth value, are important because they contain seafloor details, especially in relatively shallow water, that may not be contained in the 250-m grid used for making our maps (as already mentioned, the 250-m grid is derived from only a fraction of the full-resolution data).

Full-resolution data include sounding data judged to meet IHO standards for depth and position. This means that some of the collected data have been rejected because they have been deemed artifacts of the data collection process (de Moustier, 1986) or data collected during a tight turn of the ship. Typically these rejected data amount to no more than one to two percent or less of the total data collected. They are saved in a "cull" file. A number of corrections are applied to the full-resolution data in order to make them as accurate as possible. Several of these are corrections for the velocity of sound in seawater (including refraction of non-vertical beams), the depth of the transducer (draft correction), tidal corrections (for the intermediate depth multibeam systems only), and a correction for the offset of the transducers from the positioning antenna. All corrections applied are listed in an ASCII header file and provided on diskette.

The format of the full-resolution data (NOAA refers to this format as the SBO format) is the same as the University of Rhode Island (URI) format. The data are written in a binary format on a DEC minicomputer running under VMS. The data are not in ASCII format.

Data Dissemination

NOAA's EEZ maps are made available to the public from the National Ocean Service (NOS) in the Washington, D.C., area. Preliminary maps (black-and-white photocopies of maps prior to publication) are available from the NOS Ocean Mapping Section in Rockville, Md. Printed (published) maps are available from the NOS Distribution Division in Riverdale, Md. All maps (preliminary and published) are sent in mailing tubes. Folded maps are not available.

Gridded data on diskette and full-resolution data on magnetic tape are available from NOAA's National Geophysical Data Center in Boulder, Colo.

Additional Information

Additional information on NOAA's program to map the U.S. EEZ, plus map indexes that show locations of maps and how to order them, may be obtained from the Ocean Mapping Section, Code N/CG224, NOAA/NOS, Rockville, Md. 20852, (301) 443-8251.

Digital data may be ordered from the National Geophysical Data Center/NOAA, Code E/GC3, 325 Broadway, Boulder, Colo. 80303, (303) 497-6338.

The use of commercial names and products in this paper does not constitute endorsement of the names or products by NOAA or any other part of the U.S. government.

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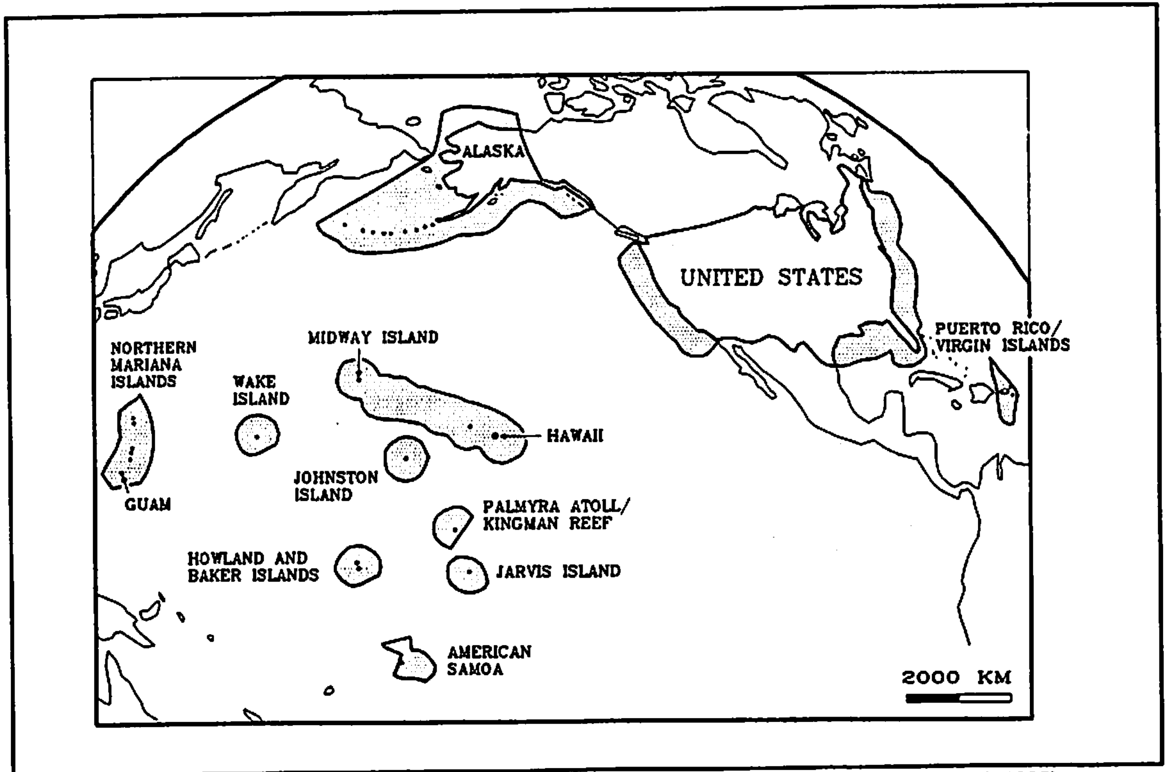

Figure 1. U.S. Exclusive Economic zone. EEZ is depicted by shading. (After McGregor and Lockwood, 1985)

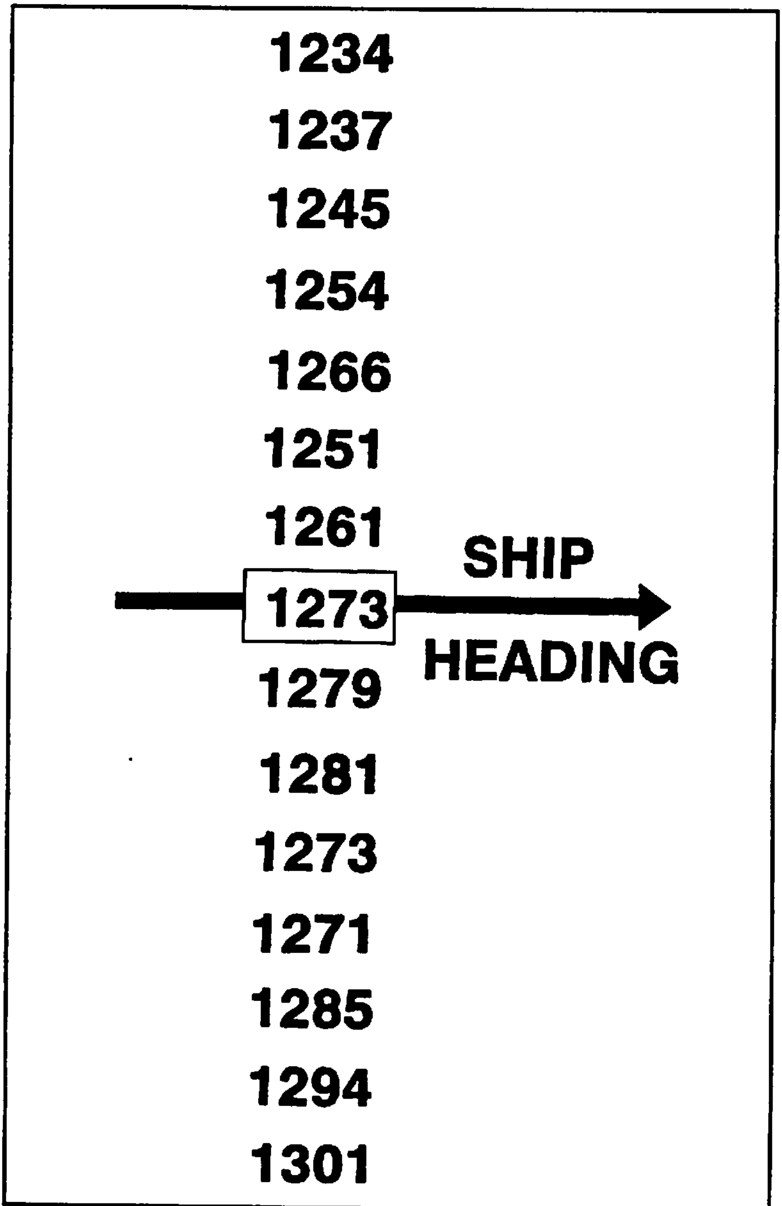

Figure 2. Soundings from a single swath. Depths in m.

Estuaries: Case Studies

RECLAIMING FILLED ESTUARINE AREAS THROUGH DEVELOPMENT: PORT LIBERTÉ, A CASE STUDY

David R. Draper
Dresdner Robin TerraSciences Inc.

Introduction

In 1985, construction began on a residential community that was to be located along a series of interconnected canals excavated from a previously filled estuarine area. The area, Caven Point in southern Jersey City, N.J., presently comprises an approximately 154-acre waterfront site along Upper New York Bay. However, only the extreme northern end of the project site occupies a natural land surface. Approximately 95 percent of the site, or more than 145 acres, had been filled into the estuary since the mid-1800s. This paper seeks to demonstrate that initial canal excavation has created or, rather, reclaimed previously filled estuarine area and, further, that the canal habitat created constitutes a valuable aquatic habitat.

Background

Between the years 1940 and 1945, the site achieved its present-day configuration due to the activities of the U.S. Army. The 1846 Map of New York Bay (Figure 1) illustrates the future Port Liberté project site as a trapezoidal figure jutting out into the Upper Bay. Beginning in 1941, the U.S. Army, spurred by World War II, purchased this last undeveloped portion of the Jersey City Waterfront and immediately embarked on a land reclamation and construction program. The early stages of the Army's filling operation are reflected on maps dating from the early 1940s (Figure 2) (Kardas and Larrabee, 1978).

The property acquired by the Army in 1941 was largely made up of land submerged under several feet of water. "The army filled it in and dredged both sides of the terminal sufficiently to dock vessels drawing 40 feet ...," creating a facility of some 700 acres. "The terminal, a vital army transport center during the war, served as an ordnance loading depot and later as a staging area for German and Italian prisoners of war (*Jersey Journal* Aug. 17, 1948)." With the end of the war, however, the Caven Point Army Terminal quickly fell into disuse, and by 1948 the Army was reportedly considering selling the property.

However, the Army decided to maintain the terminal, possibly as a result of the threat of war in Korea. The U.S. Geological Survey map of Jersey City in 1955 depicted the Caven Point Army Terminal as it had been created during World War II (Figure 3). Visible on the map was the huge land mass between the petroleum tank farm and the Claremont Terminal Channel which held the Army Terminal. Roads and railways ran generally southeast to the very tip of the "new" Caven Point where an extremely long dock, Caven Point Pier, provided the necessary connection to the deepwater Claremont Terminal Channel. Army structures were clustered at the west end of the terminal and at the tip of the point. The "old" Caven Point had been totally buried (with the narrow strip of upland having possibly been levelled) during the Army's filling activities (Kardas and Larrabee, 1978). Such was the present configuration of the site when the westernmost portion was re-acquired by Jersey City and slated for residential development.

Ecological Significance of the Site

Immediately to the east and northeast and contiguous with the Port Liberté site, the New Jersey Department of Environmental Protection and Energy acquired the Caven Point Natural Area; an area comprised of 22 upland acres and 214 riparian acres within Caven Cove. Within the natural area, the upland beach area, fronting the eastern edge of the site, is primarily vegetated with panic grass (*Panicium* sp.) and beach grass (*Ammophila* sp.) with a band of *Phragmites* running parallel to the shoreline. The natural area is bounded on the south by the Caven Point Pier, extensively used by fisherman throughout the year and by birdwatchers searching for rare gulls or Snowy Owls in the winter. On the north is Liberty State Park.

Stretching waterward from the upland beach, small but elegant tidal marshes fringe part of Caven Cove. Both low marsh cordgrass (*Spartina alterniflora*), and high marsh salt hay (*S. patens*) are present and healthy. The marsh is exceedingly important because it provides habitat for such species as the ribbed mussels (*Modiolus demissus*), bait fish, including Atlantic silversides (*Menidia menidia*) and killifish (*Fundulus* sp.), young game fish and waterbirds. The marshes are continuing to build as new, colonizing rhizomes stretch out into the tidal mudflat. The *S. patens* area (about 3/4 acre) is the northernmost salt hay community on the Hudson River Estuary.

A tidal mudflat fringes the sandy beach, extending the full length of the beach from the Caven Point Pier to the end of the peninsula and wrapping around to a small cove that is almost entirely exposed on a low tide. Though small in area, the benefits from the Caven Point Natural Area are great, precisely because it is protected and is not designated as a recreation area. Caven Cove is important as: a year-round residence for fish that are important food sources for larger fish, such as Bluefish (*Pomatomus saltatrix*) and Striped Bass (*Morone saxitilis*), a nursery for a large number of fish species—almost 70 percent of the fish collected prior to its designation as a Natural Area were juveniles—and a wintering and migrating stop-over area for geese, ducks, gulls, terns and shorebirds. The New Jersey Division of Fish, Game and Wildlife has assessed Caven Cove as one of the most important habitats in the New Jersey portion of the lower Hudson River for diving ducks (DRT, Inc., 1984). Indeed Caven Point is one of the last relatively undisturbed examples of the Hudson River estuary (Clarke and Burger, 1987).

The Development

Thus, within the context of the Caven Point Natural Area and the significance of its ecological aspects, the canal development of Port Liberté was spawned.

To date, Phase I of the five-phase project has been completed, representing approximately four to five acres of open water canal of the planned 25-acre total (Figure 4). The Phase 1 canal system has been excavated to a depth of approximately 10 feet mean low water. The upper 8 to 10 feet of material excavated consists of the original marine sands that were dredged from other areas of the New York Bight and used as fill. The lowermost extent of excavation roughly corresponds to the location of the meadowmat or original marine substrate.

Sampling Programs

Beginning in 1985 and concurrent with Phase 1 construction, a comprehensive monitoring program was conducted which included avian, aquatic resource, and water quality studies. Avian studies consisted of regular shorebird and waterfowl censusing and specific "disturbance" studies to determine the effects of certain phases and types of construction activity (Burger, 1989).

Water quality studies are conducted bi-weekly from May through October and bi-monthly thereafter. Parameters evaluated include dissolved oxygen; total and fecal coliform and fecal strep; BOD; pH; salinity; conductivity and temperature at surface and bottom depths (DRT Inc., 1991).

Aquatic resource studies consisted of originally seven, now five, fisheries surveys per year. Fisheries resources are sampled with a variety of techniques including trawl, seine and trap net. The final fall fisheries surveys of each year also include collection and analysis of benthic samples at eight locations (CES Inc., 1989).

Discussion

Comparison of the Phase 1 canal ecosystem with data collected outside the canal system indicated that the canal is functioning to provide very suitable aquatic habitat.

Regarding water quality (Figure 5), the summer dissolved oxygen (DO) levels within the canal tended to remain within an acceptable range except for a late July/early August period in 1988. Since recording these DO values, Port Liberté has experimented with two types of aeration systems to prevent future depressions. Coliform and fecal strep counts within the canal system (not illustrated) have generally been below the values recorded within the outside ambient waters.

Fisheries resources within the canal system (Area V) tend to be similar in number, when compared to non-canal locations as measured by Catch-per-Unit-Effort, but greater in diversity of species (Table 1).

Benthic resource data, though not included in this paper, likewise indicate that the benthic assemblage of the canal system was similar in density and species composition to samples collected along the Caven Point Pier. The canal bulkheads, floating docks and pilings provide substrate for a wide range of encrusting organisms, including barnacles, tunicates and various macro-invertebrates.

Thus, from review of the data collected to date, excavation of the canal system at Port Liberté is providing significant reclaimed, productive estuarine habitat in this portion of the Upper New York Bay.

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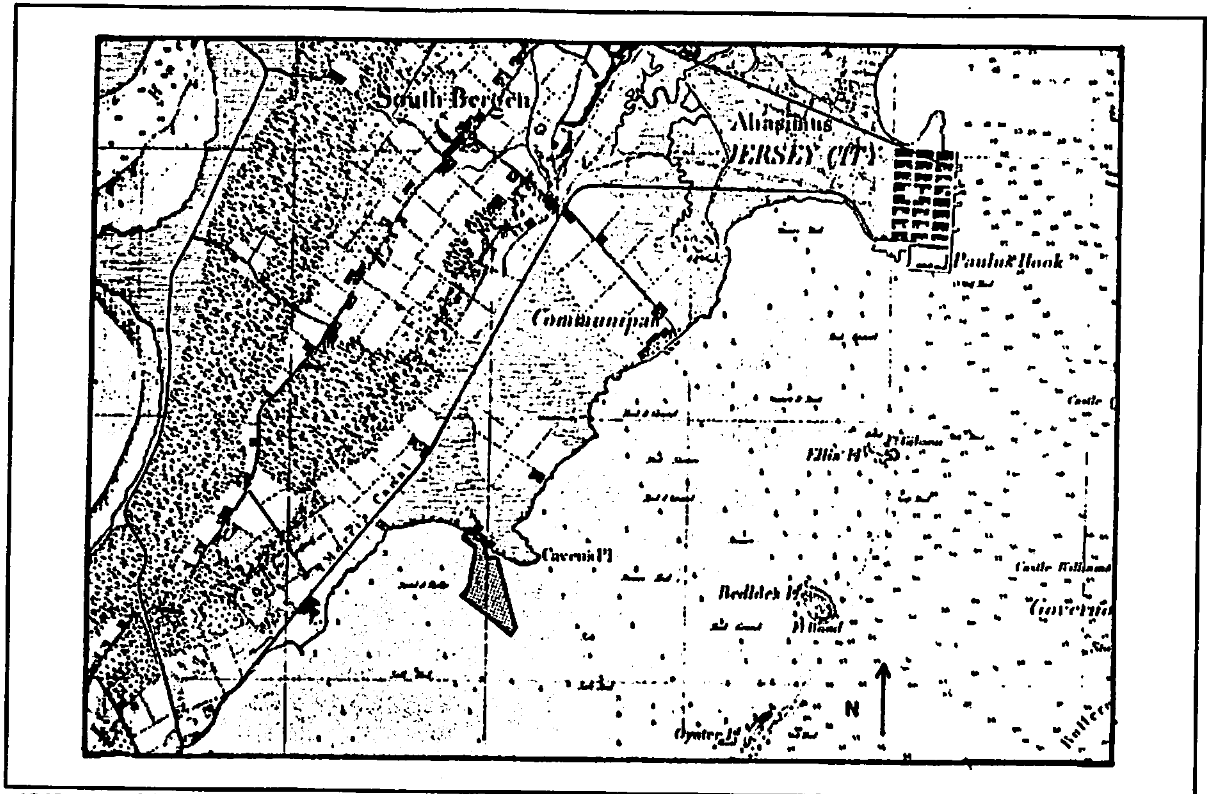

Figure 1. 1846 map of New York Bay illustrating the future Port Liberté project site as a trapezoidal figure juttingout into the Upper Bay (Kardas and Larrabee, 1978).

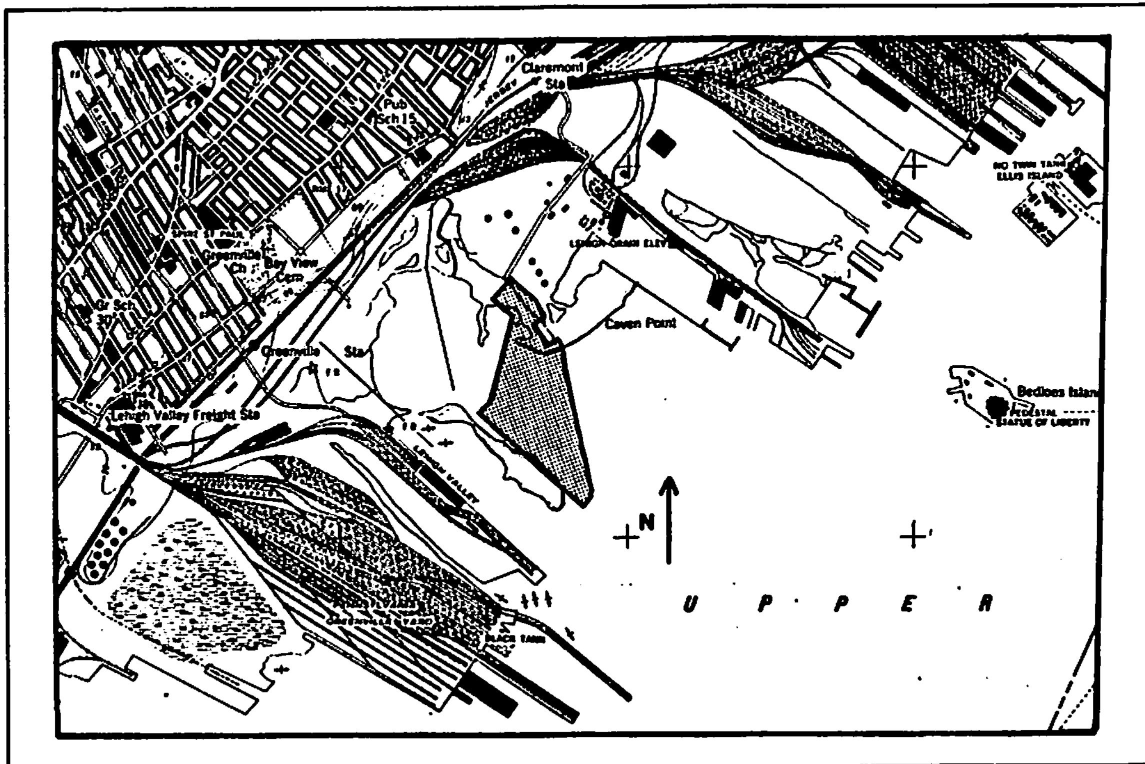

Figure 2. Map of New York Bay from the early 1940s reflecting the early stages of the Army's filling operation (Kardas and Larrabee, 1978).

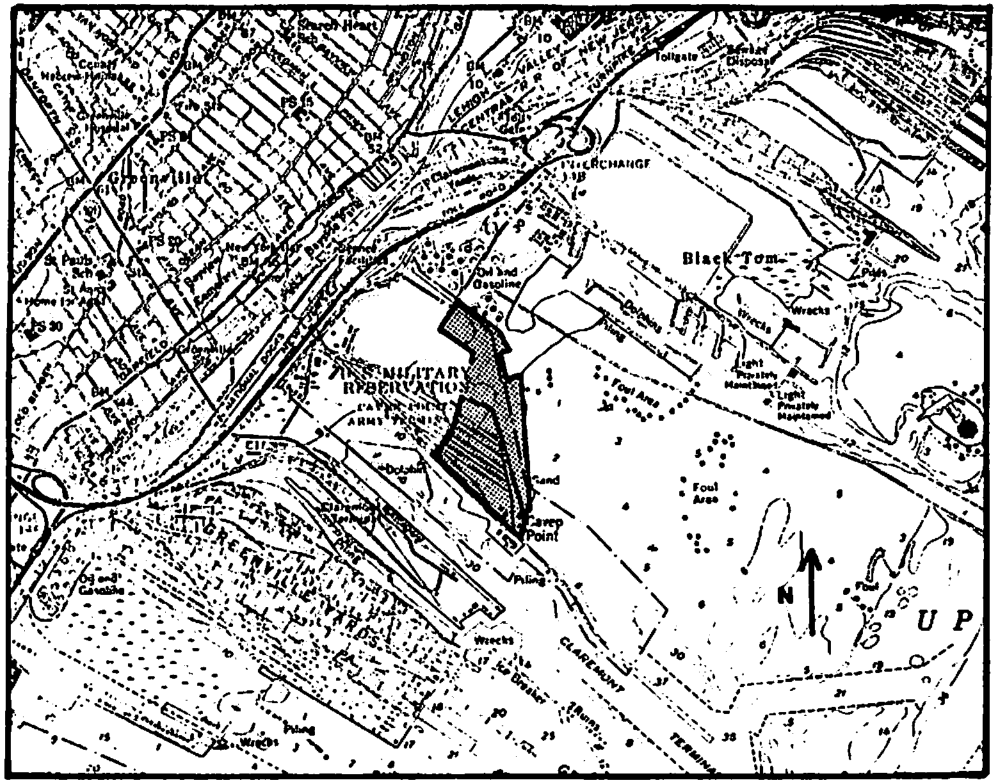

Figure 3. 1955 U.S. Geological Survey map of Jersey City, depicting the Caven Point Army Terminal created during World War II.

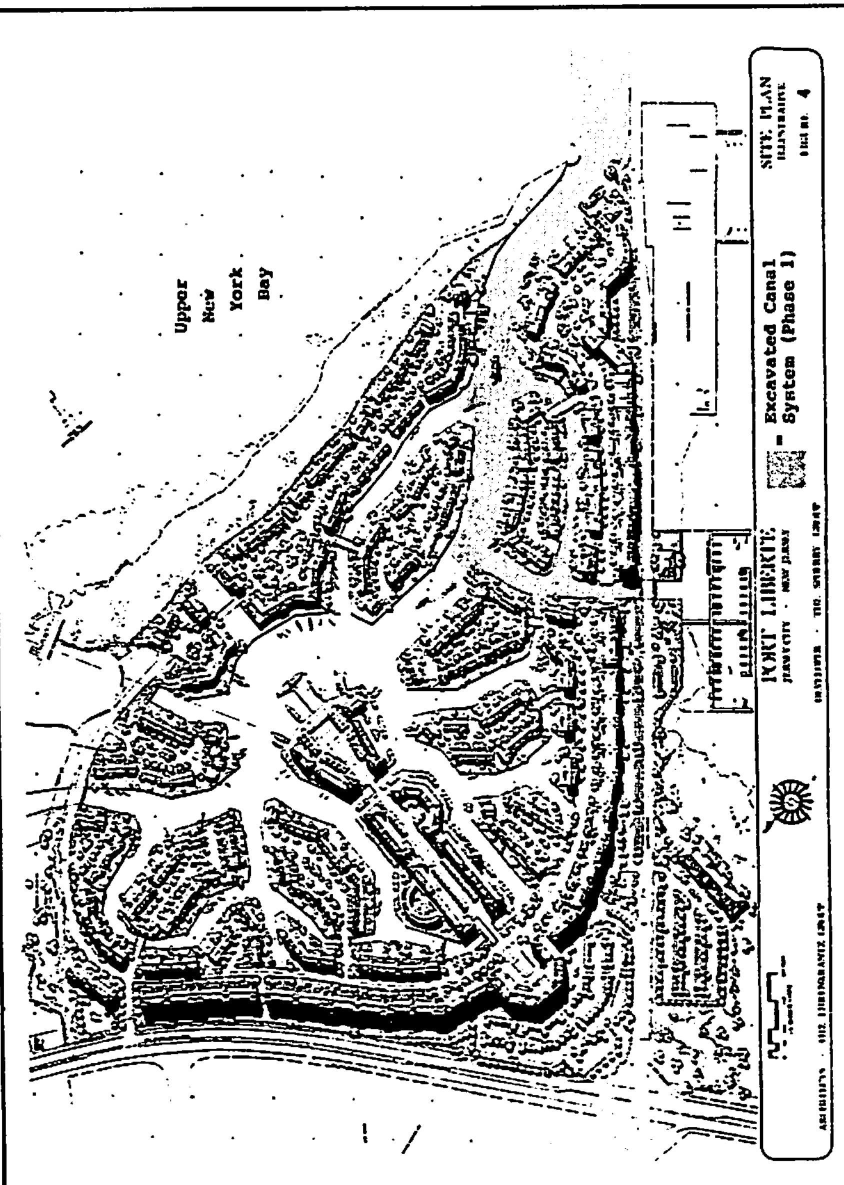

Figure 4. Architect's plan for Phase I of the Port Liberté project.

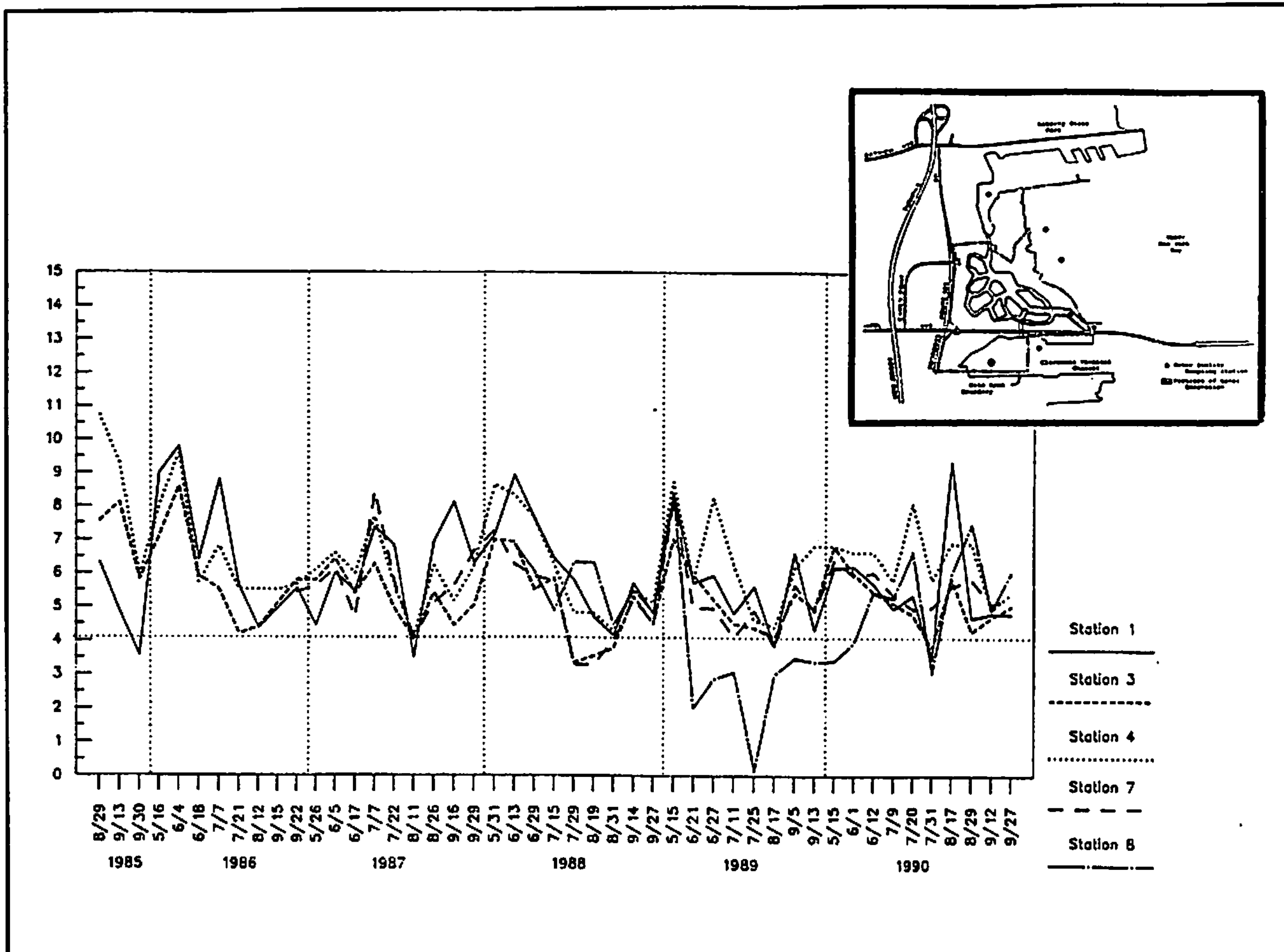

Figure 5. Summer dissolved oxygen levels at Port Liberté, 1985-1990.

	Area I																Area IV																Area V (Canal Trawl)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Striped Bass	1	.	.	.	.	3	.	6	1	.	.	.	.	15	2	1	.	.	.	.	.	2	.	.	2	.	1	.	.	6	.	.	.	.	.	.	.	1	1	.	2	1	1	.	.	49	.	3
W. Flounder	5	1	1	.	.	4	1	.	2	.	1	4	9	17	6	.	.	.	.	.	.	1	.	.	1	.	1	.	.	6	.	2	.	.	2	1	.	.	4	.	7	1	2	.	4	8	1	1
S. Flounder	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	1	.	.	.	.	14	.	2	.	.
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Cunner	.										.	.	.																	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.
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Longhorn Sculpin	.										.	.	.																	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
American Eel	.										.	.	.																	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. Menhaden	.										.	.	.																	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inshore Lizard Fish	.	.	.	.	.	.	.	.	.	.	.	.	.																	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1

1 = 5/15/86
2 = 8/05/86
3 = 10/22/86
4 = 11/19/86
5 = 2/02/87
6 = 4/01/87
7 = 5/13/87
8 = 9/09/87
9 = 11/18/87
10 = 3/22,23/88
11 = 4/27,28/88
12 = 6/23,24/88
13 = 8/23,24/88
14 = 11/28 - 30/88
15 = 3/14,15/89
16 = 9/21,22/89

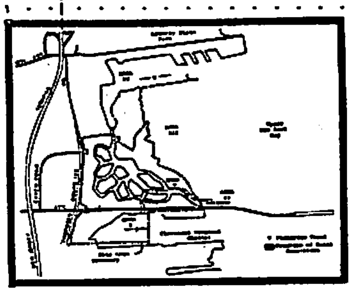

Table 1. Port Liberté trawl results for selected species, May 1986-Sept. 1989 fisheries monitoring trawls. Insets list dates of surveys and depict sampling areas.

DISTRIBUTION OF SUSPENDED SEDIMENT AND CHLOROPHYLL-A IN NORTH INLET, S.C.: A BIOLOGICAL AND PHYSICAL APPROACH

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Abstract

Multivariate regression analysis was used to test for relationships between the biological, physical and optical properties in the water column of the North Inlet estuary. Light transmissivity measurements were made at a wavelength of 630 nm over a 10-cm-pathlength cell. Suspended sediment, chlorophyll-a and tidal angle influenced 70 percent of the variability in transmissivity. The methodology used in this study may provide other scientists with a way of correlating biological and physical constituents with light transmissivity and consequently reducing the amount of field work that goes into a water quality analysis study.

Introduction

Light transmissivity has been used as a measure of different water quality constituents by physical geographers, hydrologists and oceanographers for the past few decades. Numerous attempts have been made to quantify the optical measurements made by a transmissometer (Wells and Kim, 1991; Vant, 1990; Campbell and Spinrad, 1987; Bishop, 1986; Hoskin et al., 1978). Most of the studies used light transmissivity as an indicator of suspended sediment concentrations. In most cases, the regression of transmissivity on suspended sediment produces less-than-desirable coefficients of determination. Quantification of these measurements is important because it allows scientists to understand the relationships between different water quality constituents assessed in the x, y and z spatial planes of a water body.

It is important to understand how radiant energy is transferred as it passes through the water column, because most photosynthetic activity will occur above a certain intensity (Thompson et al., 1979). The amount of light at any given depth is controlled by absorption and scattering within the water column (Lillesand and Kiefer, 1987). In estuarine waters, particulate matter, such as suspended sediment, humic acids, and nutrients, can cause selective absorption and scattering, reducing the amount of short-wavelength energy reaching a given depth in the water column. Large concentrations of dissolved and suspended matter in surface waters limit light availability to the bottom waters of the estuary, resulting in reduced phytoplankton concentrations (Peterson and Festa, 1984). Phytoplankton absorb light at wavelengths between 400 nm and 700 nm. Because most transmissometers have beams that operate at wavelengths between 600 nm and 700 nm, phytoplankton affect the amount of light measured by such transmissometers.

The main benefit of relating transmissivity to the aforementioned water quality constituents is the ease at which a transmissometer can be used in field studies. When a transmissometer is coupled with a CTD unit and in situ fluorometer, direct measurements of the different water quality constituents can be easily made. Otherwise, measurement requires collecting numerous water samples and lengthy, time-consuming laboratory analyses. Thus it becomes important to derive accurate statistical correlations between the biological/physical variables and transmissivity.

This study focused on the biological and physical processes related to the distribution of total suspended sediment and phytoplankton in North Inlet, S.C. During three days of June 1991, an intensive field study was conducted on the physical, biological and optical properties within the water column of North Inlet. The purposes of this study were to determine the spatial distribution of suspended sediment and chlorophyll and to establish multivariate statistical correlations between the different biological/physical constituents and transmissivity.

Methods

Study Site. North Inlet, S.C., (lat N33° and long W77°) is an estuarine system located on the southeastern coast of the United States, and has been a National Science Foundation Long Term Ecological Research site since 1981. The inlet is used for recreational boating and fishing. Extensive salt marshes and creeks are located throughout it, and the surrounding watershed is primarily devoid of industry and urban development. It is extremely diverse in terms of its species and dissolved/suspended material within the water column. No major rivers or streams empty directly into it, but the system receives some fresh water from Winyah Bay to the south (Kjerfve et al., 1982). The estuary experiences semidiurnal tides with a mean range of 1.7 m (NOAA, 1992).

Sampling and Measurement. The field sampling program involved longitudinal sampling along Town Creek, from the mouth of North Inlet to 5.5 km inland, (Figure 1) to measure longitudinal-vertical chlorophyll, salinity, suspended sediment, temperature, transmissivity and velocity. Longitudinal sampling along Town Creek was scheduled on three days: 16 June, 22 June and 30 June 1991, providing sampling during spring, normal and neap tides, respectively. Depth profiles (surface, mid-depth and bottom) of chlorophyll, salinity, suspended sediment, temperature and transmissivity were taken at 10 stations (Table 1) along Town Creek using a Niskin water sampling bottle, SeaTech transmissometer and YSI temperature probe. Samples were taken during both slack high and slack low at each station, beginning at Station 1 near the mouth of North Inlet and ending approximately two hours later at Station 10 near Sixty Bass Creek.

Sixty profiles were obtained during the longitudinal cruises. Whenever samples were contaminated by mud-fouling, surface readings were recorded before sensors had equilibrated, or transmissivity readings were altered by reflected sunlight, data were discarded and the area was resampled immediately. Temperature, transmissivity (10-cm-pathlength) measurements were made and recorded in situ. Water samples collected in the field were refrigerated at constant temperature for later analysis.

Chlorophyll-a Analysis. Ten ml of water was extracted from each water sample and filtered through a 0.45-μm-pore-size glass-fiber filter. The filter was placed in a scintillation vial and 1 ml of magnesium carbonate added. Each scintillation vial, holding one filter, was frozen for 48 hours, after which 9 ml of acetone (100% extract) was added. The samples were then placed in a refrigeration unit for an additional 48 hours and stirred once every 24 hours. After 48 hours, the fluorescence of the samples was determined using a Turner fluorometer and following the procedures of Parsons et al. (1985). The amount of chlorophyll-a was determined from the expression:

$$\text{mg chlorophyll-a/m}^3 = F_D \times 2.10(R_B\text{-}R_A)v/V$$

with F_D: 1x = 0.8523, 3x = 0.3012, 10x = 0.1175 and 30x = 0.0403. Standard deviation between field replicates was determined to be 0.5 mg/m^3 in a previous study (Althausen and Pinckney, unpubl. data).

Salinity Analysis. Twenty ml of water was run through a Custom Acoustics Induction Salinometer Model 2100 for salinity determination. Each sample was run in duplicate, and the mean tabulated. Instrument accuracy was ±0.05 ppt.

Suspended Sediment Filtration. The techniques of Schubel (1967) for measuring suspended sediment concentrations by filtration were followed. Pre-weighed, dried, and desiccated glass-fiber, 0.45-µm-pore-size filters were used. For each analysis, as much as 500 ml of water was pumped through the filter. Each filter with sediment was dried, desiccated and re-weighed. The weight of suspended sediment per volume of water (mg/l) was calculated for each sample, using the difference between "after" and "before" filter weights divided by the volume of the water sample. Standard deviation between field replicates was determined to be 2.0 mg/l in a previous study (Althausen and Pinckney, unpubl. data).

Data Analysis. Each of the water quality constituents examined can cause selective scattering and absorption of light in an estuary. The amount of light transmitted through a water column is thus dependent upon the biological and physical elements present. Chlorophyll-a, salinity, suspended sediment, temperature and tidal angle (Pinckney and Zingmark, 1991) were chosen as independent variables representing the biological and physical elements, because each varies in quantity in three spatial dimensions and does not usually significantly influence the others in an estuary. Statistical analysis was performed on each data set to see if any correlations could be found for the different variables. To carefully examine the critical effects that chlorophyll-a, salinity, suspended sediment, temperature and tidal angle can have on transmissivity, a stepwise multiple regression (Wolpert, 1964) was performed on each data set. The regression analysis was aimed at determining the extent to which independent variables explain the variance in transmissivity (dependent variable).

Results and Discussion

Summary statistics for the water quality variables measured in this study are given in Table 2. Average water temperatures for the June sampling period were between 25°C and 31°C, and no temperature stratification was identified. Salinity values ranged between 32 ppt and 35 ppt, and no stratification was observed due to the well-mixed conditions of the system. Suspended sediment concentrations varied between 5 mg/l and 55 mg/l. Greatest concentrations were found near the bottom during low tide. Chlorophyll-a values fluctuated throughout the estuary (5 mg/m^3 to 15 mg/m^3); in general, low-tide values exceeded high-tide values. The greater concentrations of suspended sediment and chlorophyll during low tide is most likely due to the resuspension of phytoplankton and sediment during ebb tide.

The relationship between chlorophyll-a and suspended sediment is important for an estuary that has a well-developed turbidity maximum zone (TMZ) and chlorophyll maximum zone (CMZ) (Cochlan et al., 1990). High concentrations of chlorophyll-a are usually found near the upstream boundaries of the TMZ (end of the estuarine mixing zone), where the nutrient-limiting/light-limiting boundary occurs in an estuary (Pennock, 1985). Because North Inlet receives very little fresh water discharge, partially mixed conditions, usually associated with the TMZ and CMZ, do not exist. The persistent well-mixed conditions, identified with Town Creek, reduce the likelihood that a TMZ or CMZ will form.

A transmissometer was used to make optical measurements at a wavelength of 630 nm over a 10-cm-pathlength cell. Variables that can affect light transmissivity in an estuary include suspended sediment, salinity, nutrients, humic acids, chlorophyll and plankton patches/blooms (Fisher et al., 1988). Variability in transmissivity can be attributed to the high residuals associated with a transmissometer reading. The transmissometer used in this study showed a ±5-percent variation in reading over a 30-second period over a fixed position near the bottom of the water column.

When suspended sediment was linearly regressed on transmissivity (Figure 2), a relatively poor correlation was found (r^2 = 0.37). This poor correlation suggested that other variables were involved in explaining the variance associated with light transmissivity. A stepwise multiple regression analysis was then carried out to see if a statistical model could be found to explain most of the variance associated with light transmissivity. Chlorophyll-a, salinity, suspended sediment, temperature and tidal angle were placed into the stepwise regression with the hopes of separating the variables causing the critical effects, from the variables that were not playing a significant role in explaining the light transmissivity. The t-values were used for significance testing of all five independent variables. The stepwise regression showed that chlorophyll-a (CHLA), suspended sediment (SS) and tidal angle (TANG) all play a significant role in explaining the variance (R^2 = 0.70) associated with light transmissivity (TMS) (Figure 3). The multiple regression is expressed by:

$$TMS = 83.75 - (0.94 * CHLA) - (0.90 * SS) + (4.24 * TANG)$$

Salinity and temperature were rejected by the stepwise regression because of their collinearity with chlorophyll-a. The collinearity most likely resulted from the estuary's well-mixed conditions.

Conclusions

When multiple regression analysis is used to evaluate correlations between biological/physical water constituents and transmissivity, significant coefficients of multiple determination are found. In past studies, transmissivity usually has been used to determine the amount of suspended sediment present in the water column (Campbell and Spinrad, 1987; McCarthy et al., 1974). Although those studies produced some meaningful results, the present study suggests that if other biological/physical variables had been included with suspended sediment in a regression with transmissivity, the results would have been more significant. It is hoped that future studies will be able to use the methods described here to correlate biological and physical constituents with transmissivity and, consequently, to reduce the amount of field work required for a water quality analysis study.

Some of the unexplained variability associated with transmissivity that was not accounted for can most likely be associated with the other biological/physical constituents, such as humic acids, nutrients and freshwater discharge, that were not tested for in this study.

Acknowledgements

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Table 1. Location of longitudinal sampling stations.

Station	Name	Distance (km) from Mouth
1	North Inlet Mouth	0.0
2	Jones Creek	1.1
3	Debidue Creek	2.0
4	Lone Tree	2.7
5	Old Man's Creek	3.0
6	Shoal Point	3.3
7	Shoal Bend	3.7
8	Clambank Creek	4.2
9	Oyster Landing	5.0
10	Sixty Bass Creek	5.5

Table 2. Basic summary statistics for North Inlet data set.

Variable	n	Mean	Std. Dev.	Minimum	Maximum
Chlorophyll-a (mg/m^3)	179	7.48	3.01	3.82	15.81
Salinity (‰)	179	34.00	0.87	31.98	35.23
Suspended sediment ($mg \cdot l^{-1}$)	179	17.20	4.78	7.50	33.50
Temperature (°C)	179	28.61	1.99	25.30	33.60
Tidal angle (cosθ)	179	0.10	0.77	-1.00	+1.00
Transmissivity (%)	179	61.59	9.27	36.79	77.12

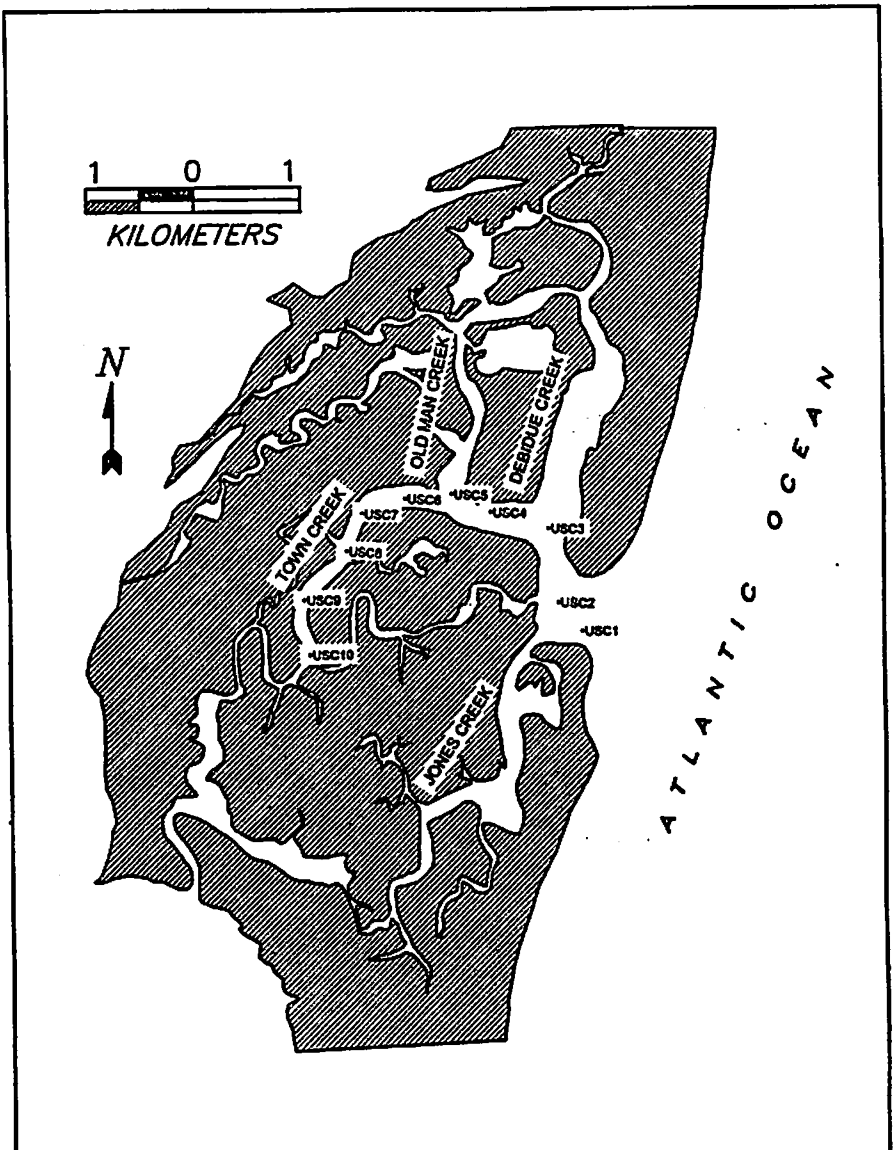

Figure 1. Map of North Inlet indicating the 10 sampling stations along Town Creek. Three small tributaries that feed into Town Creek are Debidue Creek, Jones Creek and Old Man Creek.

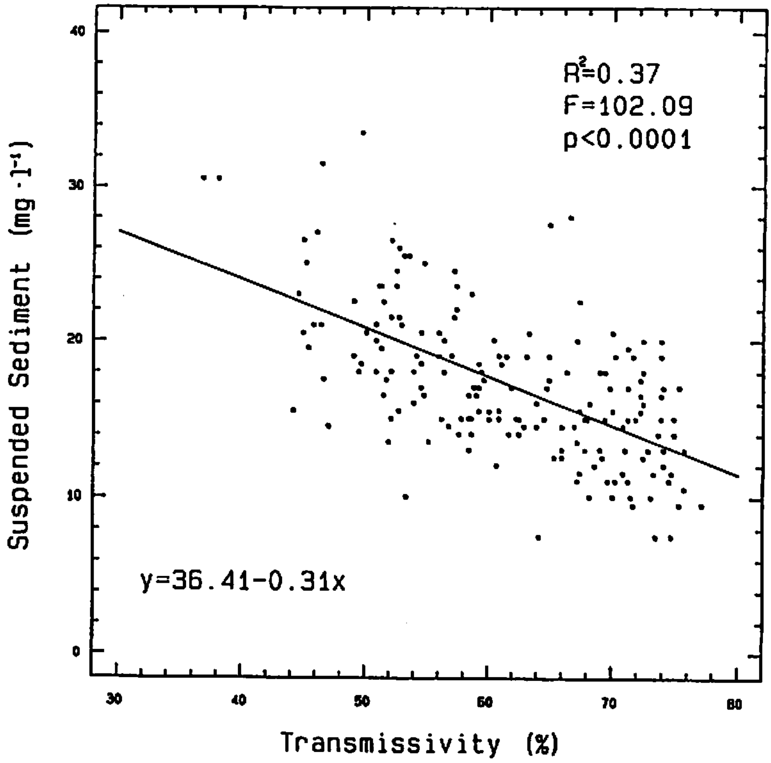

Figure 2. Linear regression of suspended sediment (mg·l^{-1}) on transmissivity (%) for North Inlet (R^2 = 0.37).

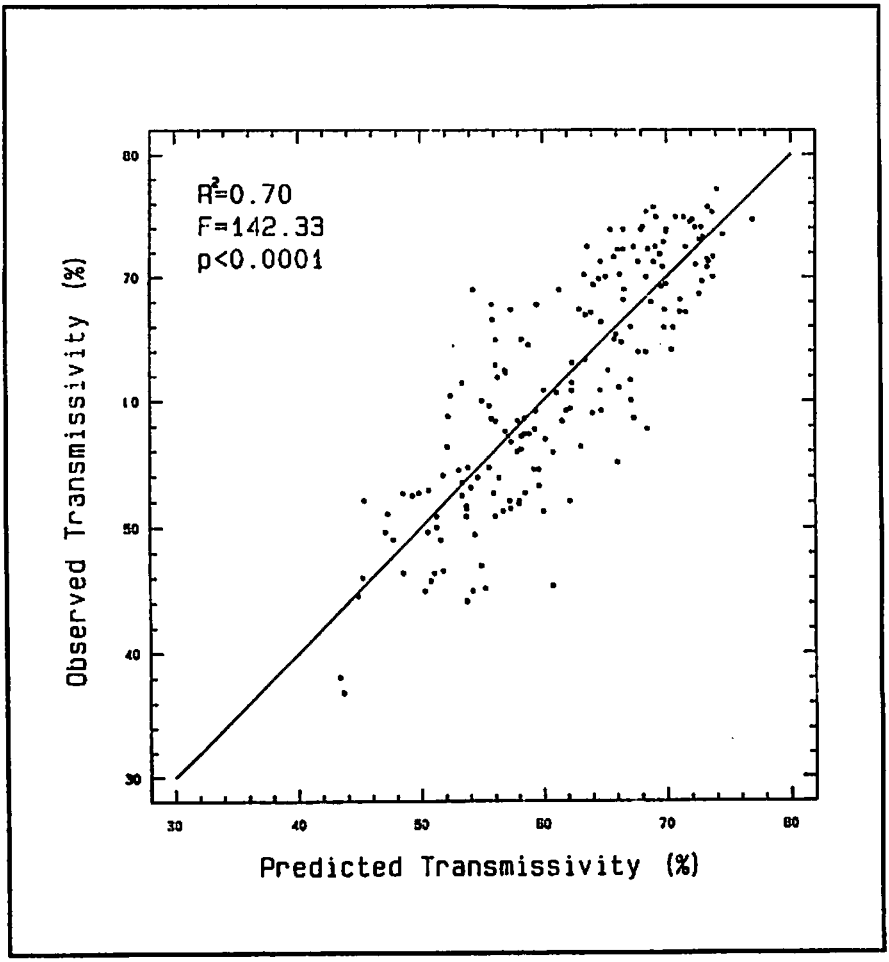

Figure 3. Regression of chlorophyll-a, suspended sediment and tidal angle on transmissivity for North Inlet (R^2 = 0.70). Two variables excluded from the step-wise regression analysis were salinity and temperature.

Pollution: Non-Point Sources

STRUCTURAL AND NONSTRUCTURAL BEST MANAGEMENT PRACTICES FOR THE MANAGEMENT OF NON-POINT-SOURCE POLLUTION IN COASTAL WATERS: A COST-EFFECTIVENESS COMPARISON

Thomas H. Cahill and Wesley R. Horner
Cahill and Associates

Abstract

The objective of this paper is to demonstrate that a growing water quality-related problem in coastal waters—increased non-point-source pollutant loadings—not only can be substantially reduced through use of nonstructural best management practices, but that this non-structural approach is significantly less expensive and more effective than the array of structural techniques that have been receiving wider application in recent years. One particular nonstructural approach to non-point source water quality management, *minimum disturbance/minimum maintenance*, is described in some detail below. A case study using hypothetical "Coastal County" has been developed. A cost comparison between non-structural and structural techniques in this hypothetical county has been set forth, demonstrating the marked cost-effectiveness of the non-structural approach.

Introduction

U.S. coastal and near-coastal waters suffer from a variety of quality problems. Although substantial data gaps make thorough analysis of water quality and water quality trends difficult, coastal water quality problems have been documented that are reflected in the algal blooms and dissolved oxygen sags observed in recent years in coastal waters. Furthermore, if the water quality data record was more complete, other water quality problems in all likelihood would be detected.

> A number of coastal areas, including Chesapeake Bay, New York Bight, and the Louisiana coast have experienced eutrophication and/or hypoxia in recent years. ... Many of the environmental quality problems affecting the Nation's estuaries stem from natural and human-induced pollution produced both within and upstream of EDAs (estuarine drainage area). Both can affect dramatically the biological productivity of estuarine waters, as well as reduce the appeal of these environments for living and recreating. Beach closures, fish consumption advisories, and evidence of toxic substances in sediments and fish tissue are all indications of pollution-related declines in the quality of estuarine and coastal waters (NOAA, 1989a). (NOAA, 1990, p. 11.)

Water quality in coastal systems is a function of both point and non-point sources of pollution. In recent years, substantial effort has been put forward to upgrade the point sources discharging into coastal waters, especially municipal sewage treatment plants. In the process, large new secondary sewage treatment plants have been constructed, often regional in nature, that have eliminated major sources of bacterial and organic contamination of rivers, estuaries and bays. Most of these new plants have substantially increased treatment capacity, which has accommodated, if not promoted, a surge of growth and development in recent years. Available sewage treatment capacity from these municipal treatment plants will be able to serve additional growth in the future as well. These new sewage treatment plants typically discharge their wastewater effluents directly into the ocean, typically 1,000 ft. or more offshore. Even these new plants, however, fail to remove substantial quantities of nutrients, phosphorus and nitrogen from wastewater during treatment.

Exacerbating the problem is that this increased sewage treatment capacity also tends to accelerate and induce land development, further increasing important non-point-source pollutant loadings (nutrients and others) to coastal waters. This long-acknowledged growth stimulation tendency of excess wastewater treatment plant capacity is amplified in coastal regions by a set of larger dynamics that are already at work, shifting people and jobs to coastal areas nationwide. Although reasons for this migration to the coast are not totally obvious, this migration far transcends simple vacationing at the shore during summer months. The migration includes year-round residential dwelling units, development of an employment base, schools and other facilities and services—far more significant than high-rise hotels along boardwalks. The preponderance of this new development *area-wise* is occurring on mainland areas, which also are located within coastal drainage areas. Aerial photos reveal large expanses of new development extending inland from the coastline. These expanses are the source of ever-increasing quantities of non-point-source pollutant loadings, which ultimately are transported into coastal waters.

Non-point-source pollution is a watershed-wide phenomenon; most pollutants are scoured from the land surface and transported by stormwater. Non-point-source pollutants are both soluble and particulate, with soluble forms tending to be transported much greater distances once dissolved into the water column. Particulate pollutants tend to settle out, although they still can be resuspended and moved considerable distances over time. Impervious surfaces, especially paved areas, tend to produce the highest levels of particulate non-point-source pollutants, although impervious areas also can generate some soluble loadings. Traditionally, non-point-source pollution in urban areas has been thought of primarily in particulate terms—as runoff from parking lots and streets carrying metals, hydrocarbons, and other matter. These non-point sources are vital to manage but are only part of the non-point-source problem. Increasingly, expanses of new development generate large amounts of soluble nutrients, pesticides and herbicides, continuing year after year after construction is completed and the site is stabilized.

Chemicals, especially nutrients such as nitrogen and phosphorus, are being applied in ever-increasing amounts throughout expansive areas of maintained landscape—the lawns and gardens accompanying the residential and nonresidential development occurring throughout coastal watersheds. During rains, considerable fractions of these chemicals wash off directly into surface waters and infiltrate the groundwater, facilitated by large-particle-size sandy soils and the quick interconnection between the ground and surface water systems. In either case, these chemicals enter the surface water system, and coastal waters become enriched and degraded.

Part of the dilemma in coastal watersheds is related to the soils and geology of much of the coastal watershed area, which allow for many landscaping chemicals to pass so rapidly through the ground and into the surface water system. The large-particle sandy soils found here promote rapid infiltration of stormwater and then an equally rapid movement from the shallow aquifers and into the surface water system. Pollutant loadings enter back bays and estuaries, causing diverse water quality problems; they ultimately are discharged through inlets into nearshore ocean waters where the problems continue. The soluble non-point-source pollutants, such as nitrogen from fertilizer applications, tend not to settle out but to continue moving through the system, promoting algal blooms and dissolved oxygen problems, for example. Of course, the complete water quality picture is infinitely more complicated than is being described here. Problems of atmospheric deposition are of growing importance and concern. Illegal discharges of all sorts from recreational boating occur; even the presence of large wildlife populations can add to pollutant loadings.

Another part of the dilemma is that maximum allowed densities of mainland development tend to decrease significantly with distance from the shoreline itself. Many communities, facing increased development pressure, have attempted to limit densities and keep lots—and lawns—as large as possible. The result has been that ever-larger areas of coastal watersheds are being converted to maintained areas to which fertilizers, pesticides and herbicides are applied in ever-increasing amounts year after year. The ongoing nature of this pollutant source stands in stark contrast to the problem of erosion control during the construction phase. Given the external development pressures impingeing upon coastal watersheds, the ironic effect is that larger and larger areas are being consumed and converted to land-cover conditions that generate such non-point pollutants. To recapitulate, it is not only the impervious areas associated with land development that cause water quality problems; the pervious areas, which have not been of great interest in the past, pose increasingly serious problems.

Unfortunately, these chemical applications in and around developed areas, which generate non-point-source pollution, are expected to increase rapidly. As serious as this problem of chemical applications might be, prospects for the future are grim. These prospects are related largely to growth and development projections that have been prepared for coastal watersheds. Most coastal states have been experiencing and are expected to continue to experience an in-migration. The exact reasons for this in-migration are not altogether clear. Nevertheless, the trend is quite real and far transcends the historical tendency for recreational and seasonal development to predominate in so many shore communities.

> Many of the Nation's coastal areas are under increasing pressures from population growth and related development. About 110 million people—almost one-half of our total population—now live in coastal areas. By the year 2010, coastal population will have grown from 80 million to more than 127 million people, an increase of almost 60 percent nationwide. Some states, including Florida, will have increased more than 200 percent. (Culliton et al., 1990, p. 1.)

The NOAA report develops an array of interesting statistics:

> Seventeen of the 20 states with the largest statewide population increases are coastal. ... Eight coastal counties in California and Florida will be in the top 10 counties in absolute population change between 1988 and 2010. ... By 1988, population density in coastal counties reached 341 persons per square mile, more than four times the U.S. average. Population density in coastal areas is

expected to increase as more people continue to move into this limited space. (Culliton et al., 1990, p. 4)

These growth statistics relate exclusively to year-round population and are not affected by seasonal and recreation-linked growth and development. This development will occur in addition to year-round residential and non-residential development. With point-source discharges increasing as well, the worst may well be yet to come in terms of coastal water quality.

Structural Best Management Techniques

Different approaches to reducing non-point-source pollutant include both structural and non-structural management measures. For the past 20 years, the conventional approach to stormwater management in new developments has been control of the peak rate of runoff through use of detention basins. In recent years, this concept of detention basins has been modified, with engineers attempting to improve pollutant removal capability through making these dry detention basins into wet basins (also called retention basins) with permanent pools of water, where more pollutants settle out. Adding wetland vegetation species to the wet basin design removes more pollutants. A few artificial wetland systems have been constructed for stormwater management in which stormwater is retained for several days, possibly even weeks. Other designs have utilized infiltration techniques, the objective being to put any stormwater generated back into the ground as close to the source as possible. Examples of infiltration include porous pavement built over stone-filled recharge beds, infiltration basins, dutch drains, and other techniques. All of these relatively recently developed techniques are included under the category of structural management techniques, where some sort of facility is constructed to remove pollutants already loaded and to reduce stormwater already generated.

Structural management techniques usually occur on a site-by-site basis and include wet ponds (retention basins); artificial wetlands; infiltration basins, trenches, and dutch drains; and detention basins. In the few cases where non-point-source pollution has been taken seriously, these structural techniques typically have been the practices used most often (although experience with these structural techniques is increasing rapidly, their application and use have not been studied over an extended period of time, in numerous different settings, by a variety of researchers). Of course, some structural BMPs work better than others; some have certain site requirements; and some are more expensive to construct and operate than others. In all cases, however, the essence of the structural technique is the same—some sort of facility is designed, engineered and constructed to solve a problem, namely, to remove pollutants that have already become a part of the runoff or to recharge stormwater that has run off of a surface that has been made less pervious.

Non-Structural Techniques:
Minimum Disturbance/Minimum Maintenance,
A Non-Structural Example

A different option—the focus of this paper—involves the *non-structural* approach to managing non-point-source pollution. The non-structural approach by definition is preventive. The essence of the non-structural approach to stormwater management is to intervene early in the management process, even before the stormwater problem has been created—before the volumes of runoff have increased and non-point-source pollutants have been created and introduced into the environment's surface and groundwaters. Because of their intervention and preventive nature, non-structural techniques have the potential of being both more effective in terms of pollutant removal capability as well as significantly less expensive to implement than most other structural techniques.

Different non-structural management approaches can be developed. *Minimum disturbance/minimum maintenance* site development is one such management technique that was developed to reduce, if not eliminate, stormwater impacts associated with developing areas. Minimum disturbance/minimum maintenance is a term assigned to a highly conservative approach to site development, in which clearing and site grading are allowed only within a carefully prescribed building envelope. It avoids new landscapes, created at great expense, that typically include proliferations of non-native plant species. These same created landscapes require substantial amounts of water, nutrients, and pesticides and herbicides (and money and time) to keep them in good condition. The transformation of land cover from forest into lawns or other high-maintenance vegetated areas also increases runoff volumes and peak discharge rates. In terms of water quality, minimum disturbance/minimum maintenance avoids the non-point-source impacts associated with the chemical applications of fertilizers, pesticides, and herbicides resulting from land development.

The minimum disturbance/minimum maintenance zone of disturbance includes the area required for proposed structures and any related utilities, driveways and walks. Areas outside of the disturbance zone are left in natural vegetation. Following construction, disturbed areas immediately adjacent to the structure and driveways and walks are revegetated with indigenous species that require minimal or no maintenance. The completed site does not require ongoing fertilization or applications of herbicides and pesticides, although some minimal level of maintenance and selective cutting may be appropriate seasonally. Lawns are not permitted; special plantings may be accommodated through containerization. In summary, the minimum disturbance/minimum maintenance concept has evolved precisely to prevent non-point-source problems. The approach can and should overlie a natural drainage system protection plan, in which disturbance or construction would not be allowed within drainageways and adjacent buffer zones in any case. In such a context, natural areas left intact as the result of minimum disturbance/minimum maintenance would reinforce the natural functions of the drainage system. In a sense, minimum disturbance/minimum maintenance is the logical extension and refinement of the natural drainage system preservation concept.

Several additional points regarding minimum disturbance/minimum maintenance need to be emphasized. The minimum disturbance/minimum maintenance approach offers great promise from a user perspective. Elimination of costly and time-consuming maintenance requirements such as lawn-mowing should be a boon to coastal property owners. Presumably, recreationally oriented users want to be freed of as many ownership maintenance responsibilities as possible, including ongoing lawn fertilization and spraying. To the extent that development is retiree-oriented, elimination of many of these responsibilities should be especially attractive. Secondly, although the natural landscape may at first appear unconventional and unaesthetic to some, the beauty of the natural vegetation will come be appreciated in time. Thirdly, this technique, when viewed within the context of different non-structural program options available, offers a remarkable degree of effectiveness while avoiding many of the drawbacks of more far-reaching planning and growth management programs. Institutions and agencies in other non-point-source management contexts have opted to identify environmentally sensitive areas and critical areas within coastal drainage and have attempted to prevent or minimize development within them. However, the potential for such programs to provide broad, watershed-wide coverage within an impacted estuary or coastal system is limited. Minimum disturbance/minimum maintenance provides watershed-wide management, while accommodating development with a minimum of water quality impact.

Again, this evaluation of non-structural measures focuses on a subset of the total non-point-source water quality problem—the generation of nutrients, pesticides, and herbicides from maintained lawns and other portions of the pervious landscape. Nevertheless, this non-point problem is becoming an increasingly critical part of the total water quality problem in coastal waters. In terms of a comprehensive management program, structural management practices also must be used when the non-structural approach is inappropriate.

Pollutant Generation and Pollutant Removal Effectiveness of Non-Structural and Structural Best Management Practices

To develop the cost comparison between the non-structural and structural practices under study here, measures of both pollutant generation and pollutant reduction effectiveness have been established. These measures are empirically based when possible but also require a variety of assumptions regarding coastal watersheds in many areas.

Studies of potential production of non-point-source pollutants from different land uses and vegetative covers have been developed, but little of this information has been developed within coastal drainage systems. The various estimates of pollutant loading, or mass transport produced per unit area of drainage on an annual basis, reflect numerous assumptions and conditions. The available estimates also tend to be grouped by land uses and impervious cover percentages, such as "residential, 40-percent impervious cover." Many sources suggest that a linear relationship exists between impervious cover and pollutant production, with non-point-source loadings increasing as impervious cover increases. Such a relationship, however, is not consistent with the fact that, as the percentage of impervious cover increases with any given type of land use, the absolute amount of fertilized and maintained land per unit area decreases. In fact, recent studies of the New Jersey coastal zone (Cahill Associates, 1991) suggest that the maximum production of certain non-point-source pollutants, nitrogen and phosphorus, occurs when the impervious cover percentage is about 40 percent in single-family residential land use. In terms of non-point-source nutrient generation, percent pervious or amount of area being maintained is a better measure of nutrient production in the context of single-family land use.

Furthermore, simply classifying a land area as residential fails to consider the degree of land maintenance and chemical application. For example, in the mid-Atlantic coastal setting, much residential development occurs on unconsolidated coastal plains with sandy soils, which must be frequently fertilized and watered if a viable lawn is to be maintained. For New Jersey, fertilizer application on coastal soils averages 129 lbs/ac/yr for total nitrogen and 33 lbs/ac/yr for total phosphorus. In the "Coastal County" example presented below, given the density assumptions used in this analysis, approximately 80 percent of a new single-family residential development lot would be maintained and fertilized. Therefore the amount of non-point-source pollution potentially generated would be less (103 lbs/ac/yr for total nitrogen and 26 lbs/ac/yr for total phosphorus).

Unfortunately, total nitrogen and total phosphorus *delivery* into coastal waters have not been measured. Some fraction of the applied fertilizer ultimately enters coastal waters, through either direct runoff or indirect movement into the groundwater and then into ocean waters (to the extent that nutrient applications are efficient and are consumed by vegetation, pollutant loadings are decreased). Using a conservative estimating methodology in this study, a uniform pollutant loading factor has been assumed at a rate of 8.7 lb/ac/yr for total nitrogen and 0.9 lb/ac/yr for total phosphorus (Table 1). Assuming the validity of the application loadings given above (103 lbs/ac/yr for total nitrogen and 26 lbs/ac/yr total phosphorus), less than 10 percent of the total application rate of nitrogen assumed here enters coastal waters; only 4 percent of the total phosphorus application rate used here is assumed to enter coastal waters. Because the pollutant delivery rates used in this analysis are extremely conservative (i.e., low), delivery rates several times as great probably hold true for areas with particularly sandy soils, typical of many coastal watershed areas.

In terms of pollutant removal effectiveness of the different management practices, the non-structural minimum disturbance/minimum maintenance practice is expected to achieve complete pollutant removal effectiveness (100 percent, as listed in Table 1) in terms of the nutrients nitrogen and phosphorus, as well as all of the other non-point-source pollutants that result from land maintenance, such as pesticides and herbicides. In a sense, pollutant removal effectiveness is a misnomer in this case, as these pollutants are not generated or loaded in the first place. The basic assumption of this analysis is that the minimum disturbance/minimum maintenance approach will eliminate fertilizer applications as assumed above in the pollutant loading analysis. For the purposes of this comparison, only nutrient loadings and removal rates have been included. Of course, other pollutant loadings not related to landscape management throughout pervious areas will not be affected by the minimum disturbance/minimum maintenance option. This also means that the forms of nitrogen and phosphorus generated from impervious surfaces will still be contained in urban runoff. In addition, some background amounts of suspended solids and organic matter will continue to be generated from the landscape, even when the minimum disturbance/minimum maintenance practice is applied. The Coastal County scenario established here for cost comparison is based on moderate-density, single-family residential development, which can be expected to generate minimal quantities of these other impervious area-related pollutants.

Major categories of structural BMPs are considered in Table 1 for comparison with non-structural BMPs. While these represent general groups of measures, such as infiltration technologies, many variations are possible for any given method. Variations in design can greatly influence the effectiveness of non-point-source pollutant removal by any given structural technique. Overall, the pollutant removal factors used here for structural techniques are reasonably high and assume effective installation and maintenance practices, again in order not to bias the comparison in favor of the non-structural approach. Infiltration technologies have been demonstrated to be reasonably efficient nitrogen removers (assumed here at 50 percent) and extremely effective phosphorus removers (90 percent; total removal is probably somewhat optimistic); these removal rates can be expected to be very much linked to soil properties, such as its cation exchange coefficient rating. Rates of removal much greater than 50 percent for even solubilized nitrogen can be accomplished with heavy, small-particle soils with high cation exchange coefficients.

Constructed or artificial wetlands also have high percentage removal values (70 percent for total nitrogen and 90 percent for total phosphorus), primarily because included here is the assumption that harvesting of biomass generated in the wetland by added nutrients will be required for nitrogen and phosphorus removal. In practice, virtually all of the wetland systems used for stormwater management do not use any sort of biomass harvesting and removal. If these systems are assumed to be the model for this structural technique, then non-point-source pollutant removal efficiency greatly decreases, as do the operating and maintenance costs. For wet ponds/retention basins, pollutant removal percentages are not as great. Use of wet ponds/retention basins here does not assume any kind of biomass removal program; therefore, wet ponds are less efficient over the long term as non-point-source reduction measures. Also, wet pond efficiencies given here assume that 10 wet ponds will be constructed on a site-by-site basis. These ponds will be viable systems; however, enhanced pollutant removal efficiencies achieved through larger systems (i.e., a system of areawide wet ponds for Coastal County) has not been assumed here, given the added institutional and other complexities of an area-wide system. Traditional detention basins have removal rates of 20 percent for total nitrogen and 30 percent for total phosphorus.

Table 1 combines pollutant loading rates with these pollutant reduction effectiveness percentages. The final column in Table 1 applies these pollutant reduction effectiveness proportions to the 500 acres/500 units of residential land development being hypothesized for Coastal County (see discussion below) on a yearly basis for an estimate of the water quality benefit being achieved by the different management practices.

Costing Methodologies

The overall study methodology developed for this report has been designed to test the different costs and levels of pollutant removal effectiveness of several structural approaches and one specific approach to non-structural practices for non-point-source pollutant reduction. Most important are the *relative* differences in cost-effectiveness results, rather than the *absolute* size of the numbers. Assumptions used have been conservative; unit costs developed for quantities of pollutants removed may appear to be high. These results, and the methodology itself, should be adjusted if absolute costs are of prime concern and if, for example, the question being evaluated is whether or not to reduce non-point-source pollutant loadings in the first place. This report assumes that reduction in non-point-source loadings is necessary; the concern here is how to achieve this reduction in the most cost-effective way.

Comparison of *structural* stormwater management techniques implemented typically on a site-specific of unit area basis to *non-structural* stormwater management approaches is made difficult by their lack of comparability in many respects. How does one reasonably compare arrays of infiltration basins and wet ponds at specific sites with planning programs that tend to be so much more "macro" in scope? Structural non-point-source management practices can be assessed individually in terms of their pollutant removal effectiveness and their respective costs, whereas non-structural practices are much more difficult to evaluate in these and other ways. Structural techniques tend to be quite site-specific, allowing construction costs to be identified relatively specifically. Whereas the non-structural minimum disturbance/minimum maintenance program becomes area-wide with cost elements (such as program staffing) hardly comparable to site-specific structures. Many assumptions must be made in order to arrive at an objective, apples-to-apples comparison. These assumptions, detailed at some length below, have been established carefully so as not to skew results toward the minimum disturbance option.

Because the non-structural minimum disturbance/minimum maintenance approach requires creation of a *program* with a particular geographical jurisdiction for implementation, we have established here a scenario—a hypothetical coastal county in a hypothetical state—where a minimum disturbance/minimum maintenance program has been hypothesized. Costs and effectiveness have been estimated and converted to a unit basis so as to be comparable with costs and effectiveness of alternative *structural* techniques.

Non-Structural: Minimum Disturbance/Minimum Maintenance Costing Methodology

In order to make such a structural to non-structural comparison, the Coastal County scenario must be further refined. Additional assumptions must be made. In further developing this scenario, we have intended to develop a Coastal County that is typical of many of the counties in coastal drainage. Coastal County assumptions include:

> Coastal County is experiencing moderate development pressure, translating into average population growth of 2,500 persons per year. Such an increase of 25,000 persons over a 10-year time period, at minimum, is certainly being experienced by many coastal counties throughout the United States. In general, growth in New Jersey counties is considerably greater and would translate into significantly more development than is assumed in this comparison. Because of the program nature of the non-structural approach and because the non-structural program of minimum disturbance/minimum maintenance relies substantially on an array of fixed expenditures, which to a large extent will remain constant regardless of the number of new developments occurring, these development assumptions are conservative. If more growth occurs, non-structural unit-costs decrease.

This annual Coastal County growth translates into land development as follows: 10 residential subdivisions at 50 acres per subdivision (500 dwelling units on 500 acres gross at a 20-percent impervious ratio; actual building lots would average two-thirds of an acre). Again, these numbers should be understood as averages; real-world variability should not change the nature of the conclusions reached here. The minimum disturbance/minimum maintenance program is applied specifically to these 10 single-family residential developments. Also, an additional 10 developments totaling 500 multi-family dwelling units will be developed on 100 acres (five units per acre at 40-percent impervious). An additional 30 commercial, industrial, and institutional projects on another 150 acres at 40-percent impervious also will be developed. In total, 50 different land developments will be constructed in Coastal County on 750 acres. Certainly, the minimum disturbance/minimum maintenance program could be extended to the multi-family and non-residential developments as well, further distributing fixed program costs across a larger base of projects and thereby reducing unit costs. Factors such as the character of the proposed developments, site constraints (e.g., no existing vegetation), and preferences of the developers can be expected to limit application of the minimum disturbance/minimum maintenance program. To facilitate understanding of the Coastal County scenario, however, we have assumed that the program would be applied only to the 10 single-family residential subdivisions.

Coastal County has in place a development approval process where site development plans must be submitted and approved to the County. Coastal County requires application of non-point-source management practices for effective water quality management, either using structural techniques, as necessary, or the minimum disturbance/minimum maintenance program.

Minimum disturbance/minimum maintenance costs incurred result from the Coastal County minimum disturbance/minimum maintenance implementation program, the annual costs of which are estimated below. In all likelihood, the implementation program office hypothesized here would become an additional work function to be included in an existing land development review process. Although this implementation program could be performed by existing Coastal County staff, the costing methodology developed here assumes the hiring of new properly trained staff with its own program budget. Added program implementation tasks would include ensuring that developers properly and fully integrate the requirements of minimum disturbance/minimum maintenance into their respective site plans. Also, a monitoring task would be necessary during construction to guarantee that the non-structural management practice was being followed. Implementation program costs will be incurred each year and may be viewed as the annual operating costs of this non-structural management approach. These costs are estimated here to be approximately $110,000.In order to initiate the minimum disturbance/minimum maintenance implementation program, a lump-sum expenditure of $50,000 has been assumed for initial studies and the establishment of implementation program requirements for Coastal County. Although federal agencies such as the Environmental Protection Agency would be able to provide general guidelines and technical support regarding the overall minimum disturbance/minimum maintenance philosophy and approach, specific tailoring to the Coastal County context will be necessary. Study tasks would include preparation of ordinance amendments, lists of indigenous plant species and adjustments in program requirements to be compatible with local building practices. Theoretically, such start-up costs should be amortized over the reasonable life of the program, just as capital costs of structural management practices must be amortized over their respective economic lives. In this case, however, we have included this sizable expenditure as a yearly cost. In so doing, this added pool of funds should provide a reasonable cushion for work not completed during the first year of program operation, for any other unforeseen costs to be covered, and for regional cost differentials to be absorbed.

In summary, creation of a new Coastal County minimum disturbance/minimum maintenance implementation program office has been hypothesized to implement this site development concept. Ten single-family residential development proposals would be processed as part of the program, applying this minimum disturbance/minimum maintenance site development concept. Program administrative/technical staff would be hired to implement and oversee the minimum disturbance/minimum maintenance implementation program. These staff actually could be located in a planning commission office or another office involved in development review and permitting. In this sense, the office should be thought of as an added reviewing function, occurring above and beyond reviewing that already is required. Developers using this approach would contact office staff and pursue a particular process established for program implementation. This process would result in the development proposal's compliance with the requirements of the minimum disturbance program. An important element in this interchange with developers would be communication and information exchange. One professional staff plus support person would be able to accommodate such a program with annual costs as follows:

Professional staff	$60,000
Support staff	30,000
Office space	15,000
Office expenses	5,000
Total	$110,000

The manner in which this process occurred could vary to some extent, county by county, state by state. The process would reflect county size, the framework of government agencies, techniques of governance, and numerous other factors. Costs would vary as well. These specific aspects of the program would be established by the initial studies and establishment of program requirements, as discussed above. Nevertheless, this level of staffing should be able to provide adequate service to 10 development projects during the course of one year. A considerably larger number of projects probably could be processed. Also, as experience is gained by the office staff and the minimum disturbance/minimum maintenance concept is better understood by the development community, the need for office services can be expected to decrease as the result of increased program operation efficiencies.

Thus, the application of one program for non-structural management of non-point pollution sources would represent a cost of about $160,000 per year, assuming an ongoing planning and review program. These costs have been entered into the appropriate columns in Table 2. If these program costs are distributed solely across the 500 acres of single family residential development assumed to occur in Coastal County, the unit area cost would be $320 per total acre developed (assuming that only 80 percent of this area, or 400 acres, would be pervious, then the unit cost increases to $400 per acre).

Structural Best Management Practices: Costing Methodology

Table 2 provides cost estimates for both non-structural and the various structural non-point-source management practices. Structural techniques have been estimated on a unit basis, in this case based on cost per cubic foot of stormwater being managed. For structural techniques that must increase in size and expense with amounts of stormwater being managed, this quantitative measure is a logical way to address unit costs. Additionally, cost estimates must be approximated here. Actual site-specific factors will influence unit costs substantially, either increasing or decreasing the costs given here.

Most of the available data on cost for stormwater management facilities is limited to capital construction costs, and much of that information deals with detention basins, for which exists a greater record of experience. Most cost analyses have focused exclusively on construction/installation costs and have failed to include a variety of other relevant cost factors included in the comparison here. For example, a major difference between surface basins, wet or dry, and larger infiltration BMPs, such as porous pavement with underground recharge beds, is that surface systems require allocation of valuable land for BMP installation. With recharge designs, many, if not most, systems become an integral part of the site design and space is used jointly, as in the case of recharge beds situated beneath parking areas, culs-de-sac or other site features. Valid comparison between these BMPs must include this cost of site land area. This land evaluation is fairly straightforward in most development projects because installation of surface basins usually results in a loss in subdivided lots or buildable land area, with a given market value. For the Coastal County scenario used here, this cost of land applied to surface impoundments is estimated to be the elimination of two lots, each with a value of $50,000, for each of the 10 developments anticipated. This adds a land cost of $1 million to the base construction cost per year.

Also, with any surface structure or basin, stormwaters must be conveyed to the appropriate location on the site by means of a systems of inlets and storm sewers. This conveyance system is a significant part of site development costs and frequently costs more than the basin construction. In the Coastal County case study under consideration, the cost per basin is estimated to be $100,000 and includes this infrastructure cost. For the developments hypothesized, two such basins per site, and 10 sites per year, add up to a capital cost of $2 million per year, and a total cost for the least expensive BMP, dry basins, of $3 million per year in Coastal County.

Again, only the single-family residential component of new growth hypothesized for Coastal County is assumed to be managed in this cost-comparison analysis. For structural techniques, the total volume of stormwater subject to design criteria must be estimated. This volume is derived from several criteria frequently used to estimate surface basin volume storage and recharge system bed storage: retention of the net differential increase in a design storm (perhaps the "100-year" storm), or retention of the total post-development volume for a storm of much greater frequency, such as the one-year storm. This number varies greatly in different hydrologic regions, of course, but if a mid-Atlantic setting for Coastal County is assumed, then we might anticipate the need to store or detain some three inches of runoff for each new area of impervious surface generated. In the assumed case study, this translates into about 100,000 cubic feet of stormwater per Coastal County development of 50 acres each with 20-percent impervious cover, or one million cubic feet of storage required. Although this amount will vary greatly, as long as the assumption made is uniform, the relative comparison among BMPs will be valid.

Thus the dry basin structural BMP reflects a total development cost of $3 million to manage some one million cubic feet of stormwater per year in our 10 new developments, for a unit cost of $3 per cubic foot, as shown in Table 2. For the infiltration technologies that are fully comparable with retention basins, capable of storing the full volumes estimated in this example, the unit costs are derived from the data that are not yet published. The construction cost per square foot is greater than that of the surface basin (it includes the cost of porous pavement surface); however, the total cost is about the same, shown here as $3 per cubic foot of storage.

For the wet basin BMP, the unit cost reflects the initial landscaping of the basin, the sediment removal pre-treatment step, and the increase in surface area to accomplish a greater retention period and standing pool volume. The unit cost, again including the land value and infrastructure elements, is estimated at $4 per cubic foot. The constructed wetlands BMP also reflects these issues of increased volume and retention period criteria, but in a substantially greater amount. On the other hand, the land value of locations in which wetlands can be created is generally less from a development perspective, with high water table and poor drainage conditions reducing the value of finished land. For this BMP, a unit cost of $5 is estimated, although the actual experience record is almost non-existent for the design proposed, which includes provisions for biomass removal.

Column 3 in Table 2 amortizes total construction costs over an assumed 30-year economic life of the facilities. For example, amortized annual costs would be $270,000 at 8.5 percent over 30 years for the $3 million estimated for either the infiltration techniques or the detention basins. The percentage rate, of course, is assumed to be constant for all management practices; economic life also has been assumed to be 30 years for all of the structural techniques.

In Column 4, other indirect costs related to the structural BMP approach figure to be far greater. Estimates reflect costs of continuing those land maintenance practices that would be made unnecessary by the non-structural BMP—growing and maintaining a lawn and other landscaping. If these costs are included in the cost comparison, all structural BMPs become much more expensive. Inclusion of this cost category requires the making of more assumptions regarding the Coastal County scenario. Most importantly, the structural approaches all assume that the 500 new single-family homes will receive conventional maintenance practices for new lawns and landscaped areas.

If residential lots are assumed to be about two-thirds of an acre in size, the do-it-yourself conventional maintenance option on such a residential lot would be a conservative $200 per year for fertilizer, insecticides and herbicides with annual equipment amortized at about $200. This minimum of $400 per dwelling unit for conventional maintenance practices totals $200,000, not entering any value for the 100 hours of mowing and general landscaped area upkeep per year per dwelling (total of 5,000 hours of owner labor for 500 homes). At the other end of the spectrum, these fees would increase to $1,300 per dwelling unit, if chemical application is supplied by a contracting service ($400 per year for six applications) and lawn mowing is contracted out ($900 per year), for a total of $650,000. In other words, these indirect annual costs range from another $200,000 to $650,000 for the 500 single-family dwelling units, above and beyond the amortized capital and operating costs, which range from $270,000 for dry detention basins and infiltration practices to $450,000 for artificial wetlands. In Column 5 of Table 2, the operating and maintenance expenses (O&M) of each BMP are estimated. This annual expenditure reflects the cost of supporting a non-structural program (see text above), maintaining porous pavement surfaces, removal of macrophytes and algae from constructed wetlands, or the removal of sediment from detention/retention basins. For the detention basin BMP, annual operating/maintenance costs for the 20 stormwater structures located in 10 different locations is estimated to be $80,000 in total (i.e., approximately $4,000 per facility; includes periodic inspections plus basin maintenance, sediment and debris removal, and all other necessary tasks). Costs for wet basins are somewhat less, as wet basins are more self-maintaining with the exception of periodic dredging. Artificial wetlands, with harvesting/biomass removal, require greatest upkeep.

Table 2, Column 6 makes the assumption that design and engineering fees required for the system of detention basin structural BMPs would be roughly equivalent to the background study assumed here for minimum disturbance/minimum maintenance option. In all likelihood, engineering and design for any of the structural practices would be significantly greater than for the non-structural minimum disturbance/minimum maintenance option. For example, preparation of plans and specifications for structural stormwater management systems often increases total project costs by $25,000 per project, assuming that some erosion and sediment control measures are required. Some structural techniques such as artificial wetlands can be expected to be more costly. Costs per project have been assumed to range from $5,000 (using either detention basins or infiltration practices) to the $8,000 per development for artificial wetlands. These design and engineering costs would be incurred prior to construction. As above, we are assuming that Coastal County requires submission of development proposals for planning and engineering review. Presumably, this capability would be necessary for a program of structural BMPs to be installed. Costs estimated for structural practices have been set conservatively low.

Finally in Column 7, the total of all annual costs are summarized. Totals indicate that the least expensive structural BMP represents an annual cost ranging from $580,000 to $1.23 million ($1,160 to $2,460 per acre) for stormwater management for 500 acres of new single-family development. To simplify the cost-effectiveness evaluation in Table 3, only low-range figures, shown in Column 7 of Table 2, will be used as the basis for cost comparison.

Comparison of Results between Non-Structural and Structural Approaches to Non-Point-Source Management

Results indicate that the non-structural minimum disturbance/minimum maintenance approach offers substantially greater pollutant removal potential at far less cost than other structural techniques. Figure 1 illustrates the substantial differences for total nitrogen removal. Table 3 combines the non-point-source pollutant removal quantities presented in Table 1 (the water quality benefit) and compares the annualized cost for each management technique developed in Table 2. This comparison allows a numeric expression of a type of benefit-to-cost ratio; in this case, Table 3 results are expressed in terms of dollars required per pound of pollutant eliminated or in terms of quantity of pollutant eliminated per $1,000 spent. Again, data appearing in Table 3 should be considered in relative terms and were developed as a basis for the comparison between structural management practices and non-structural management practices. The absolute values of these numbers should not be used out of this particular context.

Table 3 indicates that the non-structural management practice, defined here as minimum disturbance/minimum maintenance, translates into an annualized cost of $320 per acre in order to prevent the discharge of 8.75 lb/ac/yr of total nitrogen and 0.87 lb/ac/yr of total phosphorus from entering coastal waters. The non-structural practice costs $37/lb/yr for total nitrogen and $384/lb/yr for total phosphorus. In reality, this expenditure of $320 per acre results in the reduction of both the total nitrogen and total phosphorus, as well as a variety of other pollutants (including herbicides and pesticides) that this study does not consider. In other words, dividing the total cost by either the nitrogen totals or phosphorus totals is not methodologically valid in a true benefit-cost sense (ideally, the $320 should be proportioned out among the various pollutants eliminated). Practically speaking, non-point-source management and related nutrient reduction programs usually are focused on "limiting" pollutants, typically either phosphorus *or* nitrogen, where the water quality objective becomes reduction of one or the other, adding some validity to this simple division approach here. From another perspective, the non-structural option of a minimum disturbance/minimum maintenance program translates into a total annual cost of $160,000, which prevents the *application* into the environment of a total of 51,500 lb/yr of total nitrogen and 13,000 lb/yr of total phosphorus and prevents the estimated *delivery* of 4,375 lbs of nitrogen and 437 lbs of phosphorus per year (4,812 lbs of total pollutant loading, not counting pesticides and herbicides) into coastal waters.

Structural BMPs like detention basins will only reduce the non-point-source nitrogen loading by 20 percent (1.75 lb/ac/yr) and phosphorus by 30 percent (0.23 lb/ac/yr) at a cost of $1,600 per acre. Though detention basins, along with infiltration practices, are the least expensive structural techniques available, detention basins remove far less nitrogen and phosphorus and have by far the highest costs per pound of pollutant removed (i.e., they are the least cost-effective). As seen from Table 3, infiltration practices are most cost-effective in terms of the various structural practices evaluated here.

The non-structural minimum disturbance/minimum maintenance program approach requires only a small fraction of the costs of the structural approaches. Furthermore, the minimum-disturbance concept, if implemented properly, provides a significantly higher order of environmental quality than even the most effective structural technique, reflecting that structural techniques strive to remove non-point-source pollutants *after* they are generated and have become part of the increased runoff. Preservation of natural vegetation in the minimum disturbance/minimum maintenance approach provides multiple benefits, eliminating a significant source of non-point-source pollution as well as receiving and treating runoff from impervious areas that otherwise would have occurred. In this case, an ounce of prevention is worth a pound of cure—and then some.

Comparison of these statistics are dramatic and indicate to policymakers that preventive non-structural programs are substantially more cost-effective than structural techniques and should be given the highest priority in overall non-point-source management program formulation. The particular non-point-source approach developed here—minimum disturbance/minimum maintenance—is one type of non-structural program that should be investigated. Other non-structural approaches should be developed so that the non-point-source water quality problem can be managed as cost-effectively as possible. Programs can be developed incorporating blends of non-structural and structural techniques. Where the non-structural approach is not feasible, structural techniques should be used in tandem.

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Table 1. Non-point-source pollutant generation. Comparison of pollutant reduction effectiveness (nitrogen/phosphorus) of structural and non-structural best management practices for new single family development in "Coastal County" (Cahill and Associates, 1992).

BMP	Pollutant loading to coastal waters, lbs/ac/yr Total N / Total P[1]	BMP efficiency % removal[2]	Net pollutant loading with BMP, lbs/ac/yr[3]	Pollutant reduction to coastal waters, lbs/ac/yr[4]	Total pollutant reduction with BMPs on 500 acres of single-family residential development, lbs/yr N	lbs/yr P
Mininimum disturbance/ minimum maintenance	8.75 / 0.87	100 / 100	0.0 / 0.0	8.75 / 0.87	4,375	435
Infiltration practices	8.75 / 0.87	50 / 90	4.37 / 0.8	4.37 / 0.79	2,185	395
Constructed wetlands with harvesting	8.75 / 0.87	70 / 90	2.62 / 0.8	6.13 / 0.79	3,065	395
Wet retention basins	8.75 / 0.87	40 / 50	5.25 / 0.43	3.5 / 0.44	1,750	220
Dry detention basins	8.75 / 0.87	20 / 30	7.0 / 0.61	1.75 / 0.26	875	130

1. Less than 10 percent of assumed fertilizer application rates on maintained landscapes; reflects percentage of impervious surfaces in Coastal County development.
2. Pollutant removal efficiencies based on prior studies.
3. Net loadings to coastal waters vary with geohydrologic factors and coastal drainage systems.
4. The actual amount of NPS pollutants prevented from entering coastal waters per acre of development.

Table 2. Comparison of total annualized costs. Structural and non-structural best management practices for new single-family development in "Coastal County" (Cahill and Associates, 1992).

BMP	Cost per cubic foot of stormwater	Construction cost (× 1,000)[1,2,3]	Construction cost amortized (× 1,000)	Indirect cost (× 1,000)[4]	BMP O&M cost (× 1,000)[5]	Design/study cost (× 1,000)[6]	Total annual cost (× 1,000)[7]
Minimum disturbance/ minimum maintenance	$0	$0	$0	$0	$110	$50	$160
Infiltration practices	$3	$3,000	$270	$200 - 650	$50	$60	$580
Constructed wetlands with harvesting	$5	$5,000	$450	$200 - 650	$500	$80	$1,230
Wet detention basins	$4	$4,000	$360	$200 - 650	$50	$60	$670
Dry detention basins	$3	$3,000	$270	$200 - 650	$80	$50	$600

1. Only the single-family residential component of Coastal County growth is considered in this comparison.
2. All stormwater systems are designed for three inches of storage per unit area of impervious surface.
3. The estimated storage requirement for the 10 developments assumed is 1 million cu ft stormwater.
4. Reflects the cost of growing grass, vegetation and landscaping, as well as the costs of lawn mowing, landscape trimmings, etc.
5. For non-structural, includes staff salaries and other elements of minimum disturbance/minimum maintenance program; for structural, includes maintenance and inspection, such as vacuuming and cleaning of porous pavement, harvesting macrophytes and algae, removal of sediment, etc.
6. Reflects the design of structural practices or background studies to institutionalize the minimum disturbance program.
7. Total columns 3, 4 (low range), 5, and 6.

Table 3. Cost-benefit measures for structural and non-structural best management practices for new single-family development in Coastal County (Cahill and Associates, 1992).

		Pollutant Removed Annually from Coastal Waters[2]			
		Total Nitrogen		Total Phosphorus	
BMP	Annual Cost (x1,000)[1]	Cost per pound removed	Pounds removed/ $ 1,000	Cost per pound removed	Pounds removed/ $ 1,000
Minimum disturbance/ minimum maintenance	$160	$37	27	$368	3
Infiltration practices	$580	$265	4	$1,468	1
Constructed wetlands with harvesting	$1,230	$401	2	$3,113	0
Wet retention basins	$670	$382	3	$3,045	0
Dry detention basins	$600	$685	1	$4,615	0

1. Taken from Col. 7 in Table 2 and includes total annualized cost for single-family development in Coastal County.
2. Dividing total costs by each pollutant has been done to allow comparison among the structural and non-structural practices and should not be viewed as absolute in a true cost-benefit sense. For the minimum disturbance/minimum maintenance $160,000 total program expenditure, for example, all pollutants will be removed including nitrogen, phosphorus, pesticides, herbicides, and others.

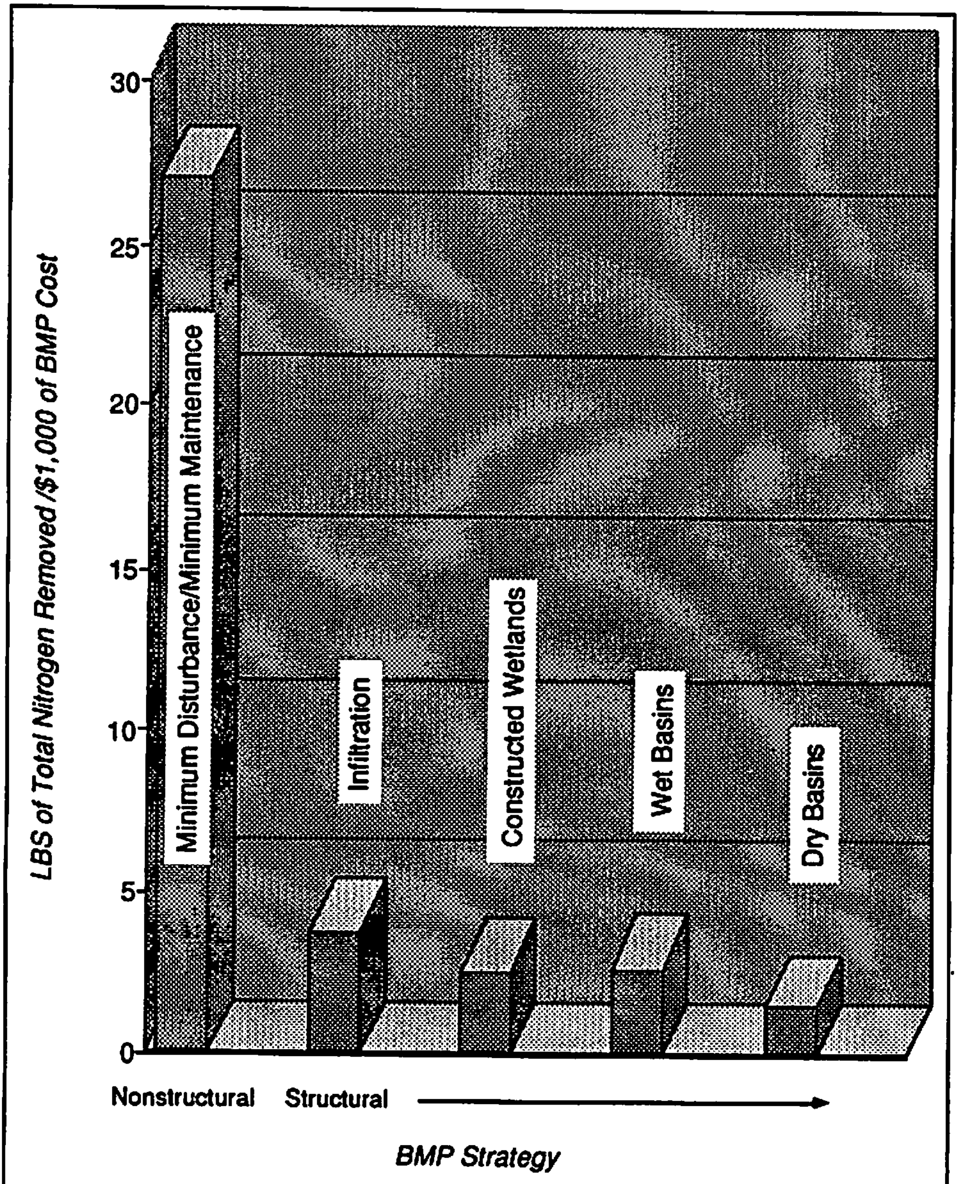

Figure 1. Non-point-source removal efficiency (Cahill and Associates, 1992).

A STUDY ON CAPACITY IMPROVEMENT STRUCTURE OF SETTLING PONDS AT OUTFALLS OF RUNOFF DISCHARGE

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Abstract

Water quality and water color of runoff discharge from land reclamation works become bad unless suitable settling ponds are constructed downstream of the site to preserve the water quality condition. If the runoff discharge flows out without any deposition of eroded soil particles, the sea, reservoir, or river is badly affected. There are many ways chemically and physically to accelerate sedimentation at the settling pond and to affect the composition of these sediments. This paper describes a system of silt protector sheets designed by the authors.

Conventional Silt Protector Sheets

Silt protector sheets are woven canvas sheets made of polyester, with a permeability coefficient of 10^{-2} cm/s. The sheets are installed around the circumference of underwater construction works. There are several ways of installation or application in accordance with the topographical and hydraulic conditions of the working sites. Figure 1 shows an example of installation of silt protector sheets for the case of river corridor dredging works at the Seta River. The Seta River is one of the famous sightseeing points and fishing grounds for Ayu (a freshwater trout) in Japan. There was a strong desire to preserve the environments of the river, particularly during periods of dredging. Dredging was inevitable for the purpose of flood protection. Silt protector sheets were installed as shown in Figure 1 and it was possible to carry out the works keeping almost the same water quality as usual at the outside of silt protector sheets. Silt protector sheets are successfully applied at many underwater construction sites. Recently, silt protector sheets have been used to decrease sediment transport from road construction, reclamation of agricultural lands, golf links and race tracks.

Since these areas have large amounts of runoff discharge, silt protector sheets with low permeability coefficients (10^{-2} cm/s) cannot sustain runoff discharge. New types of silt protector sheets must be developed. The new type of silt protector sheets should have high permeability with reasonable capacity of sediment cut off.

High Permeable Silt Protector Sheets

The authors developed a new type of silt protector sheet having high permeability, yet maintaining a certain sediment cutoff capacity. The sheet is typical, but 20-cm squares of unwoven portions are set every 30 cm in order to improve its permeability. Permeability of the newly developed silt protector sheets was 10 times that of ordinary silt protector sheets in the hydraulic model test, and cutoff capacity of sediment transport was one-third that of ordinary silt protector sheets. This new type of silt protector sheet was successfully used at a settling pond at a Yatsushiro Bay outfall. Retardation and unification capacity of the silt protector sheets would accelerate sediment deposition.

Settling Pond at Racetrack Construction Site

The Yatsushiro Bay example was the case of newly developed high-permeability silt protector sheets (installed doubly). Ordinary silt protector sheets were applied in the case of a racetrack (Morioka, Iwate prefecture) construction. Multiple sheets were installed in order to deal with spilling around edges of screens. Large discharges at one edge of the sheets were taken off alternately as shown in Figure 2.

The turbidity was measured and its result was as shown in Figure 3. The sheets seemed to generate meandering flow in the settling pond. This meandering causes extension of flow length in the pond, and percolation of the sheets accelerates sediment deposition.

Since the settling pond of the racetrack situated just upstream of the waterworks reservoir of Moriola City, turbidity inflow was strictly restricted. Then perfect deposition of sediment was requested. Open portions of silt protector sheets should have been avoided if possible. A composite type of silt protector sheets was designed. That is, the open portion of the Yatsushiro Bay layout was replaced by newly developed high-permeability silt protector sheets. Then permeability of the sheets was changed with the portion of the sheets, this generated meandering flow in the pond, too. The plane view of the improved design is shown in Figure 4. The flow pattern sediment cutoff capacity was examined by field tests, hydraulic model tests and numerical simulation.

Other Examples

Shimokita. Shimokita is the north end of the Japan mainland (Honshu Island), where reclamation of agricultural land is carried out by the prefectural project of Aomori. The end of the project area is very close to the sea (Mutsu Bay) where scallops are cultured. Runoff discharge from reclaming agricultural land transports large amounts of sediment to the sea, and this leads to mortality of cultured scallops near the outfall. Scallop culture fishermen requested compensation for the damage and measures to halt spread of the sediment from the outfall. Aomori Prefecture planned to construct a settling pond just upstream of the outfall, but it was impossible to make it long and wide enough to deposit runoff sediment. They are planning to install multiple high-permeability silt protector sheets in the settling pond. In the case of Shimokita, investigations will be carried out at the site beginning this month. Once data are gathered, numerical simulation will be followed to establish design criteria.

Hachinohe Plain. Hachinohe is in northern Aomori Prefecture. The project of this area is also reclamation of agricultural land, but the project manager is the national government (Ministry of Agriculture, Forestry and Fisheries). The outfall of this project area is also close to the sea where fishermen manage shellfish culture. As the construction progressed, sedimentation at the surrounding area of the outfall became obvious, and mortality of shellfish occurred. This area also planned to construct a settling pond just upstream of the outfall. Some structures may also be necessary to lengthen flowing distance in the pond. Structures that are easy to remove and repair are desirable for such a case.

Conclusion

Settling ponds with silt protector sheets, having some open portions, were recognized to be effective to cut off sediment transportation. High-permeability silt protector sheets improved permeability, but the ratio of permeability improvement is much greater than that of sediment cutoff capacity decrease. Therefore, the open portion of ordinary silt protector sheets replaced by the high permeable silt protector sheets must be much more effective to cut sediment transport.

By adjusting the pond dimensions and the arrangement of silt protector sheets in the settling pond, sediment transport can be effectively reduced. A settling pond then becomes a useful structure to preserve downstream aquatic areas.

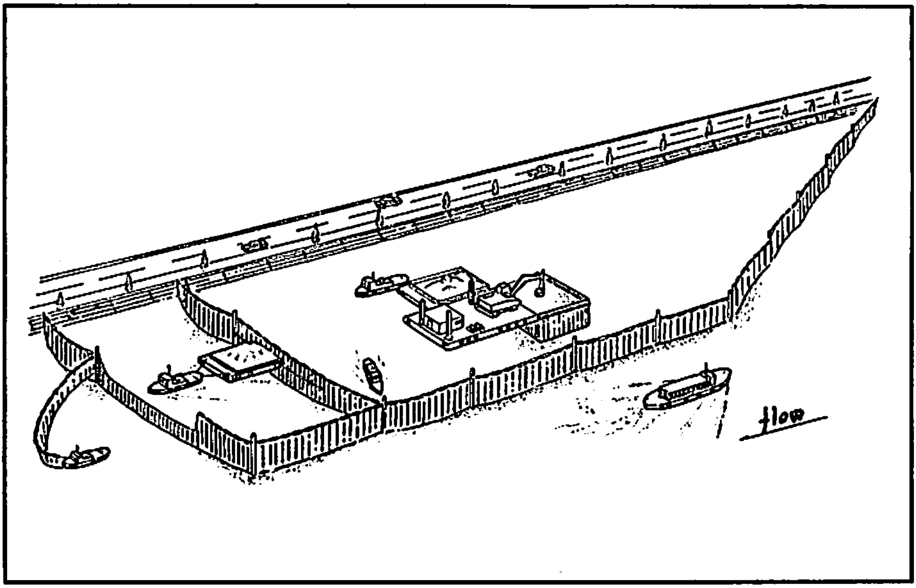

Figure 1. Silt protector sheets at the site of dredging.

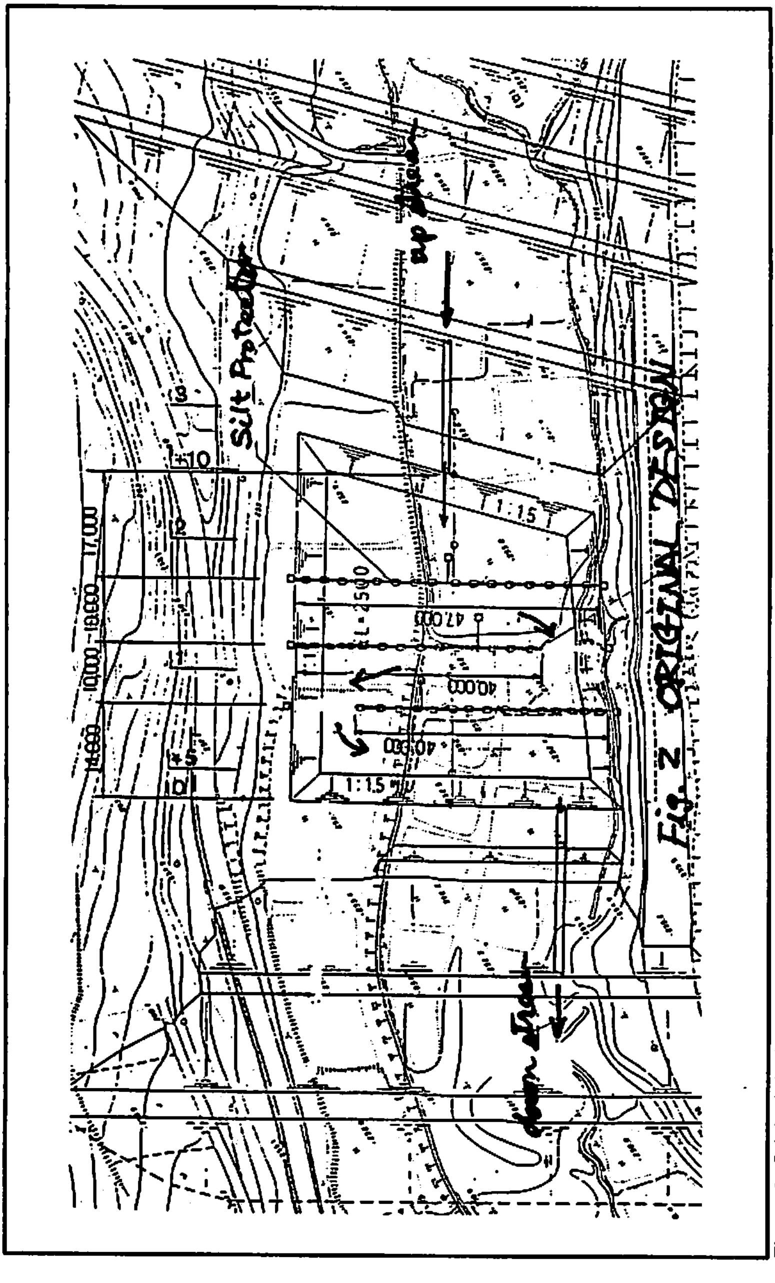

Figure 2. Original design.

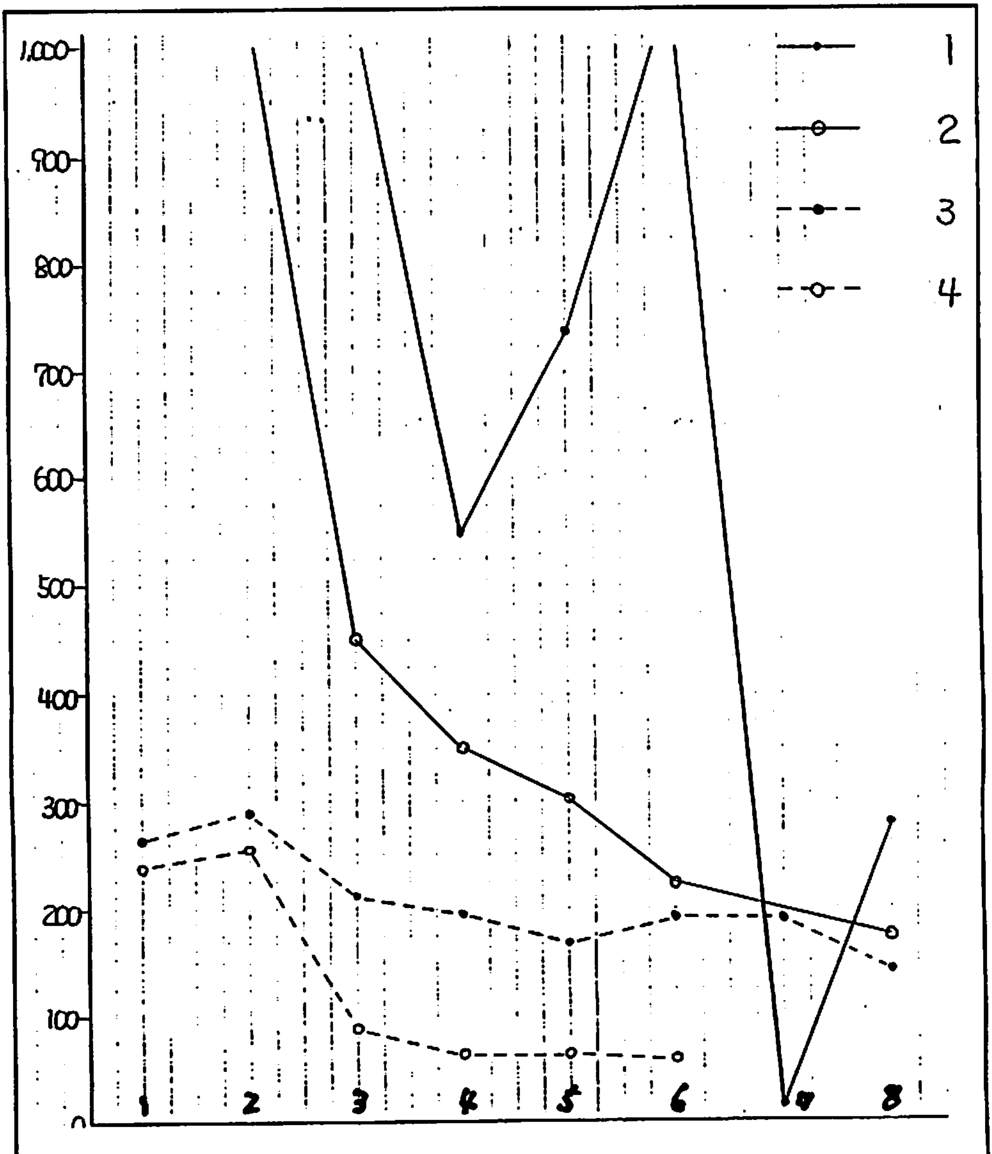

Figure 3. Turbidity measurements.

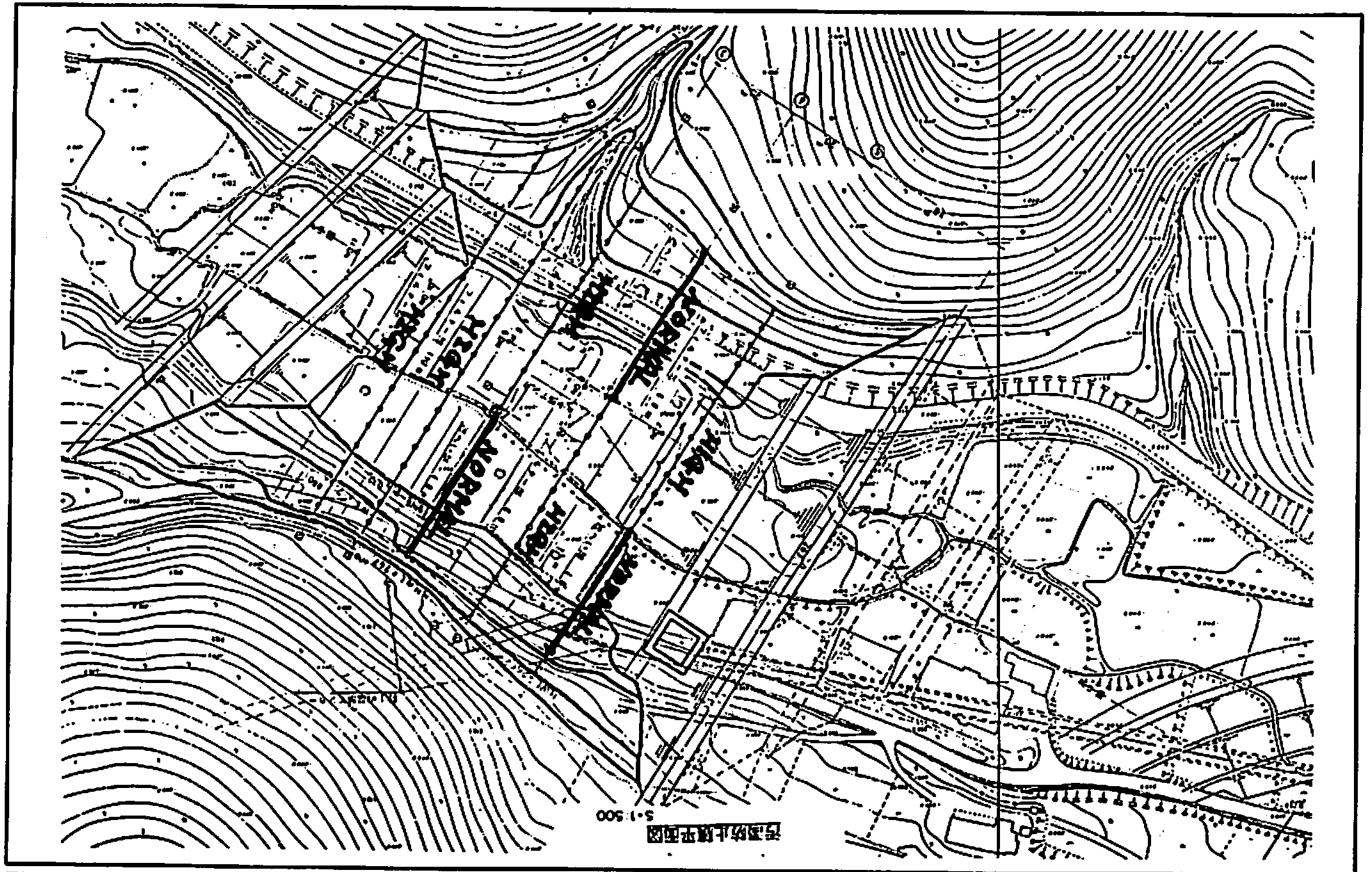

Figure 4. Improved design.

NOAA's Damage Assessment and Restoration Program

RESTORATION: NEXT STEPS FOR NATURAL RESOURCE TRUSTEES

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Abstract

The National Oceanic and Atmospheric Administration (NOAA) is a natural resource trustee under a number of federal statutes. In 1989, NOAA began to develop a comprehensive program to address its natural resource trustee responsibilities. The program integrates the scientific, economic and legal disciplines into the Damage Assessment and Restoration Program. This paper will focus on one component of that program—restoration, the ultimate goal of the natural resource trustee. The paper will provide a brief background on natural resource trusteeship. It will then consider three aspects of restoration planning—program organization, role of the Restoration Center and restoration methodology.

Background

The National Oceanic and Atmospheric Administration (NOAA) serves as a Federal natural resource trustee[1] pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA);[2] the 1988 amendment to the Marine Protection, Research, and Sanctuaries Act (MPRSA);[3] the Federal Water Pollution Control Act (FWPCA);[4] and the Oil Pollution Act of 1990 (OPA).[5] As a natural resource trustee, NOAA must assess injury to trust resources caused by the release of hazardous substances, the discharge of oil, or physical impacts for resources located in national marine sanctuaries; pursue monetary recoveries for such injuries and assessment costs from the responsible parties; and use the money recovered to restore, replace or acquire the equivalent of the injured resource.[6]

While these statutes define natural resources expansively,[7] they do not apportion them among the trustee entities. Rather each trustee determines its scope of trusteeship based on resource statutes or other authorities that confer management, control or protective responsibilities for natural resources. Due to overlapping statutory responsibilities, trusteeship for many resources is shared by several federal and state trustees. Because of this shared trusteeship, NOAA coordinates closely with its federal and state co-trustees. In cases of co-trusteeship, NOAA typically proposes a memorandum of understanding that outlines the common goals and procedures to be followed by the trustees and emphasizes consensus decision making. NOAA believes that this cooperative approach is the most productive way to achieve the common goal of the trustees, restoration of the injured environment including its living marine resources.

Among the Federal trustees, NOAA is the principal trustee for the living and non-living resources of the marine environment. Its trusteeship encompasses all fishery resources of the exclusive economic zone (EEZ) of the United States, as well as anadromous species and Continental Shelf fishery resources of the United States, both within and beyond the EEZ; certain threatened and endangered species including designated critical habitat; certain marine mammals; and environmentally sensitive areas.[8]

NOAA is actively involved in a number of cases on the East and West coasts of the United States and the coast of the Gulf of Mexico. These sites represent diverse habitats, resources and contaminants. NOAA works closely with EPA at sites where remedial actions are underway in an attempt to have its natural resource concerns addressed through that process. At sites where there is no remedial action underway or where the remedial action will not address NOAA's concerns, NOAA first attempts to involve the responsible parties in the damage assessment process. Should the responsible parties decline to participate, NOAA will pursue litigation.

Organization

Although the role of a natural resource trustee is not a new one for NOAA,[9] it was not until 1989 that NOAA took the first steps to develop a comprehensive program to implement fully its natural resource trustee responsibilities. In that year, NOAA created the Damage Assessment Center (DAC) within the National Ocean Service (NOS). The DAC is composed of natural scientists, economists and administrative personnel. The DAC identifies sites of interest, assesses injuries to trust resources and quantifies such injuries into monetary terms. In the same year, the NOAA Office of General Counsel created a section of attorneys devoted solely to natural resource trustee issues.

As settlement dollars became available, it became evident that NOAA needed to refine its proficiency to implement the restoration mandated by these recoveries. In 1991, NOAA established the Restoration Center within the National Marine Fisheries Service (NMFS) which draws on the experience and expertise of its scientists to provide the institutional focus necessary to identify and evaluate restoration methodologies and research as well as to develop priorities and strategies for successful restoration. The Restoration Center became the final component of NOAA's Damage Assessment and Restoration Program (DARP).

A multi-disciplinary team governs the DARP through a board of directors. The board is composed of voting members from the NOS, the NMFS and general counsel with advisory members from the Sea Grant Program, the Coastal Ocean Program and the Strategic Policy and Planning Office.

While much of the DARP personnel is located in the greater Washington, D.C. area, there is a growing emphasis on regionalization. Natural resource attorneys are co-located with four of the five NMFS regional offices,[10] and the DAC scientists are located in two of the regions. The Restoration Center is in the process of developing and building a network with the NMFS regional offices and science centers in each of the five regions. Regardless of the geographic location, a team composed of representatives of the Office of General Counsel, the Damage Assessment Center, and the Restoration Center is assigned to each case. This early integration of all of the relevant disciplines allows a comprehensive approach to all stages at sites of concern from case development through implementation of restoration.

Development of the DARP demonstrates NOAA's commitment to its responsibility as a natural resource trustee. As part of this commitment, NOAA must develop more fully an understanding of the living marine resources, including their habitats and provide information and technology to restore, replace and rehabilitate injured natural resources. The newly established Restoration Center is crucial in meeting this commitment.

Role of the Restoration Center

Through the process of identifying and understanding the successes, failures, and limitations of habitat restoration activities, NOAA, through the National Marine Fisheries Service, has been able to set the course for the future. This course is NOAA's commitment to increase its in-house expertise in restoration and habitat research to support NOAA's habitat conservation, enhancement and restoration mandates. The mission of the Restoration Center includes:

Developing the national expertise and institutional focus required to address research and development priorities now limiting the effectiveness of efforts to restore, enhance, replace or acquire the equivalent of living marine resource habitats;

Providing expert assistance in identifying and evaluating restoration methodologies for specific cases during the damage assessment process which is led by another NOAA component, the Damage Assessment Center;

Planning and executing the operational programs to restore NOAA trust resources after successful settlement of natural resource damage claims by the Damage Assessment Center and General Counsel; and

Providing advice and assistance to the NMFS Habitat Conservation Program's process of reviewing applications for permits to modify coastal and nearshore habitats based on state-of-the-science research and management information.

A concerted and coordinated effort by NOAA is particularly important now with the increase in population development in the coastal counties; the requirement of the NMFS to provide recommendations to habitat managers on permit applications; the requirements of the Damage Assessment Center for information on restoration methodologies; and the necessity to develop and implement restoration plans after settling natural resource damage claims.

The Restoration Center is building on existing in-house expertise in the area of restoration ecology. This program is not only designed to address the shortcomings that are now being recognized in the science of restoration but also to generate, implement and monitor restoration plans for sites associated with damage assessment cases through interaction between co-trustees and the scientific community. The Restoration Center will enhance the expertise within NOAA to conduct research on restoration of functional values of critical living marine resource habitats through augmentation of existing expertise and also through redirecting NMFS research as appropriate. This emphasis on habitat function and restoration within NMFS forms the basis of recommendations to habitat managers on permit review activities and to the Damage Assessment Center on state-of-the-art restoration methodologies for restoration of areas injured by hazardous substances or oil. The resulting strategy will lead to a policy of ensuring that responsible management approaches and decisions will be based on the best scientific information available.

In addition to its goals to develop further its restoration expertise and to apply such expertise to specific environments that have been injured, the Restoration Center is developing policies that will guide the DARP as it approaches restoration issues. The Restoration Center has emphasized to the DARP board of directors the need for a comprehensive approach to working on cases, one that begins when DARP initiates actions and continues to the point at which restoration is complete. After the successful conclusion of a case, whether through litigation or settlement, the leadership within DARP shifts from the Damage Assessment Center and the Office of General Counsel to the Restoration Center. Nevertheless, the involvement of each office is crucial throughout the process. This is critical from the restoration aspect because the various methodologies and associated cost estimates developed during the presettlement phase provide the bases for the development of the actual restoration plan. The Restoration Center also intends to encourage public participation throughout the restoration planning and implementation phase.

Restoration Methodology

Although NOAA has accepted the challenge to restore injured habitats, its ability to achieve this goal successfully needs to be enhanced greatly. NOAA's experience and the scientific data base in habitat restoration, which is extremely limited, strongly indicates that although many techniques exist to create and restore coastal habitats, the general process of habitat restoration and mitigation has not been overly successful nor have there been many long-term evaluations of restoration actions. Functional qualities of these habitats simply have not been restored completely, and the stability of these resultant systems is unknown. This is particularly the experience of the permit process with which NOAA and other resource agencies interact with the U.S. Army Corps of Engineers.[11] Sound, peer-reviewed scientific information is required to propose effective restoration and mitigation measures to minimize overall environmental impact. Further, restoration and mitigation recommendations in the permit process must be enforced.

Many techniques for restoration and enhancement of physically damaged habitat exist, and the development of new or replacement habitats is seeing greater use. However, few of the techniques have been developed and implemented where hazardous wastes have affected the habitat. Because there is a lack of basic information on the functional values of major coastal estuarine habitat types, there is no generally accepted definition of when a restoration action can be considered functionally successful. Little effort has been devoted to restoration and mitigation follow-up studies. Little information is available on the rates at which functioning systems are restored, the influence of habitat type and geographic location on recovery rates, and the resiliency of these restored habitats to natural and anthropogenic stresses. Consequently, the success and existence of historic and even current projects are poorly documented. Complicating this is the possibility that approaches that have evolved historically for wetlands may not apply to areas where there have been or are high levels of toxic contamination.

A prerequisite for decision-making regarding habitat restoration and success of these actions is a comprehensive knowledge of the functional value of specific habitats. Intelligent management promoting production of living marine resources is not possible without a fundamental understanding of how habitats function to provide requisites for growth and survival or how they differ in importance between species under various circumstances. Such functional values need to be soundly developed if resource agencies are to make rational management decisions regarding conservation of habitats, habitat loss and impacts, and restoration and enhancement options.

The Restoration Center is structured to have direct input from researchers in the development and implementation of its research plan. The NMFS has identified the need for a coordinated research program of studies of estuarine and coastal habitat restoration and mitigation that should attempt to address a number of shortcomings. A primary objective is determining the ability of restored, enhanced, or newly-created habitats to provide functional values that are equivalent to those of natural habitats. The time-course for achieving this and the factors controlling the process also are of interest. Data obtained from research on natural systems will be used in establishing the variability of natural habitats, and in developing an operational definition of successful restoration and mitigation. Restoration research will incorporate experimental approaches in the laboratory, greenhouse, microcosm and mesocosm, and in the field, and will be designed to address the development of functional processes of restored habitats. This will require comparison with natural systems and controlled conditions. Such research may require assessment of physical, hydrologic and biological parameters. Initial field approaches will include evaluating restoration and mitigated habitats over time and of varying ages and in establishing experimental restoration sites. Long-term, nationwide observations will be required. These research approaches also must be coupled with augmented management evaluations on historic and current permit-related mitigation and wetland loss rates.

To ensure a continued expertise in the field of habitat research, the NMFS facilities will carry out research activities in specific areas of expertise and maintain a current knowledge of research activities conducted by other recognized research groups and institutions. The Restoration Center will be developing an information database assimilating current activities as well as historic restoration activities.

To date, the Restoration Center has become an active participant in a variety of programs and initiatives which are not directly related to the CERCLA or the OPA cases but which have a direct impact on enhancing knowledge of habitat restoration and understanding of the functional values of those habitats. In particular, the Restoration Center is active with the NOAA/U.S. Army Corps of Engineers Memorandum of Agreement which is designed to support restoration activities with the possibility of conducting research at civil works sites. NOAA is actively involved in the program developed pursuant to the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) which Congress enacted in 1990. This legislation, commonly referred to as the Breaux Bill, establishes a Coastal Wetlands Trust Fund and a CWPPRA Task Force to use the fund to develop a wetlands conservation plan and projects to restore, conserve and enhance coastal wetlands in Louisiana. The Breaux Bill also creates a wetlands conservation grants program for coastal states which is administered by the U.S. Fish and Wildlife Service. Additionally, NOAA is an active participant in an Administration initiative called Coastal America, which is designed to facilitate the communication and coordination of federal agencies to work together and identify restoration projects that could be mutually funded and implemented.

The end product of what has been presented is a NOAA effort that has intermeshed the policy-making process with the research development. NOAA's efforts to better understand the nation's coastal and estuarine habitats and marine living resources today will enable NOAA to make responsible decisions tomorrow.

Notes

1. The federal trustees are designated pursuant to Executive Orders 12580 and 12777 to carry out natural resource trustee responsibilities under the CERCLA, the FWPCA and the OPA. In those Executive Orders, the president has named as trustees the secretaries of Commerce, Defense, the Interior, Energy and Agriculture. The secretary of Commerce has delegated this authority to the under secretary for oceans and atmosphere, who also serves as the administrator of NOAA. Department Organization Order 10-15, amend. 2, issued Nov. 8, 1989; Department Organization Order 10-15, issued Jan. 11, 1988.
The CERCLA and the OPA also name Indian tribes and authorized representatives of each state as trustees. In addition, OPA designates foreign governments as trustees "for natural resources belonging to, managed by, controlled by, or appertaining to such country." 42 *U.S.C.* 9607(f)(1); OPA section 1006(a).
Under the CERCLA, the governor of each state designates state officials to act as trustees for natural resources. Pursuant to the OPA, the governor also may designate local officials as trustees. While the CERCLA does not address further delegation concerning Indian tribes, the OPA authorizes the governing body of any Indian tribe to designate tribal officials; and the head of any foreign government to name a trustee. 42 *U.S.C.* 9607(f)(2); OPA section 1006(b).

2. 42 *U.S.C.* 9601 *et seq.*

3. 16 *U.S.C.* 1443.

4. 33 *U.S.C.* 1321(f)(4) and (5).

5. P.L. 101-380. The OPA replaces prospectively the natural resource provisions of the FWPCA.

6. Money recovered under the MPRSA is handled differently from that recovered under the CERCLA, the FWPCA or the OPA. The MPRSA provides that NOAA must set aside 20 percent of a recovery to finance future response actions and damage assessments. The statute establishes a list of permissible uses for the remaining 80 percent in the following order of priority: to restore, replace or acquire the equivalent of the injured sanctuary resource; to manage and improve the national marine sanctuary where the injured or destroyed resources were located; and to manage and improve any other national marine sanctuary. 16 *U.S.C.* 1443(d).

7. 42 *U.S.C.* 9601(16); OPA section 1001(20); 16 *U.S.C.* 1432(8).

8. *See, e.g.*, Magnuson Fishery Conservation and Management Act, as amended, (Magnuson Act), 16 *U.S.C.* 1802(9) ("fisheries resource" includes habitat of fish) and 1852(i) (fishery management councils authorized to make recommendations concerning habitat of fishery resources under their jurisdiction); Federal Water Pollution Control Act, 33 *U.S.C.* 1344(c) (authority to restrict siting of disposal areas where the discharge would have unacceptable adverse effect on shellfish beds, fishery areas, wildlife); National Ocean Pollution Planning Act, 33 *U.S.C.* 1701, *et seq.* (NOAA mandated to study the input, fates and effects of pollutants in marine environment); Coastal Zone Management Act, 16 *U.S.C.* 1461 (authorizes NOAA to designate estuarine research reserves).
In addition to the statutes listed above, NOAA derives its trusteeship from a number of other statutes, including, but not limited to, Atlantic Tunas Convention Act, 16 *U.S.C.* 971, *et seq.*; Tuna Conventions Act, 16 *U.S.C.* 951 *et seq.*; Pacific Salmon Treaty Act, 16 *U.S.C.* 3631, *et seq.*; Atlantic Striped Bass Conservation Act, 16 *U.S.C.* 1851 note; North Pacific Halibut Act,

16 *U.S.C.* 773; Marine Mammal Protection Act, 16 *U.S.C.* 1361, *et seq.*; Whaling Convention Act, 16 *U.S.C.* 916, *et seq.*; Fur Seal Act, 16 *U.S.C.* 1151, *et seq.*; Endangered Species Act, 16 *U.S.C.* 1531, *et seq.*

9. In 1983, NOAA, through the U.S. Department of Justice, filed the first Federal CERCLA claim seeking damages for injuries to natural resources resulting from contamination by polychlorinated biphenyls (PCBs) of New Bedford Harbor and adjacent waters. *See, Acushnet River & New Bedford Harbor: Proceedings re Alleged PCB Pollution*, CA No. 83-3882-Y (D. Mass. 1983). Prior to that, NOAA assisted in the evaluation of the effects of the 1978 *Amoco Cadiz* oil spill off the coast of France. Work on that spill was the first effort by NOAA to conduct a damage assessment.

10. Those offices are located in Seattle, Long Beach, Calif., St. Petersburg, Fla., and Gloucester, Mass. The fifth regional office is located in Juneau, Alaska.

11. NOAA annually evaluates between 8,000 and 10,000 proposals for development in estuarine and coastal habitats that have the potential to affect upwards to one million acres.

ASSESSMENT AND RESTORATION OF DAMAGED RESOURCES IN NATIONAL MARINE SANCTUARIES: TWO VESSEL GROUNDINGS IN THE FLORIDA KEYS

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Introduction

Under section 312 of the Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA, 16 *U.S.C.* 1431 *et seq.*), the under secretary for oceans and atmosphere is authorized to claim damages against persons who destroy, cause the loss of, or injure sanctuary resources in national marine sanctuaries. Sanctuary resources include any living or non-living resource of the sanctuary that contributes to its conservation, recreational, ecological, historical, research, educational or aesthetic value. These resources range from coral reefs to fish to marine mammals to sea birds. Under the statute, the National Oceanic and Atmospheric Administration (NOAA) is authorized, among other things, to commence civil actions to recover for response costs and damages. Damages include compensation for:

The cost of replacing, restoring, or acquiring the equivalent of a sanctuary resource;

The value of the lost use of a sanctuary resource pending its restoration or replacement or the acquisition of an equivalent sanctuary resource; or the value of a sanctuary resource if the sanctuary resource cannot be restored or replaced or if the equivalent of such resource cannot be acquired; and

The cost of damage assessments.

NOAA interprets Section 312 of the MPRSA to allow the agency to conduct injury assessments for a variety of incidents that affect sanctuary resources. These include natural perturbations such as hurricanes and typhoons, and outbreaks of disease. NOAA's Sanctuaries and Reserves Division, in cooperation with other interested parties, conducts site-specific and resource-specific assessments.

Natural Resource Damage Actions Under the MPRSA

The 1988 amendments to the MPRSA added Section 312 and strengthened NOAA's ability to pursue natural resource damage actions by explicitly establishing a regime for restoring resources of a national marine sanctuary that are destroyed, injured or otherwise lost. The new provisions of the statute were modeled largely after similar liability regimes under the Federal Water Pollution Control Act and the Comprehensive Environmental Response, Compensation and Liability Act. To date, the Sanctuaries and Reserves Division has pursued seven natural resource damage actions, two of which are still in litigation (Table 1). Prior to the 1988 amendments, the following natural resource damage actions were pursued under the MPRSA:

Against the M/V *Wellwood*, a 400-foot Cypriot-registered vessel that grounded at Molasses Reef within the Key Largo National Marine Sanctuary (KLNMS) in August 1984;

Against the M/V *Mini-Laurel*, a 215-foot Panamanian-registered freighter that also grounded on Molasses Reef in the KLNMS in December 1986; and

Against the T/V *Puerto Rican*, a 632-foot U.S. registered vessel which spilled over one million gallons of petroleum products that injured resources within the boundary of the Gulf of the Farallones National Marine Sanctuary in November 1984.

Section 312 of the MPRSA specifically defined the term damages and directed SRD to use the monies recovered as a result of natural resource damage actions to support future damage assessment and response activities and for restoration. So far, Section 312 authority has been invoked to pursue natural resource damage actions in four instances:

Against the *Apex Houston*, a tank barge that spilled oil off the central California coast in January and February 1986 (This natural resource damage action was referred to the U.S. Department of Justice in December 1988, after the enactment of the 1988 amendments to the MPRSA.);

Against the 155-foot M/V *Alec Owen Maitland*, a domestic heavy equipment freighter, that ran aground south of Carysfort Reef lighthouse in the KLNMS in October 1989;

Against the 470-foot M/V *Elpis*, a Greek registered vessel that ran aground near The Elbow reef in the KLNMS in November 1989; and,

Against the *Jacquelyn L*, a 55-foot sport fishing boat that ran aground on Western Sambo Reef within the Florida Keys National Marine Sanctuary in July 1991.

This paper will focus on two natural resource damage actions pursued under section 312 of the MPRSA as case studies. We will review the M/V *Alec Owen Maitland* and M/V *Elpis* cases and provide information on the assessment and restoration of damaged resources in national marine sanctuaries.

Assessment of Physical Injury

To support emergency response and damage assessment activities in national marine sanctuaries, section 312 includes a specific formula for distributing funds recovered as a result of natural resource damage actions. Twenty percent (up to a maximum balance of $750,000) is allotted to finance future response actions and damage assessments, including anthropogenic and natural disturbances, such as hurricanes or outbreaks of disease. In general, the damage assessment process in national marine sanctuaries begins with assessing the extent of physical injury.

Within KLNMS, SRD estimates that between 20 and 40 small vessels (under 50 feet in length) run aground on coral each year. To date, SRD has elected to use a civil penalty procedure for these groundings even though their cumulative impact may be as extensive as the larger vessel groundings. Since the civil penalty amount is related to the extent of injury, the biologists at the Key Largo and Looe Key National Marine Sanctuaries have developed a standard procedure for measuring the physical injury. The extent of partial and total injury is quantified and the species affected are identified. NOAA biologists also provide information on the distribution of floral and faunal resources in the affected area.

The procedure for assessing injury from small vessel groundings provides the foundation for assessing injury from large vessel groundings, even though the magnitude of injury is much greater. Medium vessel (between 100 and 250 feet) and large vessel (over 250 feet) groundings typically produce injury that jeopardizes the structural integrity of the coral reef. While smaller vessels generally affect the organisms that grow on the surface of the reef, medium and large vessels typically destroy the underlying reef framework.

In coral reef environments, the injury assessment needs to be initiated shortly after the incident. Algae eventually camouflage the superficial injury to coral colonies and the dynamic nature of the marine environment can lead to secondary injury. In addition, mitigation and restoration efforts cannot be undertaken until portions of the injury assessment are complete. Assessing injury in a marine environment can be difficult since the resource is submerged and inclement weather can interfere with assessment activities.

At the M/V *Alec Owen Maitland* and M/V *Elpis* grounding sites, SRD biologists assessed the following physical injury:

M/V *Alec Owen Maitland*	
Partial Destruction	930 m^2
Total Destruction	680.5 m^2
Reef Framework Injury	8 m^2
Reef Displacement Injury	82 m^3
M/V *Elpis*	
Partial Destruction	468 m^2
Total Destruction	2,604.75 m^2
Reef Framework Injury	878 m^2
Reef Displacement Injury	293 m^3

The measurement of **Partial Destruction** encompasses those portions of the reef that were struck by the vessel's hull or affected by the propeller wash but were not completely destroyed at the time of the grounding. This includes the partial burial of benthic organisms as well as injury to corals where the entire colony is not obliterated. The partial destruction category encompasses a very broad range, from virtually untouched to near total devastation.

The measurement of **Total Destruction** encompasses those portions of the reef where the surface was completely denuded through the fracturing and grinding action of the vessel's hull, large-scale movement of reef substrate by the force of the water driven by the ship's propeller, or burial of living reef by material displaced by the vessel hull and propeller washout.

The measurement of **Reef Framework Injury** is encompassed in the measurement of total destruction and includes the cracking, crushing, splitting or fracturing of the naturally cemented matrix of living and dead coral, sediment and other lime-secreting organisms that form the basic structure of the reef and provides the foundation for continued growth. The injury is caused by the impact of the vessel as it struck the reef, the weight of the vessel as it rested on the reef, and the movement of the vessel while aground.

The measurement of **Reef Displacement Injury** refers to the excavation of large quantities of buried reef material following the fracturing of the overlying reef framework by a grounding. Large amounts of coral debris, cobble, boulders, rubble and sediment were ejected from beneath the fractured framework surface by the violent water turbulence created by the vessel's propeller. During the M/V *Elpis* and M/V *Alec Owen Maitland* litigation, the close linkages between physical injury assessment, the overall damage assessment and the development of a restoration plan were apparent (Figure 1).

Damage Assessment

Choice of Assessment Methodology. Injuries to national marine sanctuary resources pose a unique challenge in the choice of methodologies to assess damages. The two assessment strategies outlined by Department of Interior (DOI) in their regulations on measuring damages to natural resources, the Type A and Type B strategies (U.S.D.I., January 1987; U.S.D.I., June 1987), were not drafted to apply to coral reef grounding cases where no spill occurs. The Type A strategy is based on a computer model that simulates the biological and economic losses associated with spills of toxic substances and thus is not appropriate for valuing the losses associated with grounding events. While applicable from a technical standpoint, the Type B assessment strategy is often rejected on the basis that it may violate DOI's definition of reasonable costs of assessment, which states that "the anticipated cost of the assessment is expected to be less than the anticipated damage amount" [43 C.F.R. 11.14(ee)]. For grounding cases, the size of the area affected, and thus, the size of damages is often significantly less than is the case for a major oil spill or waste site contamination, yet the costs of data collection and analysis as specified by the Type B regulations do not decrease commensurately. Thus, the Type B strategy may be less appropriate for estimating the damages resulting from many grounding events relative to other types of injury.

As a solution, NOAA has developed a "hybrid" strategy for assessing damages attributable to groundings that combines the technical applicability of the Type B strategy with the cost effectiveness of the Type A model. This strategy relies on existing data and literature values where possible, and employs original data collection efforts where existing information is insufficient to accurately characterize the extent or nature of the injury.

Description of Assessment Methodology. The goal of this hybrid strategy is to value the lost services associated with the injured portions of the coral reef(s). The three major components of this valuation strategy are determinations of the extent and nature of the injury; the extent and nature of the recreational services provided by the reef prior to the injury; and the value of these services to recreational participants. The latter two components is discussed below in detail.

Extent and Nature of the Lost Services. The Florida Keys provide a wide variety of recreational services which may be affected by a grounding event, including scuba diving, snorkeling, boating and fishing. Recreational participation in the affected area is estimated by analyzing entrance records for areas where such data are maintained, such as John Pennekamp Coral Reef State Park or Key Largo National Marine Sanctuary. For areas where trustees do not keep regular participation data, this information is obtained from private providers of recreational services, such as dive shops and charter boat operators.

While lost recreational services account for the majority of interim lost use damages in most grounding cases, other services provided by coral reefs, such as scientific research, storm protection and aesthetics can be affected adversely by grounding events. With sufficient data, estimates of the diminution in value of these services as a result of grounding events can be incorporated into the overall damage assessment process.

Examining the effect of groundings on recreational services captures a large portion of the lost *use* value, but this type of analysis fails to account for the fact that people who currently do not participate directly in any recreational activities associated with the reef system nonetheless may place a value on its existence. Such individuals may wish to visit the resource in the future, preserve its beauty for future generations, or simply may derive utility from the fact that the unique and spectacular ecosystem exists and is protected in its natural state. NOAA currently is exploring the use of contingent valuation to estimate the loss in *non-use* value associated with an injury to the Florida reef system.

Value of Services to Recreational Participants. Once a determination has been made as to the types of recreational services affected by a grounding, the next step in the damage assessment process is to estimate the value to recreational users of these lost services. In economic terms, this value is referred to as "consumer surplus," since it is the amount that a recreational user would have been willing to pay for a given recreational opportunity in excess of what he or she actually had to pay. Consumer surplus, rather than total expenditures, is the relevant measure for assessing damages.

A simple example illustrates this point. Bob is a scuba diver planning a trip to the Keys. Assume the trip will cost him $2,000, but the experience of scuba diving in this area is worth an additional $500 to him (his "consumer surplus"). If there is a grounding event that prevents Bob from diving in this area, his net loss is $500, not $2,500 since he still is able to spend the $2,000 on something else.

Consumer surplus values for recreational users in the Florida Keys have been estimated using the travel cost methodology as part of an ongoing, nationwide natural resource valuation project being conducted by NOAA's Strategic Environmental Assessments Division.

Readers interested in the details of the travel cost methodology should refer to Bockstael, N.E., K.E. McConnell and I.E. Strand, "Chapter VIII: Recreation" in

Measuring the Demand for Environmental Quality, John B. Braden and Charles D. Kolstad (ed.), Elsevier Science Publishers, North-Holland, 1991.

Relationship Between Damage Assessment and Restoration. Despite the tendency to view damage assessment and restoration as two distinct, sequential phases in the process of protecting marine resources, restoration planning provides a number of critical inputs to economic damage assessments. The nature of estimating *interim* lost use value involves determining the value of services lost until the injured resource is fully recovered. Estimating total damages is done first by estimating annual damages and then discounting them over the recovery horizon to determine the present value of damages. Note, however, that annual damages will continue to decrease as the injured resource recovers over time. Restoration planning is instrumental in determining the horizon over which annual damages are discounted, and the pattern by which recovery takes place over time, thereby further reducing annual damages.

Restoration

In the M/V *Alec Owen Maitland* and M/V *Elpis* litigation, our damage claim included estimates for response costs, restoration costs and interim lost use. In developing a restoration plan, we began with the assumption that it was not technically possible to repair the reef to its pre-grounding condition. Nonetheless, it was possible to undertake measures that would enhance the natural recovery processes. The goals of our restoration plan were:

To prevent secondary damage to the surrounding habitat (through removing or cementing rubble at the grounding site);

To expedite natural recovery (through stabilization of the substrate);

and

To restore three-dimensional relief to the injured area (habitat value).

SRD proposed to undertake four categories of restoration activities at the grounding sites of the M/V *Alec Owen Maitland* and the M/V *Elpis*. A description of the categories, listed in sequential order, follows:

Monitoring. A long-term monitoring program is essential for providing baseline data on the post-grounding/pre-restoration condition of the grounding site and for evaluating the success or failure of restoration efforts.

Reef Displacement Repair. Excavations in the reef framework provide an unsuitable surface for natural recovery and must be filled in, either with exhumed debris scattered around the grounding site or other fill material. The surface of these filled holes must be stabilized, either through cementing or through the placement of large pieces of limestone.

Reef Framework Repair. Fractured reef surfaces do not provide a suitable surface for long-term natural recovery and must be stabilized through cementing and the removal of smaller, unstable pieces of debris.

Partial Restoration. This involves re-creating three-dimensional relief on leveled reef surfaces through transplanting live hard corals or cementing coral rubble to the reef substrate.

NOAA believes that monitoring is an integral component of restoration and is fundamental to determining the recovery of the injured resources. The fact that monitoring is spread over a long time period (at least 10 years in a coral reef environment) may make the cost estimates appear large relative to the amount spent on restoration.

Monitoring, reef framework repair, and partial restoration (coral transplanting) techniques were all were employed at the grounding site of the M/V *Wellwood.* The techniques proposed in the restoration plan for the M/V *Alec Owen Maitland* and M/V *Elpis* included minor modifications to these techniques based on the results of the monitoring effort.

A formal cost-benefit analysis was not conducted to select a restoration plan for these grounding sites, although an informal analysis was done. A consensus building approach among our scientific experts and program staff was used to select appropriate restoration techniques and to develop cost estimates that reflected the "best professional judgement" of our scientific experts. We also relied on market prices to determine product prices and previous experience to estimate expenditures of effort, which were then used to develop a reasonable restoration plan. In future natural resource damage actions, we plan to undertake a more rigorous evaluation process to select the most cost-effective restoration alternative.

The M/V *Elpis* and M/V *Alec Owen Maitland* natural resource damage claims were settled in 1991. The monies received by SRD must be spent in accordance with priorities specified in Section 312 of the MPRSA. Six categories of activities are listed, including response costs, damage assessments, restoration, replacement, management and improvement. Twenty percent of the monies recovered must be used to finance response actions and damage assessments. Of the funds remaining, they must be used, in priority order for:

Restoring, replacing or acquiring the equivalent of the sanctuary resources which were the subject of the action;

Managing and improving the national marine sanctuary within which are located the sanctuary resources which were the subject of the action; and

Managing and improving any other national marine sanctuary.

Conclusions

An examination of the M/V *Alec Owen Maitland* and M/V *Elpis* litigation indicates the value of conducting research on restoration techniques, compiling economic data, compiling resource data, and evaluating assessment techniques prior to pursuing a claim. SRD is in the process of implementing a variety of efforts (visitor use studies, habitat mapping surveys, contingent valuation studies, etc.) that should assist with future damage claims.

The pursuit of natural resource damage actions in national marine sanctuaries is simplified by the fact that SRD is often the only trustee involved. In addition, since SRD has day-to-day management responsibility for these sites, we frequently have baseline data on sanctuary resources and on the users of these marine protected areas. This enhances our ability to conduct damage assessments and to implement restoration plans. These strengths, combined with the expertise contained in NOAA's Damage Assessment and Restoration Program, ensure that the resources of national marine sanctuaries are protected from damage for future use.

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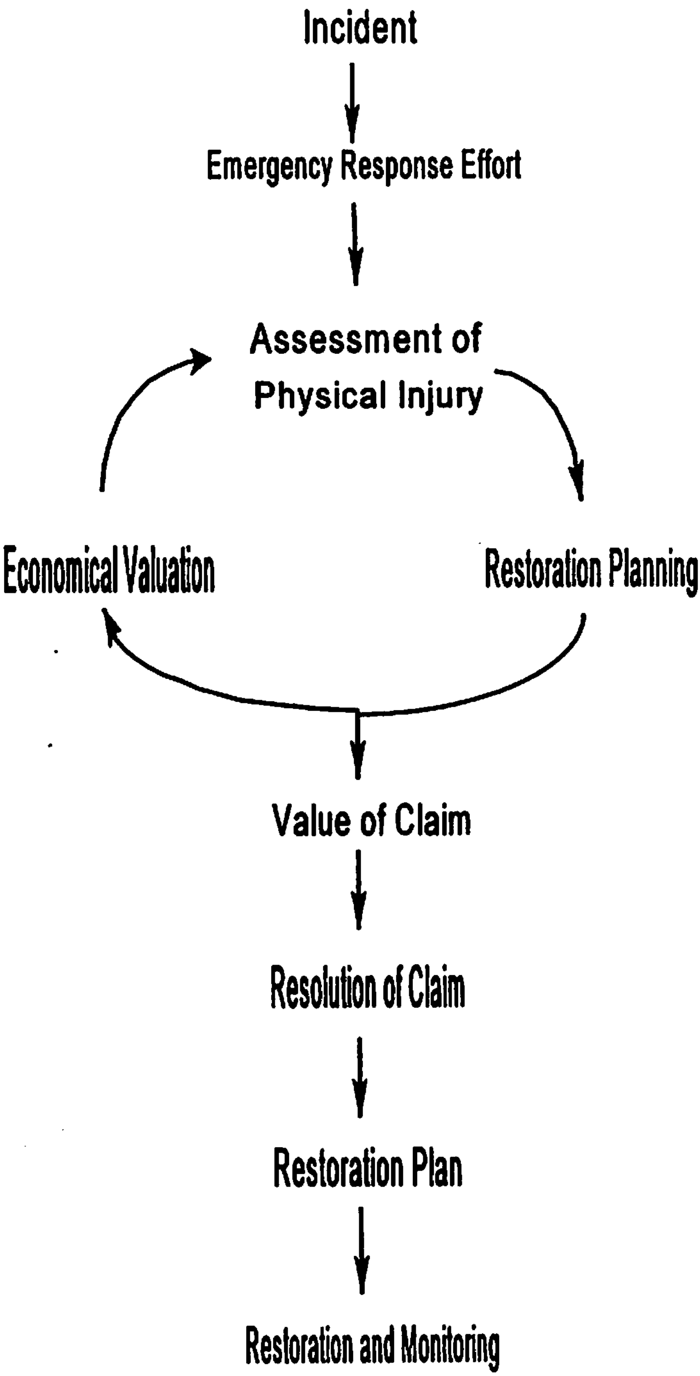
Table 1. Natural resource damage actions under the Marine Protection, Research, and Sanctuaries Act of 1972.

Vessel Name and Incident Date	National Marine Sanctuary Affected	Primary Resources Affected	Amount of Recovery[1]
M/V *Wellwood* August 1984	Key Largo	Coral reef habitat	$6,275,000 over 15 years
T/V *Puerto Rican* November 1984	Gulf of the Farallones	Sea birds	$718,000
Apex Houston Jan.-Feb. 1986	Gulf of the Farallones	Sea birds	In litigation
M/V *Mini-Laurel* December 1986	Key Largo	Coral reef habitat	$30,000
M/V *Alec Owen Maitland* October 1989	Key Largo	Coral reef habitat	$1,450,000
M/V *Elpis* November 1989	Key Largo	Coral reef habitat	$2,275,000
Jacquelyn L July 1991	Florida Keys	Coral reef habitat	In litigation

[1]In addition to amounts recovered under Section 312 of the MPRSA, settlements may also include civil penalty and forfeiture funds under Section 307.

Figure 1. Progression of natural resource damage actions under the Marine Protection, Research and Sanctuaries Act.



CONSERVATION MONITORING OF BENTHIC COMMUNITIES IN THE FLORIDA KEYS: ECOLOGICAL METHODOLOGY

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Abstract

A long-term monitoring project was initiated in 1989 on two nearshore hardbottom communities in the Florida Keys to document and assess changes in community structure and spatial patterning of benthos. Conservation-level monitoring included the application of specific survey methodologies for documenting changes in hardbottom benthos, including species presence and absence lists and quantifying density and area coverage of benthos utilizing belt quadrats. Undergraduate students from the University of Miami Marine Biology Laboratory were trained by advanced marine science students in terms of species identification and survey methodologies. Survey sites were sampled during seven 2-day sampling periods from 1989 to 1991. For each year this monitoring program has produced an annual report summarizing data collected by students. This report has been distributed to the Florida Department of Natural Resources (DNR), the Florida Institute of Oceanography (FIO) and local universities.

Short-term results of specific community parameters suggest that the rate of change in nearshore hardbottom communities is accelerated by coastal development and eutrophication from point and non-point sewage discharge. The cause or mechanism of this change is not yet fully understood, but nutrient loading is clearly evident along developed coastlines in the Florida Keys. Decreased water quality has resulted in a reduction in the number of species of typical hardbottom benthos, as well as decreases in density and area coverage of organisms, principally stony corals (Orders Scleractinia and Milleporina), octacorals (Order Alcyonacea) and sponges. In addition, nutrient loading has resulted in increased sedimentation and area coverage of macroalgae at impacted sites. These findings, coupled with field assistance from trained student surveyors, represent an important model for conservation monitoring of hardbottom communities in the Florida Keys, both in terms of applicable field methodologies for documenting changes in communities and the incorporation and training of student surveyors for the collection of quality data. This program further increases the documentation of the effects of coastal development and eutrophication on nearshore hardbottom communities in the Florida Keys.

Introduction

Ecological monitoring of the benthos requires the analysis of spatial characteristics of community structure and temporal fluctuations in specific survey parameters. An ultimate goal of conservation monitoring is the documentation of changes in natural communities and the establishment of baseline values for community parameters from which to assess changes. Conservation monitoring of marine hardbottom communities is detail-driven, but there exist difficulties in assessing the effects of specific disturbances from long-term fluctuations in communities (Brown and Howard, 1985). Two features characterize all natural communities: they are dynamic systems and spatially heterogeneous. There is a lack of adequate baseline data for tropical/subtropical marine hardbottom communities, including reef areas, which makes management of protected areas more difficult and provides for little historical information to assess long-term changes in lieu of anthropogenic disturbances (Dahl, 1981; Dahl and Lamberts, 1977). Historical data can allow for the establishment of baseline values for specific community parameters, which can be useful in determining the effects of anthropogenic impacts on communities (Grigg and Dollar, 1990; Davis, 1982).

There exist few long-term databases on tropical/subtropical hardbottom communities, although recently there has been an increase in the number of monitoring programs initiated in specific areas in the Caribbean region (Rogers et al., 1983; Hughes and Jackson, 1985; Dustan and Halas, 1987; Wittenberg and Hunte, 1992). The lack of adequate data for hardbottom communities from which to assess changes, whether natural or anthropogenic in effect, is due to the constraints of cost and labor, lack of trained personnel and little uniformity in the utilization of specific survey protocols and benthic parameters measured. As such, there exists an overall deficiency in the focus of marine biodiversity and conservation compared to terrestrial systems. Along the southeast Florida coast, selected monitoring studies on hardbottom communities, particularly reef areas, have documented changes in community structure due to thermal stress (Porter et al., 1982), dredging (Marszalek, 1981), and natural destructive events, such as hurricanes (Shinn, 1976). The majority of monitoring programs have focused on benthic distribution patterns of stony coral (Scleractinia and Milleporina) on platform margin reef communities, but very few studies have included other benthic components of hardbottom communities, specifically octacorals, sponges and macroalgae (Brown and Howard, 1985). In addition, other types of hardbottom communities found along the southeast Florida coast, particularly patch reefs and livebottom communities, have been largely ignored.

The establishment of the Florida Keys National Marine Sanctuary in 1990 has raised questions as to effective resource management of both terrestrial and marine components within protected areas. In 1989 a conservation monitoring program was initiated on two nearshore hardbottom communities in the Florida Keys to assess differences in community structure of nearshore areas impacted from coastal development and decreased water quality. Anecdotal accounts and quantitative information from line transects from 1986 to 1988 suggested a decline in species diversity of dominant benthic invertebrates, decreased area coverage of stony corals and sponges, increased overgrowth of octacorals by filamentous algae and loss of adjacent seagrass areas. Specific survey methodologies were implemented to assess changes in these hardbottom communities in terms of benthic patterning. The purposes of this study are: (1) to outline a sampling program appropriate for characterizing and monitoring hardbottom communities in terms of specific survey methodologies and (2) to present short-term results of alterations in nearshore hardbottom communities that are due to anthropogenic effects.

Materials and Methods

Survey Sites. Two nearshore hardbottom communities in the middle Keys were selected for study to document changes in specific parameters of benthic community structure (Figure 1). Both sites were selected on the basis of shallow depth (<2 m), low physiographic complexity and close proximity to the Keys Regional Marine Lab on Long Key. Craig Key reef (CKR) is an 8-ha site located offshore (<250 m) on the ocean side of Craig Key, an uninhabited island built primarily from fill during the construction of the overseas highway. Fiesta Key reef (FKR) is a 1-ha site located offshore (<150 m) on the bayside of Fiesta Key, an inhabited island with a marina and a KOAN campground. Fiesta Key contains a point-source sewage discharger (domestic facility) that discharges effluent into Florida Bay. In addition a resort and the KOAN campground on FKR contain wastewater treatment facilities and shallow injection wells (EPA, 1991).

Both study sites are characterized as low-relief hardbottom communities (livebottom), in which these areas are typically nearshore, shallow (<2m) and adjacent to tidal channels. Shallow-water communities in the Florida Keys are often impacted by thermal stress, particularly during the winter months (Roberts et al., 1982; Burns, 1985). These communities exhibit lower physiographic relief compared to patch reefs and outer bank reefs found along the southeast Florida coast (Jaap, 1984). The faunal and floral elements of hardbottom communities are usually non-consistent and are generally composed of sponges and octacorals with a few hardier stony coral species. Areas adjacent to hardbottom communities are typically seagrass or sedimentary environments. In terms of area, low-relief hardbottom communities are the dominant community-class found in the Florida Keys (Marszalek, 1977).

Benthic Sampling Strategy. Students from the University of Miami undergraduate Marine Biology Laboratory were brought to the Keys Regional Marine Lab on Long Key for two-day trips. During this time, students were divided into specific taxa groups (i.e., corals, sponges, etc.) and were trained in species identification and survey protocols by higher-level students, who had previously taken the undergraduate marine biology course, in addition to advanced invertebrate biology. Appropriate prescribed data sheets were given to each taxa group with specific instructions as to the collection of data. During all field surveys, trained higher-level students always accompanied newly trained students to assist in species identifications and quantitative data collection procedures and were responsible for data fidelity and all subsequent data analyses.

Both qualitative (presence/absence) and quantitative (belt quadrats) data were collected. Species presence and absence data were collected for dominant benthic macroalgae, sponges, stony corals (Scleractinia and Milleporina) and octacorals (Alcyonacea) based on species (field-identifiable) lists that were compiled for hardbottom communities along the southeast Florida coast (Jaap, 1984; Goldberg, 1973; Opresko, 1973; Woelkerling, 1976). Field guides and color photographs were used and corrected for taxonomic consistency. Both study areas were surveyed for any species that were present in the community that may not have appeared in the belt quadrat sampling. Species identifications were made in situ, although unknown specimens were collected and returned to the laboratory for subsequent identification. Taxonomic sources were used for benthic macroalgae (Littler et al., 1989; Taylor, 1960; Woelkerling, 1976), sponges (Wiedenmeyer, 1977; Colin, 1988), octacorals (Bayer, 1961) and stony corals (Smith, 1971).The method of data acquisition was similar to those of Dodge et al. (1982) and Sullivan and Chiappone (1992), in which belt quadrats were used. Fifteen-meter transect lines were randomly placed at each survey site and were used as a guide for the placement of 1-m^2 quadrats. Sampling adequacy was tested by plotting species-area curves, in which the cumulative number of species was plotted as a function of area sampled (Gleason, 1922). CKR and FKR were sampled during 14 two-day survey periods from September to November each year.

For belt quadrat surveys, information was collected on substratum and lifeform characteristics for each study site. For each 1-m^2 quadrat sampled, the substratum was scored according as: (SM) sand-mud, (S) sand, (RB) rubble and (HR) hard reef. Lifeform cover was classified as: (AT) algal turf, (SG) seagrass, (SC) soft coral-sponge and (HC) hard coral. Cover classes were delineated as follows: <10 percent, 10 to 30 percent, 30 to 70 percent and >70 percent. Percentage cover classes were chosen based on easier discrimination in field surveys compared to other possible cover classification schemes. For each quadrat surveyed, 100 percent of the lifeform and substratum coverage was accounted for. In addition, for each quadrat sampled, the species of sponge, octacoral and stony coral were identified and counted. Because of the great variability in growth morphology and difficulty with in situ identifications, octacoral data were pooled for all species. For sponges and stony corals, the number of individuals and colonies were counted and measured for density and area coverage estimates. A colony or individual was considered to be any individual growing independently of its neighbors (Connell, 1973). In cases where a colony or individual was clearly separated by the death of intervening portions, each living part was considered to be a separate individual. Area coverage (cm^2) of sponges and stony corals was calculated from plan measurements of colony or individual dimensions (diameter, length, width), which were subsequently used in areal formulas for a circle or rectangle. Area coverage data were not collected during 1989. Colony heights were measured for octacorals.

Data Analysis. For substratum/lifeform coverage data, plots were constructed for each site from 1989 to 1991 based on coverage (cm^2) (mean $\pm$ 1 SD) per m^2. Original scoring for coverage classes for substratum/lifeform was converted to cm^2 of coverage for each quadrat. For species presence and absence data, inventory lists were compiled for each taxon. Similarity values between sites and within sites were computed for each taxon using the coefficient of Dice (Hubalek, 1982; Dice, 1945). This coefficient heavily weighs joint species presences compared to joint species absences (Legendre and Legendre, 1983). Similarity matrices were constructed separately for stony corals, octacorals and sponges, in which inter-site and intra-site comparisons were made for CKR and FKR during 1989 to 1991. Similarity matrices were used to construct dendrograms based on the UPMGA clustering strategy (Pielou, 1977).

For belt quadrat information, data were analyzed in two ways: (1) pooled information for taxa groups and (2) species-level information. For pooled data, inter- and intra-site comparisons were made for parameters measured using a one-way Analysis of Variance and subsequent multiple comparison testing using Tukey's Least Significant Difference (LSD) Test (Sokal and Rohlf, 1981; Zar, 1984). All quadrat data (density, area coverage, height) were transformed to $\log_{10}(x+1)$ based on previous heteroscedasticity of variances (Bartlett's test, $p>0.05$) (Zar, 1984). Density comparisons were made for stony corals, octacorals and sponges based on mean $\pm$ 1 SD values per m^2. Area coverage and area per colony (mean $\pm$ 1 SD) comparisons were made for stony corals and sponges, while height per colony values (mean ± 1 SD) were compared for octacorals. Size-frequency distributions were constructed for dominant benthic invertebrates. Species-level data were utilized for stony corals and sponges to compute similarity matrices for density and area coverage based on each species percentage of the total density and area coverage for stony corals or sponges (Field et al., 1982; Wolda, 1983). Dendrograms were computed for each classification. In addition coral colonies and sponge individuals were classified into logarithmic size categories. A percentage similarity matrix was derived based on each size class's percentage of the total number of colonies or individuals. A resultant dendrogram was computed for stony coral and sponge species.

Results

Overview of Program. The incorporation and training of undergraduate students for this monitoring study was successful in that students were able to effectively learn species identifications, both in the laboratory and the field, and quickly adapted to the benthic sampling program. To ensure data fidelity and quality control, the presence of trained upper-level undergraduates ensured that accurate information was being collected by the newly trained students. In addition prescribed protocols and data sheets enabled students to concentrate on collecting the information, which effectively eliminated confusion concerning what data to collect and how to collect it. The incorporation of students significantly reduced the cost of this study, particularly in terms of labor.

Substratum and Lifeform Characteristics. The substratum features at CKR remained constant from 1989 to 1991, the period for which this community is characterized by a low-relief carbonate platform with relatively little sediment accumulation (Figure 2). Lifeform characteristics changed somewhat, as shown by a decrease in algal turf coverage over a three-year period at CKR. In addition, octacoral-sponge coverage and hard coral coverage have decreased since 1989. At FKR the substratum features are similar, although sand-mud coverage has increased since 1989. Lifeform coverage changes have been more dramatic at FKR, where algal turf coverage has increased, while the coverage of seagrass, octacorals-sponges and hard corals decreased over the three-year span.

Species Presence and Absence. At CKR the number of stony coral, octacoral and sponge species remained relatively constant from 1989 to 1991 (Table 1). In contrast, the number of species of benthic invertebrates at FKR decreased dramatically over three years. Similarity has decreased between CKR and FKR since 1989 based on the reductions in species richness at FKR compared to CKR. Figure 3 illustrates this trend of decreasing similarity between the two sites based on stony coral species presence and absence data. In 1989 there were seven species of stony corals common to both sites, but by 1991 there were only three species common to both communities; FKR has lost four stony coral species since 1989. Similar results were documented for octacoral and sponge species. In contrast, the macroalgal assemblages at both sites remained constant from 1989 to 1991, although differences do exist in the macroalgal species composition between CKR and FKR.

Belt Quadrat Data. In terms of pooled density values for taxa, CKR exhibited significant ($p<0.05$) increases in the density of stony corals, octacorals and sponges from 1989 to 1991 (Table 2). In contrast, FKR exhibited significant ($p<0.05$) decreases in the density of octacorals and sponges, with a non-significant ($p>0.05$) decrease in stony coral abundance as well. For example, Figure 4 illustrates that at FKR there have been significant reductions in the colony numbers of octacorals since 1989. In terms of density, CKR and FKR have become more dissimilar, with CKR exhibiting significantly higher densities of benthic invertebrates by 1991. In terms of area coverage, stony coral coverage decreased significantly ($p<0.01$), while sponge area coverage increased ($p>0.05$) from 1990 to 1991 at CKR. At FKR, both stony coral and sponge area coverage decreased significantly ($p<0.01$) from 1990 to 1991. By 1991, CKR and FKR were significantly different in terms of area coverage of stony corals and sponges. In terms of the size-frequency distribution of benthos, CKR exhibited a significant ($p<0.01$) reduction in the mean (+ 1 SD) area per colony, while the sponge area per individual slightly increased from 1990 to 1991. The mean height per colony for octacorals at CKR has significantly ($p<0.01$) increased since 1989. At FKR the stony coral area per colony slightly increased ($p<0.05$) from 1990 to 1991, while the sponge area per individual significantly ($p<0.01$) decreased. CKR and FKR have become more dissimilar in terms of the octacoral height per colony, while the stony coral area per colony has become statistically ($p>0.05$) similar. Figure 5 illustrates that in terms of stony coral species-level area coverage, in which similarity is based on the relative coverage of each species, CKR and FKR have become more dissimilar, principally due to the fact that FKR has exhibited decreases both in density and area coverage, as well as a significant decrease in the number of species. These two communities have become more similar in terms of the size-frequency distribution of stony coral colonies, in that CKR has lost large (>100 cm^2) colonies while FKR has lost smaller (<10 cm^2) colonies.

Discussion

The incorporation of student surveyors was successful in that a significant amount of quality information could be collected in a relatively short time period each year. In addition, when students were given species lists and were instructed as to the benthic sampling techniques used in this study, students were able to quickly grasp the important concepts. Formatted and prepared data sheets eliminated the collection of either unnecessary or erroneous data. The collection of data by 120 students each year has allowed for the construction of this monitoring database. Even with supervised students collecting field data, it was clear that the pattern of coastline development was having a significant impact on nearshore communities.

The methods and parameter analyses outlined in this report are not unique, but the combination of specific community parameters may prove to be effective in appropriately monitoring tropical/subtropical hardbottom communities. Monitoring of natural communities is purpose-oriented, and clear objectives must be established for assessing temporal changes in ecological systems. As such, ecological monitoring is dynamic in philosophy, because all natural communities are subject to differential intensities and directions of change (Usher, 1991; Hellawell, 1991; Sousa, 1984; Connell, 1978). Difficulties in monitoring concern the objectives of a particular study, the selection of appropriate sites and specific parameters to be measured. In addition, complications arise because of the need to select a standard norm with which to assess changes. As such, the documentation of changes in natural communities does not necessarily constitute monitoring, for changes in community parameters are expected based on disturbance events, life history strategies, abiotic factors and stochastic events.

Presence/absence data, while only qualitative, provide information on the complexity of hardbottom communities, and as applied to monitoring, provide a coarser level of resolution on overall community structure. Presence/absence data are limited, in that the method is not exhaustive and only dominant benthos are taken into account. It could be hypothesized that, barring catastrophic disturbances, hardbottom species composition would be less likely to fluctuate compared to more specific parameters that take into account relative abundances. Quantitative data provide for a more descriptive analysis of community structure, but survey parameters (density, area coverage) are most effective when used in concert. This may be particularly important for communities composed of clonal organisms. Density data alone are useful to the extent that information is provided on the spatial patterning of organisms, but size and numerical abundance must be coupled to assess the size-frequency distribution of benthos. The density of benthos may not fluctuate as dramatically, but area coverage, based on the demographic consequences of clonal growth, would be expected to change more frequently.

The application of clustering techniques allows for the tracking of community parameters, but again these parameters are most effective when coordinated. The pooling of data for any one taxon (i.e., stony corals or sponges) allows for the monitoring of communities in terms of overall community parameters, which provides information on changes in taxa relative to one another and may be important in assessing stress events or anthropogenic impacts. Species-level analysis provides data on relative species factors, such as density and area coverage, which again may be important in assessing how communities change in relation to one another, whereby communities may be similar in pooled community parameters (i.e., density) but differ in relative species abundances. These differences may be related to differential life history strategies and susceptibility to stress.

For hardbottom communities in the Keys, appropriate questions for ecological monitoring will include: (1) How much have communities changed?; (2) In reference to these changes, how have communities changed relative to one another, and; (3) What are these differences in direction and intensity due to? (Keddy, 1991). Communities are expected to change, but how do similar community types (i.e., nearshore hardbottom) change as a function of different environmental factors? These questions may be important in assessing human impacts in the Florida Keys, particularly as related to how these impacts manifest themselves in the rate and direction of change in communities.

The results from this report suggest that the rate and direction of change at FKR are being affected by coastal development, particularly nutrient loading. This impact has clearly been manifested at FKR, particularly in terms of the loss of typical hardbottom benthic species and the unnatural rate of change in community structure. Neither CKR nor FKR is subjected to diving or fishing pressures, but nutrient loading at FKR has seriously degraded this community. Preliminary water quality data at FKR indicate that nutrient concentrations are at eutrophic levels, while at CKR water is oligotrophic. This change at FKR has been documented in light of "natural" fluctuations in nearshore hardbottom communities (CKR) in the Keys. It is evident from the data that mortality events may be a frequent feature of these communities, but the changes documented at FKR indicate that the direction of change in this area is different that at CKR. The increase in sediment due to increased area coverage of macroalgae, loss of area coverage of stony corals and sponges, and decreases in the size-frequency distribution of benthos at FKR suggest that this community is undergoing an alteration in the structure. Similar findings have been reported for areas impacted from decreasing water quality, in which increased sewage pollution led to sediment trapping by macroalgae, exposing benthic organisms to increased sediment loads (Walker and Ormond, 1982; Moore, 1977; Babcock and Davies, 1991; Wittenberg and Hunte, 1992). Nearshore hardbottom communities are susceptible to natural disturbances (e.g., thermal stress), but anthropogenic disturbances will likely cause a permanent change to the community. Subsequent recruitment of typical hardbottom benthos may be prevented, prolonged or altered (Pearson, 1981; Endean, 1976; Loya, 1976; see Margalef, 1975; Rappaport et al., 1985).

Comparatively little attention has been paid to nearshore hardbottom areas in terms of human-induced stresses, such as anchor damage, commercial collecting, fishing pressures and water quality. Not only are low-relief hardbottom communities the dominant community class found in the Keys in terms of area coverage, but also serve as an important recruitment base for fishery target species, such as the spiny lobster (*Panulirus argus*) and grouper (Serranidae). In addition, little is known concerning recruitment patterns, specifically of benthic invertebrates, such as corals and sponges, between nearshore areas (inside of Hawk Channel) and the outer bank reefs. If there is inshore-offshore recruitment of typical benthos, then the destruction of nearshore areas will significantly affect the viability of offshore communities. In addition, nearshore communities will exhibit immediate responses to land use in the Keys, whereas offshore communities would likely experience declines in typical benthic parameters only after nearshore areas are significantly degraded.

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Table 1. Species presence/absence (+/-) and quadrat summary for CKR and FKR, 1989-91. For presence/absence data, the number of species is given for dominant benthic invertebrates and macroalgae. For belt quadrat data, mean + 1 SD values are given for density, area coverage, area per colony or individual, and height per colony based on 1 m^2. Coverage data not collected in 1989 for CKR or FKR. Sample sizes (m^2) are given, as is the number of colonies or individuals for each taxon.

	CKR (1991)	CKR (1990)	CKR (1989)	FKR (1991)	FKR (1990)	FKR (1989)
Sample size						
Quadrats sampled, corals	26	50	50	44	20	26
Quadrats sampled, sponges	26	36	45	26	21	26
Stony coral colonies recorded (n)	122	206	97	61	91	69
Octacoral colonies recorded (n)	135	238	208	30	46	46
Sponge individuals recorded (n)	237	248	117	31	71	42
Species Presence/Absence						
Stony coral species	9	10	10	3	4	7
Octacoral species	17	17	17	3	5	5
Sponge species	15	19	18	15	23	21
Macroalgae species	13	13	13	16	16	16
Density (no. per m^2)						
Stony coral density	5.1 ± 3.0	7.3 ± 5.0	2.0 ± 1.7	1.3 ± 2.0	4.5 ± 4.7	2.5 ± 3.4
Octacoral density	5.9 ± 2.8	5.3 ± 2.5	3.6 ± 2.4	0.7 ± 1.7	2.6 ± 2.5	1.5 ± 1.7
Sponge density	9.1 ± 4.8	6.9 ± 3.0	2.6 ± 2.7	1.2 ± 1.2	3.4 ± 1.9	1.6 ± 1.3
Area coverage (cm^2 per m^2)						
Stony coral area coverage	46.9 ± 81.5	388.1 ± 544.2	N/A	12.7 ± 27.3	34.5 ± 37.8	N/A
Sponge area coverage	408.3 ± 592.1	283.3 ± 194.5	N/A	228.4 ± 315.6	725.4 ± 767.6	N/A
Colony or individual sizes						
Stony coral area per colony (cm^2)	10.0 ± 30.0	67.5 ± 238.5	N/A	10.0 ± 20.7	7.6 ± 10.8	N/A
Sponge area per individual (cm^2)	43.4 ± 140.9	41.3 ± 78.7	N/A	178.5 ± 276.6	214.6 ± 414.8	N/A
Soft coral height per colony (cm)	45.9 ± 22.4	45.5 ± 20.8	36.1 ± 19.4	37.0 ± 10.8	44.2 ± 14.8	44.5 ± 27.8

Table 2. Statistical summary of belt quadrat data for CKR and FKR, 1989-91. All ANOVA tests were rejected ($p<0.005$) and subsequent multiple-comparison testing was performed using Tukey's LSD test for density, area coverage and colony or individual sizes for stony corals, octacorals and sponges. (* = $p<0.05$, ** = $p<0.01$, ns = not significant)

Comparison	Stony Coral Density	Octacoral Density	Sponge Density	Stony Coral Area Coverage	Sponge Area Coverage	Stony Coral Area per Colony	Sponge Area per Individual	Octacoral Height per Colony
CKR 89:CKR 90	Incr (ns)	Incr*	Incr**	—	—	—	—	Incr**
CKR 90:CKR 91	Decr (ns)	Incr (ns)	Incr (ns)	Decr**	Incr (ns)	Decr**	Incr**	Incr (ns)
CKR 89:CKR 91	Incr*	Incr*	Incr*	—	—	—	—	Incr**
FKR 89:FKR 90	Incr (ns)	Incr (ns)	Incr**	—	—	—	—	Decr**
FKR 90:FKR 91	Decr**	Decr**	Decr**	Decr**	Decr**	Incr*	Decr*	Decr**
FKR 89:FKR 91	Decr (ns)	Decr*	Decr*	—	—	—	—	Decr**
CKR 89:FKR 89	ns	**	*	—	—	—	—	ns
CKR 90:FKR 90	*	**	**	**	ns	**	**	ns
CKR 91:FKR 91	*	**	**	**	**	ns	**	**

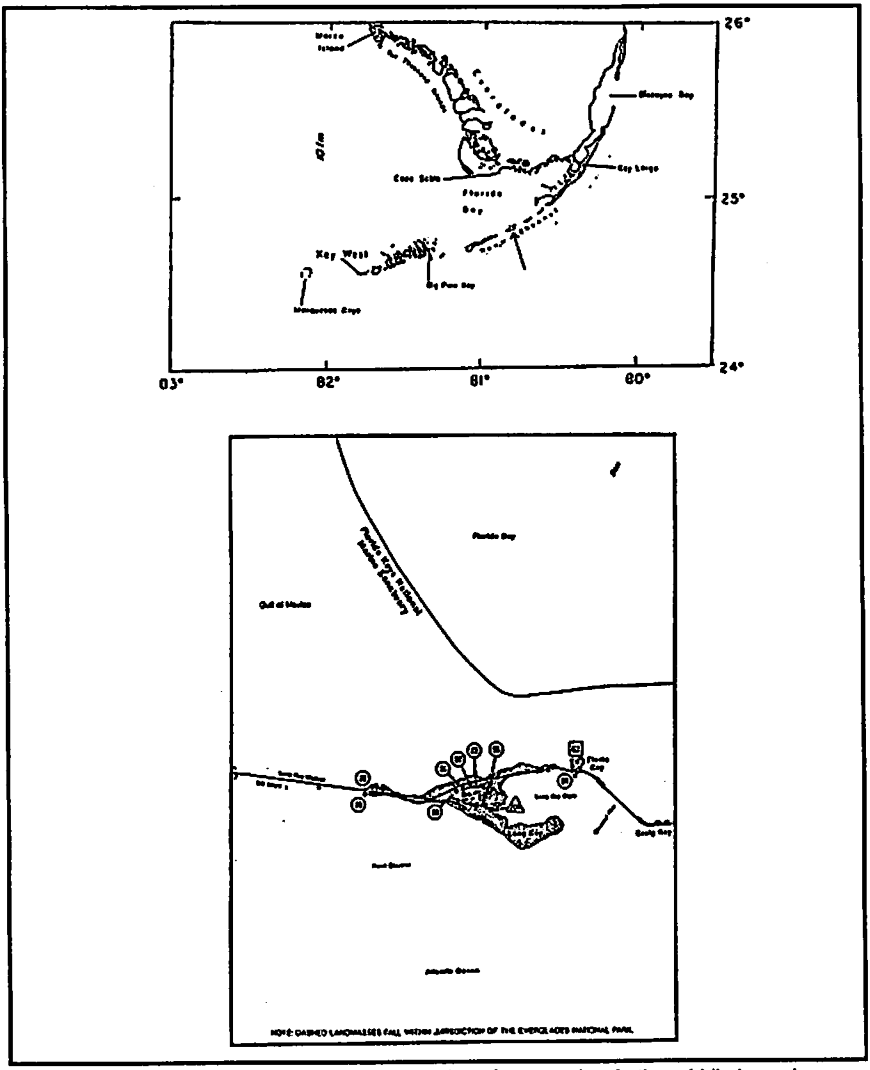


Figure 1. Map of southeast Florida showing location of survey sites in the middle keys. In addition, the location of sewage discharge canals on Long Key and Fiesta Key are illustrated. A circled number represents the location of an injection well, while squares and rectangles represent locations with NPDES permits or other surface-water dischargers (from EPA, 1991).

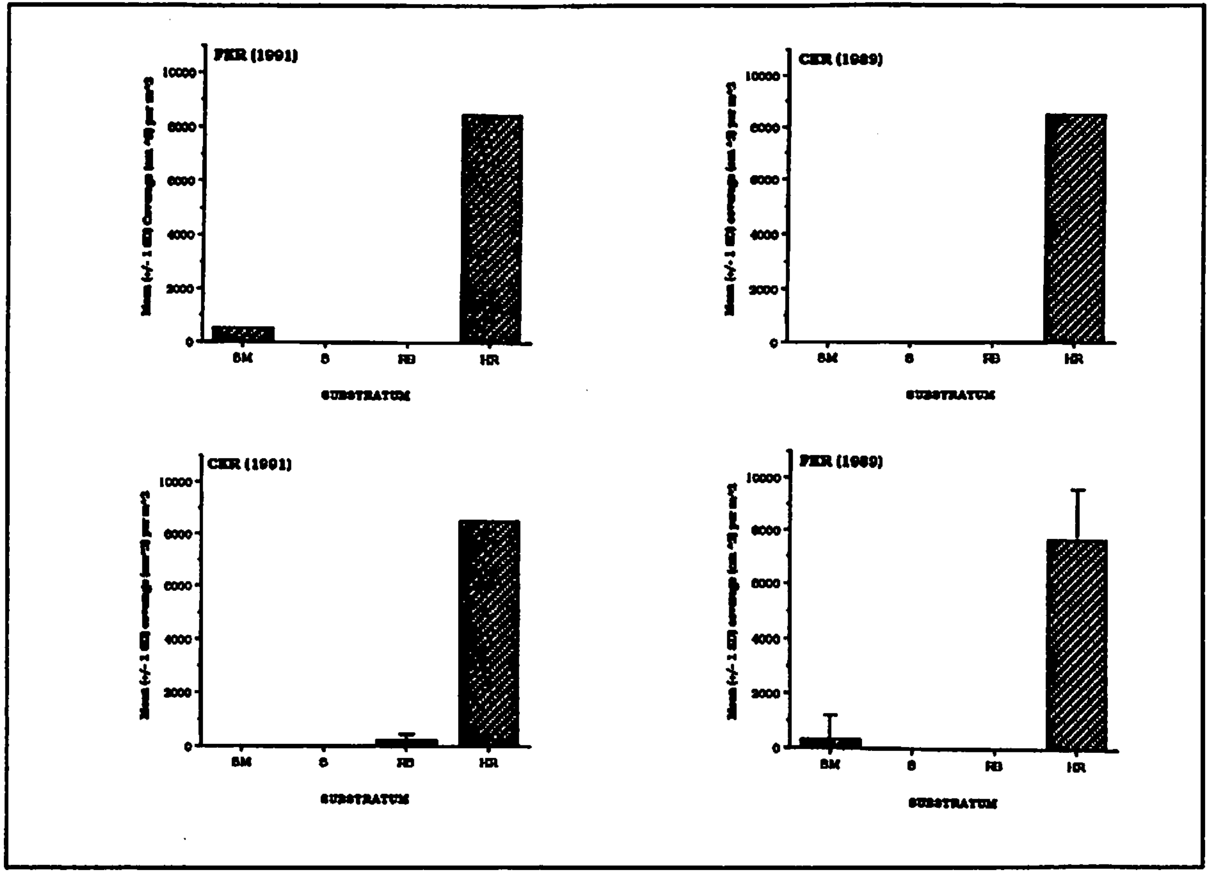
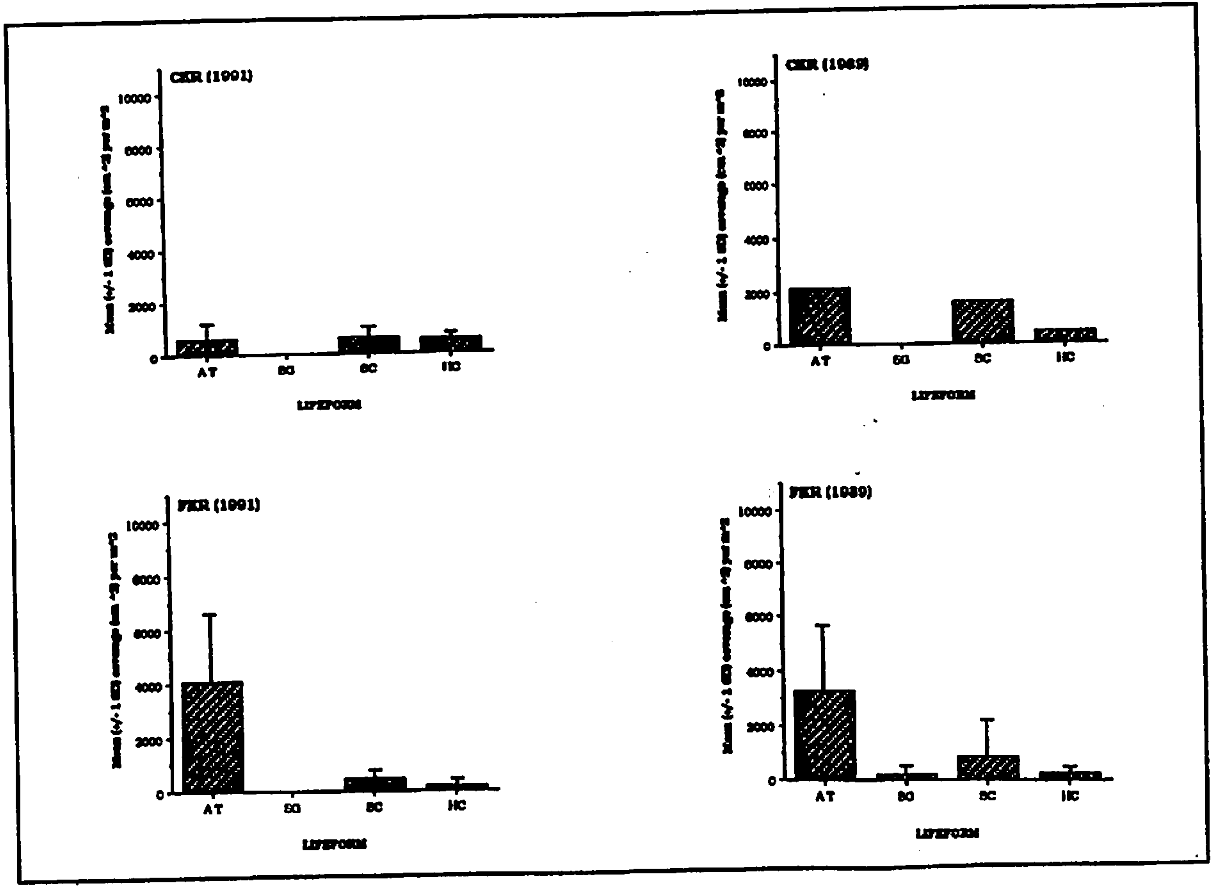


Figure 2. Substratum/life-form coverage plots for CKR and FKR, 1989-1991.

Figure 2. (continued)



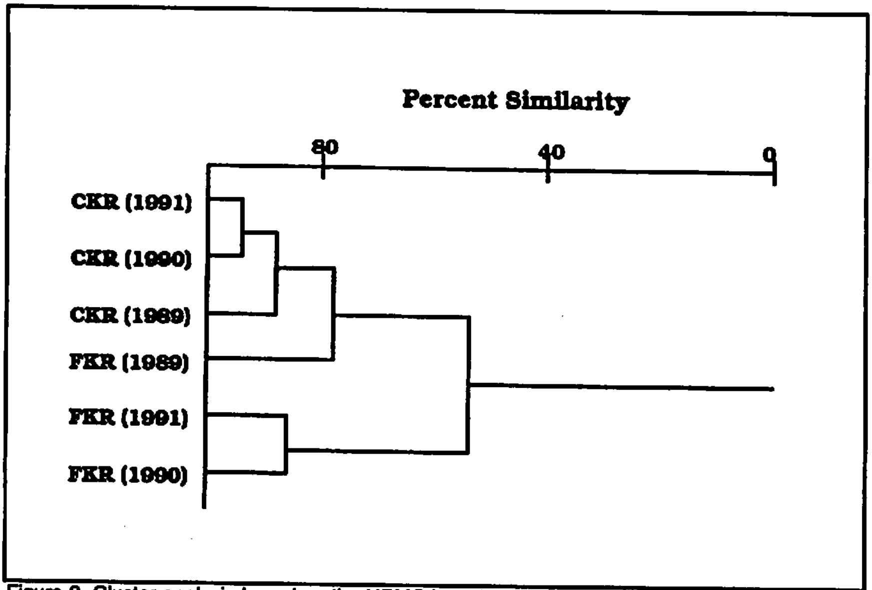


Figure 3. Cluster analysis based on the UPMGA sorting strategy for stony coral (Scleractinia and Milleporina) species presence and absence data (Pielou, 1977). The dendrogram is based on similarity coefficients computed from the coefficient of Dice.

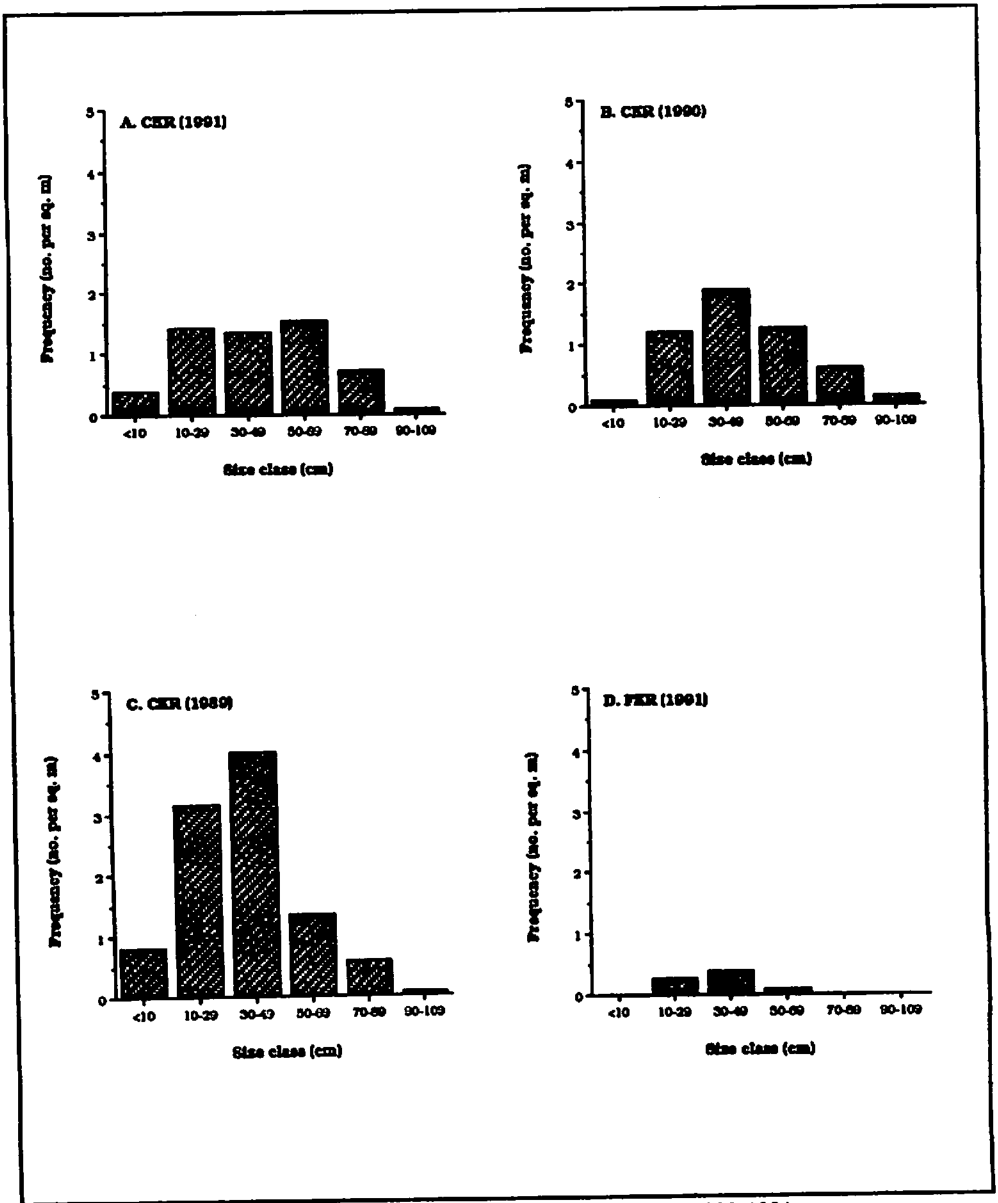
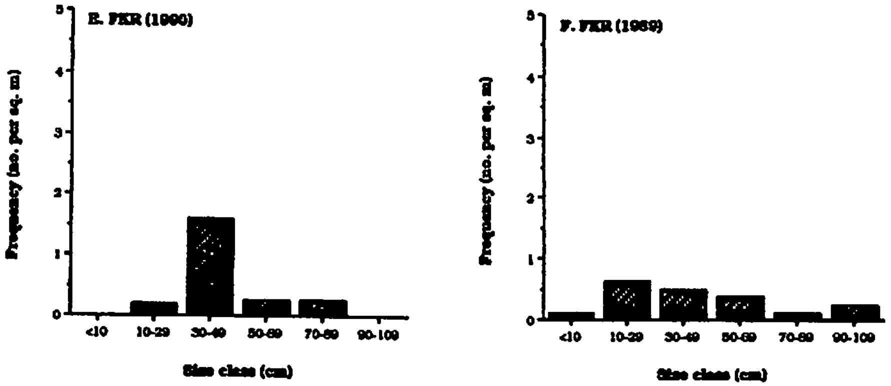


Figure 4. Size frequency distributions for octacorals at CKR and FKR, 1989-1991.

Figure 4.(continued)



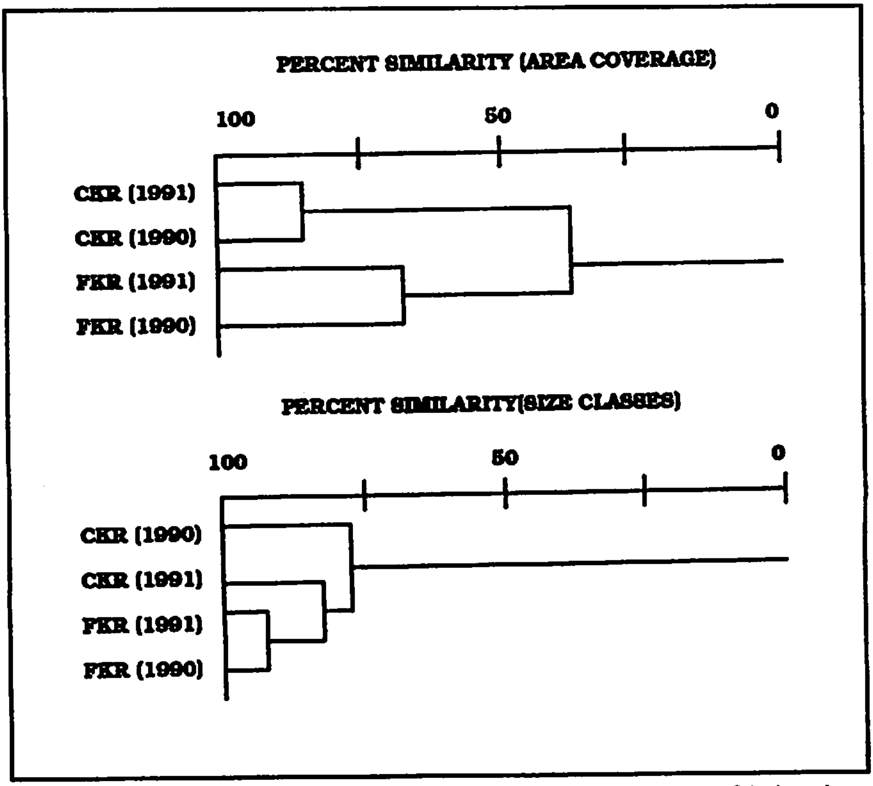


Figure 5.Cluster analysis for species-level area coverage data utilizing the UPMGA clustering strategy (Pielou, 1977). Values are based on the percentage similarity matrix for stony coral species area coverage and the relative coverage of logarithmic (base 10) size classification of coral colonies.

Ocean Governance

MANAGEMENT OF PUBLIC LANDS IN THE UNITED STATES: LESSONS FOR OCEAN MANAGEMENT

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Introduction

Few would disagree that one of the most formidable challenges facing ocean governance is dealing with multiple-use conflicts that have contributed to and exacerbated the all-too-familiar fragmented structure of U.S. ocean management. Given this problem, some valid questions worth considering include: Does planning, particularly integrated multiple-use planning, hold promise for resolving some of these conflicts; how would such planning be carried out; what statutory guidance should be created; and what kind of organizational structure and process should be established?

While the growing literature on sea-use planning has provided the foundations to begin studying integrated ocean planning, important insights toward answering some of the above questions are available by examining the multiple-use management and planning experience for public lands. With this in mind, the purpose of this paper is to contribute to understanding of the projected needs of effective ocean governance by examining the experiences and lessons learned from nearly 100 years of public lands multiple-use planning in the United States. This is part of a larger study in ocean governance that seeks to develop a conceptual framework for multiple-use management in U.S. waters that takes into account the intergovernmental factors peculiar to the United States.

Although the natural features of the public lands and the ocean are quite different, the public lands management experience serves as a useful comparative model because both realms share several important elements. First, both the public lands and the oceans have traditionally provided local and national economic opportunity, yet they are also the subject of public trust and stewardship debates. Second, both areas share the need for trade-offs among competing and sometimes incompatible uses. Third, both must confront the dilemma of resolving disputes between local and national interests. And finally, the greatest challenges of multiple-use planning for both public lands and the oceans are not resource-related, but cultural and socioeconomic.

The multiple-use management and planning practice of the U.S. Forest Service was selected for analysis because no other federal agency can match its breadth of experience in this field. The Forest Service has practiced multiple-use planning since 1905 when the national forests were placed in its stewardship, although such planning was not expressly authorized until 1974. The Forest Service has multiple-use planning (including timber, recreation, wilderness, mining, grazing

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[1]This paper reports preliminary findings from research in progress funded by the Delaware Sea Grant Program titled "Multiple-Use Ocean Management in the United States: Toward a New Conceptual Framework," Professors Biliana Cicin-Sain and Robert Knecht, principal investigators.

and watershed protection) responsibility for 191 million acres of national forests and grasslands located in 42 states and Puerto Rico. Like the fragmented nature of oceans management, the national forests are managed through a "crazy quilt" of 130 federal statutes (U.S.D.A., 1990, 2:28). Thus, on account of its size, historical experience, range of responsibilities and legal complexity, Forest Service multiple-use planning provides a useful model for thinking about ocean governance (Gale, 1985).

Analysis of the multiple-use management experience of the Forest Service is organized in four parts. First, the statutes that have had the most significant impact on multiple-use planning are discussed. Second, those aspects of national forest multiple-use planning of most relevance to ocean governance are analyzed. This is followed by a discussion of the lessons learned from the Forest Service planning experience, focusing on planning, the relationship of planning with the budget process, and the results of an extensive Forest Service study of its planning program. Finally, a set of implications of the public lands multiple-use planning experience for ocean governance are presented.

Summary of U.S. Forest Service Multiple-Use Experience

The National Forests were established with the passage of the Creative Act in 1891 out of fear that excessive logging was damaging watersheds and depleting timber supplies of western forests. One of the deficiencies of the Creative Act, however, was that it did not provide for any regulatory program to manage these public lands. Congress addressed this issue in 1897 with passage of the Organic Administrative Act. The Organic Act stated that the forest reserves were to be established only to secure favorable water flow conditions and to furnish a continuous timber supply (Wilkinson and Anderson, 1985). The Organic Act did not specify that any particular mix of uses be planned (Coggins and Evans, 1982).

Despite the lack of clear statutory authority, Gifford Pinchot, chief of the Division of Forestry, instituted the doctrine of resource planning in 1898 based on the premise that wise use and preservation of all forest resources were compatible (Wilkinson and Anderson, 1985). These dual management directives of resource use and preservation established at the turn of the century have remained the fundamental approach to Forest Service planning (Wilkinson and Anderson, 1985). The informal planning process, however, was complicated by Congress, which, over the years and without any purposeful objective, periodically added new uses for Forest Service lands, such as recreation, wildlife management, the construction of summer homes, and the building of dams. During this early period, conflict among users was kept at a minimum, not because of the direct success of planning efforts, but because the national forests were large enough to satisfy the demands of the individual user groups.

After World War II, demand for timber and National Forest recreation increased significantly, and as a result conflict developed between preservationists, who advocated a single use of forest lands, namely wilderness designation, and lumber interests, who wished to continue their over-use practice of harvesting trees. From this debate emerged consensus toward the compromise concept of multiple use, and in 1960 Congress passed the Multiple Use Sustained Yield (MUSY) Act (Wilkinson and Anderson, 1985).

The act states, "It is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (MUSY Act, 1960). The term "multiple-use management" was given to mean:

> the management of all the various renewable surface resources of the national forest so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the lands for some or all of these resources or related services over are large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some lands will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit of output (MUSY Act, 1960).

In passing the act, Congress did not establish a procedure for evaluating priorities in forest use and management, nor does the act explicitly state that the Forest Service is to undertake multiple-use planning. Despite these formal omissions, the legislative history of the MUSY Act makes it clear that Congress intended the Forest Service to engage in comprehensive planning (Coggins and Evans, 1982).

Planning under the MUSY Act began in 1963, first nationally and later locally. The strongest feature of these early multiple-use plans was specific land classifications, which indicated appropriate uses for specific forest areas. The plans, however, suffered from poor inventory data, limited public participation, and the implication that all uses would be carried out on each individual acre (Wilkinson and Anderson, 1985; Coggins and Evans, 1982).

In these early plans the Forest Service adopted zoning as the basic planning device. Each ranger district was divided into zones according to allowable uses. Zoning criteria varied from region to region, but typically the planners provided for all of the multiple uses to some degree. Specific resource coordination requirements were outlined for each zone to ensure that the authorized uses were carried out as compatibly as possible with the goal of avoiding or resolving resource conflicts (Coggins and Evans, 1982).

Zoning is still the basic planning method used by the U.S. Forest Service and can be thought of somewhat like a county zoning ordinance. Like a zoning ordinance, current forest plans allow or prohibit some uses and establish standards and guidelines that regulate all resource use for a particular area. Also, like a zoning ordinance, forest zoning practices constrain and govern future decision-making by requiring all activities to be consistent with the approved ordinance established for a particular planning area (U.S.D.A., 1990, 10:19).

The idea of multiple-use zoning, however, was challenged in *One Third of the Nation's Land*, the 1970 report of the Public Land Law Review Commission. The purpose of the commission was to study the demands on the public lands and likely demands for the foreseeable future. The most controversial recommendation of the commission read:

> Statutory goals and objectives should be established as guidelines for land-use planning under the general principle that within a specified unit consideration should be given to all possible uses and the maximum number of compatible uses permitted. This should be subject to the qualification that where a unit, within an area managed for many uses, can contribute maximum benefit through one particular use, that use should be recognized as the dominant use, and the land should be managed to avoid interference with fulfillment of such dominant use (Public Land Law Review Commission, 1970).

The commission did not advocate that all public lands be placed in one or another dominant use zone but only that those areas having an identifiable highest primary use at the time of classification be placed in a dominant use category. The remaining lands should remain in a category where all uses are considered equal until a dominant use becomes evident (Public Land Law Review Commission, 1970).

Although Forest Service planning procedures were modified in the early 1970s to comply with the National Environmental Policy Act, there was increasing uneasiness over Forest Service resource policies and management practices to meet national goals. The result of this public debate was passage of the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974.

The RPA calls upon the Forest Service to determine the resources available, develop a plan for the use of the resources, and then to implement the plan through forest management (Coggins and Evans, 1982). To accomplish these goals the RPA requires the Forest Service to prepare three planning documents: a resource assessment; a resource program; and an annual report.

The Forest Service was required to prepare a resource assessment in 1975, 1979 and every 10 years thereafter. The purpose of the assessment is to analyze present and anticipated demand and supply of renewable resources; to provide an inventory and description of the renewable resources of all the nation's forest and range lands; to describe the management program of the Forest Service, including program interrelationships; and to discuss other important policy considerations (RPA, 1974). The Forest Service is also to prepare a resource program every five years until 2020. The program proposes long-range objectives with a planning horizon of at least 45 years for all Forest Service activities (RPA, 1974). Finally, the Forest Service is to prepare an annual report that evaluates Forest Service activities in comparison with objectives proposed in the resource programs (RPA, 1974).

Despite the planning process established by the RPA, there continued to be dissatisfaction with the multiple-use management practices of the Forest Service, in part because the national planning mandate of the RPA focused on process but neglected to provide substantive policy direction (Coggins and Evans, 1982). Then, in 1976 renewed attention was directed on national forest planning when environmentalists challenged the practice of clearcutting as a violation of the 1891 Organic Act (Coggins and Evans, 1982). Congress reacted by repealing the provisions of the Organic Act that precluded clearcutting and by passing new planning standards in the National Forest Management Act (NFMA).

While passage of the RPA in 1974 seemed to many to be a means of promoting greater centralization of decisionmaking and national top-down planning, the passage of the NFMA just two years later was likewise seen as a measure to restore decentralized decisionmaking. This balancing act is to be accomplished through the forest plans themselves and through the influence of bottom-up forest planning data in subsequent RPA planning (U.S.D.A., 1990, 2:42). The NFMA requires the Forest Service to attempt to complete 123 local and land resource management plans by 1985; all but seven have been completed as of May 1992 (NFMA, 1976). For the first time, these plans are to be legally binding in that they are intended to specify definitive land-use allocation and resource management policies in accordance with the Multiple-Use Sustained Yield Act (NFMA, 1976). The act also established the policy that all contacts and permits issued to implement specific projects must be consistent with an approved forest management plan (NFMA, 1976).

Forest Planning Process

Full description and analysis of the U.S. Forest Service planning process is beyond the purpose of this paper; therefore, only those aspects of the planning process that are unique to multiple-use forest planning and that may be of significance to ocean governance are briefly discussed (36 *CFR* 219).

First, the planning process is essentially interactive in that the information from the forest level flows up to the national level, where in turn information in the RPA program flows back to the forest level (36 *CFR* 219.4(a)(3)).

Second, planning for units of the national forest system involves two categories of decisions. The first is development of a forest plan that provides direction for all resource management programs, practices, uses and protection measures. The forest plan consists of both forest-wide and area-specific standards and guidelines that provide for land uses with anticipated resource outputs under the given set of management constraints. These outputs, however, are not hard and fast decisions, because all conditions required to produce outputs, such as annual budget appropriations, are not controlled at the unit level. The second category of planning involves site-specific analysis and implementation of management practices designed to achieve the goals and objectives of the forest plan in accordance with NEPA (U.S.D.A., 1922).

Third, the planning process consists of three levels of planning, national, regional and forest-level. National-level planning focuses on the goals and objectives established by the chief of the Forest Service in the resource assessment and resource programs. Regional-level planning links the RPA assessment and program with local forest planning (U.S.D.A., 1987). The regional forester establishes regional policy for forest planning in accordance with these documents and promulgates regional guides. The regional forester approves all forest plans in the region, but such plans are forwarded to the Washington, D.C., headquarters for final review. Regional foresters also work with state forestry officials to coordinate state involvement in national forest planning. Finally, at the forest-level, the forest supervisor has overall responsibility for the preparation and implementation of forest plans and the preparation of the accompanying environmental impact statement for these plans. The forest supervisor also appoints and supervises an interdisciplinary team that helps prepare forest plans (36 *CFR* 219.4(b), 219.5(a), 219.8).

Fourth, forest-level planning and regional-level planning review must incorporate an interdisciplinary team approach. The purpose of the interdisciplinary team is to ensure that there is coordinated planning of the various resources. The team consists of members representing the physical, biological, economic and social sciences, and the environmental design disciplines. Furthermore, the team is restricted to Forest Service staff and other federal government personnel, but team members are permitted to consult with other persons when specialized knowledge does not exist within the team itself. Lastly, the planning regulation specifies the skills and attributes these members should possess (36 *CFR* 219.5).

Fifth, the planning process must incorporate 14 planning principles at the forest-level planning and regional-level approval stages. The most significant principles include: recognition that the national forests are ecosystems and that their management requires awareness and consideration of interrelationships among all of the resources and environmental factors; early and frequent public participation; and responsiveness to changing conditions of land and to changing social and economic demands of the American people (36 *CFR* 219.1(b)(1)-(14)).

Lessons Learned

Any planning process as ambitious and of such a scope as that undertaken by the Forest Service will produce both problems and positive experiences that can be assessed as useful lessons learned. Three areas of lessons learned presented here relate to the planning process at the project-level and in relation to the overall program; the relationship between the budget process and the forest planning process; and results from a Forest Service in-depth study of its planning program.

Planning

Project-Level Problems. Recurring problems at the project level are of two types. The first is deferral of decisions on a number of broad, forest-wide management issues, from forest planning to the project planning stage. At times, senior Forest Service officials have decided to proceed with implementing most of a forest plan but to defer other important and difficult resource management decisions. Such actions shift the burden for resolving conflicts to every project plan involving that particular activity. For example, the forest was by-passed in most forest plans, to be dealt with on a case-by-case basis afterwards (U.S.D.A., 1990, 2:55).

A second source of recurring conflict at the project-level is the adequacy of the environmental analysis for proposed projects. NEPA requires that a programmatic environmental impact statement accompany the forest plan and that cumulative and site-specific impacts of a given project be identified and disclosed in a separate project-level environmental analysis. Preparing project-level analyses that are simultaneously broad enough to include the cumulative impacts of the other current and foreseeable projects, and yet narrow enough to provide detail on the project at hand, has been a difficult challenge and an area ripe for litigation (U.S.D.A., 1990, 2:56).

Overall Problems with the Program. Detailed analysis of national forest disputes conducted by Julie Wondolleck reveals that the forest planning process is undermined by three types of issues (Wondolleck, 1988). First, the process is not sufficiently informative or convincing. Forest Service analysis, no matter how thorough and seemingly objective, does not indicate what decision should be made. Moreover, because no decision can be proven to be the correct one, the process is not convincing to those groups who perceive that a different outcome is more appropriate than that reached by the Forest Service. Second, the process is divisive. It separates different interest groups into adversarial camps and encourages strategic behavior among them. It provides no means for bridging the gap between groups and hence only exacerbates the political conflict over the decision that must be made. Third, the process is not decisive. Even when the Forest Service ultimately makes a decision, the decision seldom ends the controversy. Instead, it merely begins the next phase of the decisionmaking process through the use of appeals, lawsuits and pleas to Congress.

Relationship between Budget Planning and Forest Planning

The purposes of the RPA are to direct the Forest Service to project demand and supply of the various forest resources and for this information to be transmitted to budget needs. Examination of the record of RPA program targets to actual appropriations (for the period 1977 to 1986) reveals, however, that there is a significant gap between these two funding levels. Comparison of the RPA goals to Forest Service appropriations indicates that the proportion of the RPA goal achieved varied across programs from 21 to 119 percent (Sample, 1990).

Figure 1(a) shows the distribution of RPA resource management funding for FY 1977-1986, while Figure 1(b) shows the distribution of resource management funding in appropriations for the same period (and for comparison, back to 1960). (The irregularities in FY 1981 and FY 1986, particularly with respect to the timber program, correspond to the first year of each new RPA program, when the program budget goals are matched with the proposals in the president's budget.) Figure 1(a) projects a decreasing share allotted by the Forest Service for timber, while a steadily increasing share of funding was envisioned for several of the non-commodity resource programs, particularly fish and wildlife, and recreation. Actual appropriations (Figure 1(b)), however, illustrate a departure from the direction called for in Forest Service multiple-use program planning. The timber and mineral programs are gradually constituting a greater share of overall funding, while other programs (such as soil and water and recreation, which received relatively greater emphasis in the RPA planning document) account for a decreasing share of budget funding (Sample, 1990).

Critique of Land Management Planning

The study *Critique of Land Management Planning* represents an attempt by the Forest Service to document what had been learned in a decade of planning and to determine how best to respond to the planning challenges of the future. The report, published in June 1990, was conducted by the Forest Service in conjunction with the Conservation Foundation and the department of forestry and natural resources at Purdue University. The critique used the results developed from inputs from 3,500 people involved in a broad cross-section involved in planning, including forest supervisors, regional forester, planners, members of interdisciplinary teams, local citizens, elected officials from local governments, Indian tribes, interest groups and representatives from other agencies. The major findings, lessons learned and recommendations relevant for ocean governance are summarized below (U.S.D.A., 1990, 1-10).

Major Findings: Planning Technique

Planning was much more complicated than expected and took much longer to complete. To some the process seemed to be more important than the end product.

There was considerable agreement on what needs to be done, namely that the planning regulations need to be simplified.

More time was spent on modeling resource data than addressing sociopolitical issues.

Because the real issues were not identified or were not focused enough, the technique of making trade-off decisions was poorly understood.

Major Findings: Organization and Administration

The change in professional forestry philosophy from managing resources individually (e.g., timber, grazing or recreation) to managing them in an integrated manner has proven to be a difficult struggle.

Although the NFMA mandates an interdisciplinary approach, when forest plans are reviewed in regional offices and in Washington, they are reviewed by single-resource staff areas, often resulting in changes that bring the plans back in line with the traditional single-resource planning approach.

Lessons Learned: Planning Techniques

Comprehensive multiple-use planning is difficult to implement. Many of the pre-planning conflicts will continue and some may intensify as a result of the planning process.

Solutions at the local level are easier. The spirit of compromise and of finding acceptable solutions seem to be strongest at the local level and weakest at the national level.

Local multiple-use plans cannot be expected to resolve conflicts that have nationwide significance, e.g., oil and gas leasing.

Multiple-use planning is more than just a scientific process. Just bringing the facts together and running a computer model does not produce "right" answers to everyone's satisfaction. Planning is much less scientific and much more social and political.

Recommendations: Planning Technique

Treat state/local representatives as partners in the planning process, not as special-interest groups.

Involve more social scientists in planning.

Develop incentives to overcome functional planning approaches.

Implications of Forest Planning for Ocean Multiple-Use Planning

The information presented in this study on the legal, fiscal and practical developments of forest multiple-use planning indicates that ocean governance can benefit from the successes of the public lands experience and perhaps avoid some of its mistakes. Seven implications seem most evident. First, the marine policy community needs to debate the desirability and potential effectiveness of multiple-use and RPA-type legislation to guide national ocean planning (and whether such legislation should establish resource-use priorities). Second, as for public lands, comprehensive ocean multiple-use planning will likely be constrained by prior historical use patterns and management practices. Third, ocean multiple-use legislation does not guarantee that decisionmakers will take opportunities to innovate. Schooled under the traditional single-sector approach of resource management, these resource managers may continue this practice despite a statutory requirement to use multiple-use methodologies. Fourth, comprehensive ocean planning will likely struggle with the difficult task of finding a balance between national top-down and field-level bottom-up approaches to planning. Sixth, even with a comprehensive ocean planning process, it is unlikely that there will ever be a technically "correct" solution to ocean management trade-offs or that such planning will finally resolve complex social and political problems. Seventh, site-specific planning cannot be expected to resolve highly controversial national issues.

In conclusion, the most significant outcome that the forest planning experience offers to ocean governance is the concept that simply defining a planning process is not enough. If the process provides little more than cookbook techniques without also providing incentives to change the behaviors of resource managers and other interested parties, comprehensive planning will only marginally improve the process or reduce conflict. Planning is a careful mixture of art and science, and in the field of ocean governance it will face its greatest challenge and perhaps its greatest reward. As long as the limits of planning are recognized and the lessons from similar models, such as those for public lands, are considered, ocean governance planning may offer a means to overcome the conflicts endemic to ocean management.

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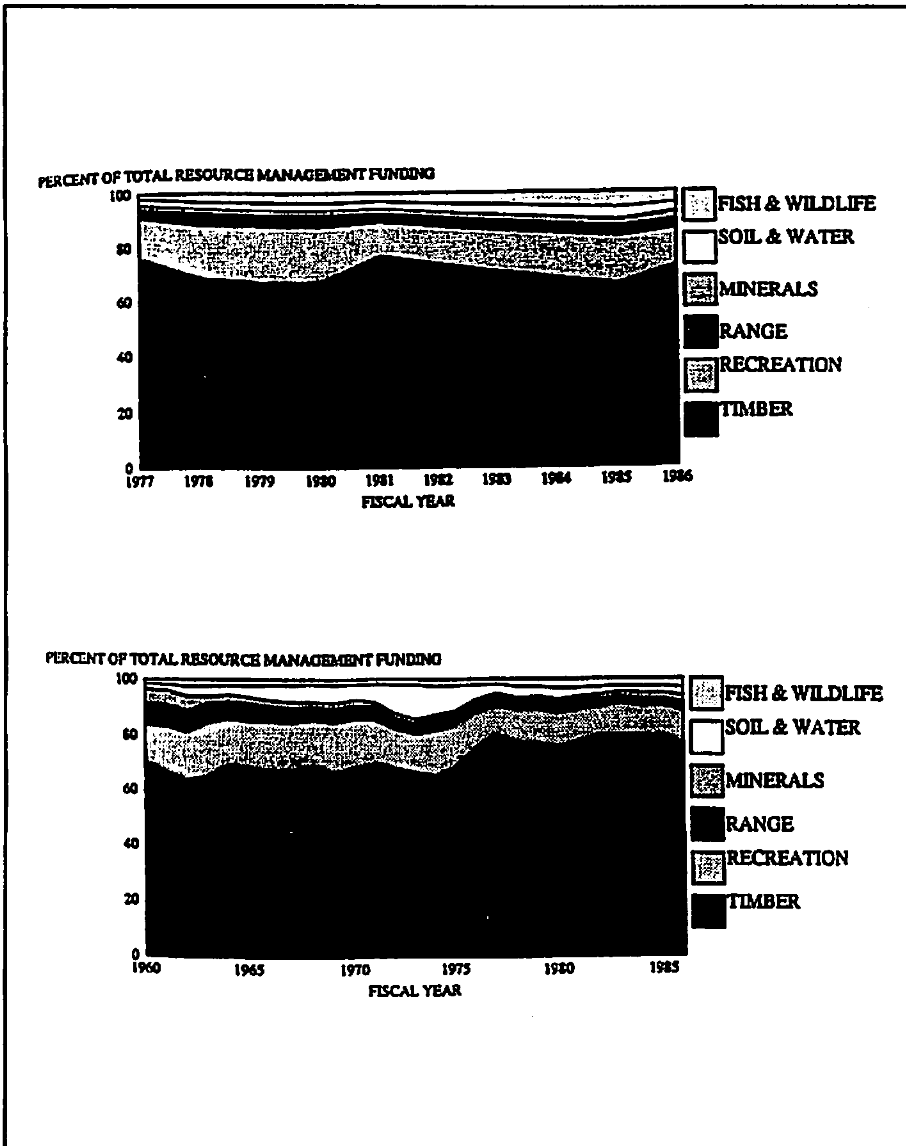

Figure 1. (a) RPA budget targets, FY 1977-1986; (b) U.S. Forest Service appropriations, 1960-1986 (Source: Sample, 1990).

Ocean Resource Management

MARITIME SAFETY AND THE PRIVATE MARITIME COMMERCIAL TOWING AND SALVAGE INDUSTRY: A POLICY EVALUATION OF PUBLIC LAW 97-322, SECTION 113[1]

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Introduction

This paper evaluates the privatization mandate effected by Public Law 97-322, §113 on Oct. 15, 1982. The U.S. Coast Guard has experienced intense budget pressures and increased administrative responsibilities over the past two decades. These circumstances facilitated the privatization of some Coast Guard operations. The Oversight Report of the House of Representatives Committee on Merchant Marine and Fisheries (1981) recognized that "[i]t is official Coast Guard policy not to compete or interfere with private towing operations." However, the subcommittee hearings discovered that the Coast Guard may not be consistently and significantly "interpreting or implementing its policy" (Oversight Report, 1981). This finding initiated action by private towing firms to secure legislative assistance in protecting their lawful enterprise.

The private maritime commercial towing and salvage industry is akin to the American Automobile Association in providing assistance to boaters in non-distress situations. The Coast Guard had traditionally provided these services complimentarily while not prohibiting private enterprise. Thus, government-subsidized, unfair competition inhibited the industry's development.

The text of Public Law 97-322, Section 113 is:

> The Commandant of the Coast Guard shall review Coast Guard policies and procedures for towing and salvage of disabled vessels in order to further minimize the possibility of Coast Guard competition or interference with private towing activities or other commercial enterprise (*Public Law 97-322*, 1982).

The transfer of a traditional public service to a private enterprise may prove either positive, negative or neutral for the public's welfare (Oversight Report, 1981). This research is intended to determine the effect caused by this policy upon the public with respect to maritime safety. The research performed may provide applicable knowledge to the evolving privatization of maritime functions such as oil spill recovery and maintenance of aids to navigation.

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[1]This paper is from the author's master's thesis, submitted for the master of public administration degree to Cornell University June 11, 1991.

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The official policy for evaluation is the United States Coast Guard Maritime Search and Rescue Non-Distress Assistance Policy which was implemented pursuant to the subject law. A Commandant Instruction states:

> ... 6. ... c. *Guiding Principles in Non-Distress Cases.* When specifically requested assistance, such as a commercial firm, marina, or friend, is not available, a request for assistance will be broadcast. If a commercial provider is available and can be on scene within a reasonable time, usually one hour or less, or an offer to assist is made by a responder listed in the previous paragraph [private organizations (non-commercial), State and local organizations, and good Samaritans], no further action by the Coast Guard, beyond monitoring the incident, will be taken. Otherwise, a Coast Guard Auxiliary facility, if available, or a Coast Guard resource may be used. Three principles which guide assistance to vessels not in distress are:
>
> (1) Assistance normally will be provided by the responder which first arrives on scene of the vessel requesting assistance,
> (2) If a Coast Guard resource or Auxiliary facility takes a disabled vessel in tow, the tow will normally terminate at the nearest safe haven, and
> (3) Once undertaken, there is no requirement to break the tow except as described below. ... (*Commandant Instruction*, 1988).

The *Commandant Instruction* notes; "However, there is no legal duty for the Coast Guard to undertake any particular mission" (*Commandant Instruction*, 1988).

The current policy is the result of scrupulous development since 1982 by the commercial maritime non-distress assistance industry, the Coast Guard, the Coast Guard Auxiliary, the commercial and recreational boating interests, the Administration, and the U.S. Congress. These parties have arrived at a consensus that this policy is reasonable and progressive. The initial conflicts that confronted the parties were substantial, yet have proven to be surmountable.

Background

Recreational Boating. It is estimated that 73.3 million persons participated in recreational boating in 1989. Also, more than $17.1 billion was spent at retail during 1989 for boats and associated equipment and accessories. There were more than 15.5 million recreational boats owned in 1989 (NMMA, 1989).

Maritime non-distress situations occur frequently and variously due to several factors indigenous to boating especially recreational boating. Boats are vulnerable to many debilities due to poor economy of scale regarding preventive maintenance and durability features. Most recreational boaters are not required to retain any boating education or operator's license. Assistance response can be unavailable for a significant period of time. And most critical, the sea is an inherently dangerous environment. The instable element, water, introduces the injurious risks of drowning, hypothermia and others. The unstable element, weather, often turns safe conditions rapidly into extremely hazardous ones.

The U.S. Coast Guard. The Coast Guard was established on Jan. 28, 1915, as a military service and branch of the armed services. It is now an agency of the U.S. Department of Transportation, except when operating as a service in the U.S. Navy (*U.S.C.*, Title 14).

The modern Coast Guard is a national and international, multi-mission organization. Essentially, the peacetime missions are to:

Administer programs designed to protect life and property at sea;
Maintain regulatory control over much of the marine transportation industry; and
Enforce all federal laws on waters subject to U.S. jurisdiction (Government Accounting Office, 1980).

The Coast Guard is popularly regarded as a worthy and dependable force. The work of lifesaving on the sea in hostile conditions is arduous and trying. The distress search-and-rescue mission is as indispensable as the analogous lifesaving operations on land.

The U.S. Coast Guard Auxiliary. The Coast Guard Auxiliary originated as the Coast Guard Reserve by an Act of Congress on June 23, 1939 (Oversight Report, 1981). The auxiliary was officially established on Feb. 19, 1941, as a non-military organization administered by the commandant under the discretion of the secretary (*U.S.C.*, Title I, Ch. 23, Sec. 821). The legislated purposes are to assist the Coast Guard:

(a) to promote safety and to effect rescues on and over the high seas and on navigable waters;
(b) to promote efficiency in the operation of motorboats and yachts;
(c) to foster a wider knowledge of, and better compliance with, the laws, rules, and regulations governing the operation of motorboats and yachts; and
(d) to facilitate other operations of the Coast Guard (*U.S.C.*, Title I, Ch. 23, Sec. 821).

The auxiliary comprises 32,000 civilian volunteers, 9,362 privately owned boats, and 228 aircraft (Coast Guard Auxiliary, 1989). In 1988, it saved 458 lives, $157 million in property, assisted 27,131 persons, educated 330,170 persons, and performed 287,935 courtesy marine examinations (Coast Guard Auxiliary, 1989). The Coast Guard Auxiliary performs approximately 25 percent of Coast Guard search-and-rescue missions (Coast Guard Auxiliary, 1989). These statistics illustrate the extensive benefits to the public from this volunteer organization. Moreover, these services were provided with little expense to the public (Oversight Report, 1981).

Auxiliary members are reimbursed for expenses incurred on duty, such as those for fuel, oil, water and necessary mission supplies (Oversight Report, 1981). In addition, they are provided federal status for their pleasure craft while on duty in lieu of personal liability insurance (*U.S. Coast Guard: Status*).

In discussing the auxiliary's mission, *Commandant Instruction 16101.2B* states, "Auxiliary operational facilities are excellent resources which can, within the capabilities of these facilities, enhance the Coast Guard's ability to respond to maritime emergencies" (*Commandant Instruction*, 1988).

Issues and Arguments

The issues and arguments of this policy are briefly discussed.

A major factor cited for driving the policy reform was the growing imbalance between Coast Guard resources and responsibilities. In 1980, the *Comptroller General's Report to the Chairman, Committee on Commerce, Science, and Transportation of the United States Senate* (*U.S. Coast Guard: Status*) reported that the Coast Guard's responsibilities have increased dramatically without a commensurate growth in resources. Prioir to the report, Congress had passed much legislation that mandated increases. The report provided an alternative of "[t]ransferring certain Coast Guard missions to industry" (*U.S. Coast Guard: Status*).

The Oversight Report (1981), which included the results of the subcommittee on Coast Guard and Navigation hearings into all phases of Coast Guard programs and procedures, expressed concern for this imbalance. It stated, "the Subcommittee intends early next year to act on legislation implementing the major recommendations contained herein" (Oversight Report, 1981).

The imbalance was magnified by the explosive increase in recreational boating at the time of increasing responsibilities. In 1970 there were an estimated 8.8 million recreational boats owned, in 1980 there were 11.8 million and in 1989 there were 15.6 million (NMMA, 1989). Calls to the Coast Guard for assistance increased from approximately 45,000 annually in 1970 to 70,000 in 1979 (President's Private Sector Comm., 1983). It was reported that the rate of effectiveness of the Coast Guard's search-and-rescue effort of saving lives and property in distress situations declined from 85.3 percent in 1977 to 69.4 percent in 1980 (Oversight Report, 1981). This decline was considered very damaging because of the lives and property at stake without alternate rescue sources.

An explanation for this decline is that the Coast Guard's aged fleet is slow and thus needs all the response time possible. Hence, unnecessary preoccupation with non-emergency towing reduces lives and property saved.

This much larger boating population eliminated one potent barrier to entry for the towing industry by creating a large market for non-distress assistance (Oversight Report, 1981). The historical boating population was likely too small to constitute a viable market for private industry. The nature of the industry is high annual operating costs and thus requires many sales of services (Smith, 1990; Frohnhoeffer, 1990). Also, the auxiliary generally operates only during peak boating times; therefore, boaters cannot fully depend upon this assistance source.

Another related factor was President Reagan's objective of reduced government intervention. This manifested itself in budget constraints created by pressure from the administration for program reductions and eliminations. Moreover, recreational boating interests were exceptional targets due to the stigma of wealth so associated.

The Subcommittee on Coast Guard and Navigation recommended that:

> The Coast Guard should be relieved of any responsibilities which can be fulfilled with equal or greater competence and efficiency by other federal agencies, by state or local government, or by the private sector. Particularly strong consideration should be given to the transfer of some duties in the areas of ... towing and salvage operations. ... [emphasis added] (Oversight Report, 1981).

The subcommittee concluded it "is convinced ... that the Coast Guard needs to make a greater effort to deal fairly with the private towing industry. ..." (Oversight Report, 1981). The subcommittee stated that it:

> (5) [R]ecommends stricter adherence by the Coast Guard to its official policy of not interfering unnecessarily with private companies in the provision of towing services to vessels stranded in other than emergency situations. The Coast Guard should review its written instructions to its personnel to clarify any ambiguity which presently exists in its policy of non-interference with private industry (Oversight Report, 1981).

Proponents of the private towing industry argued that discouraging negligent vessel operation, a common cause of non-distress, via financial burdens is effective. Operators will rationally exercise greater discretion in maintenance, fuel checks and operating if the consequence of failure is costly. This financial disincentive is served by the industry (Literature of, and conversations with, the industry, boaters, and Coast Guard).

The Coast Guard Auxiliary opposed the reformed policy on the basis that it caused its membership and morale to suffer. It argued that the search-and-rescue mission was a major attraction to members. Consequently, declines in membership would cause severe losses in its other missions (Subcommittee on Coast Guard, April 19, 1988; Subcommittee on Coast Guard, April 25, 1988; Oversight Report, 1981).

An investigation by the secretary of transportation to determine if the Coast Guard's non-distress assistance policy had any effect on the auxiliary's declining membership was mandated by *Public Law 99-640* (1986). There was no conclusive evidence that "a great many Auxiliarists have left because of the existing [1983] non-emergency assistance policy ...," according to Commodore William C. Harr, U.S. Coast Guard Auxiliary (*Non-Emergency Towing Hearing*).

Some boating interests opposed privatization because of the new expense to boaters resulting from the elimination of complimentary non-distress assistance provided by the government.

The subcommittee was exceptionally committed to the privatization of towing. In regard to principles for user fee legislation, it stated:

> (9) The assessment of user fees for services presently provided by the Coast Guard should not be allowed to detract from an examination of the wisdom of delegating appropriate responsibilities to private industry ... (Oversight Report, 1981).

Theory

The theory to be tested is inspired by the directive mandated by the Congress in Public Law 99-640 which required review of the reformed policy's effect on maritime safety (*Public Law 99-640*, 1986; Oversight Report, 1981). The theory to be tested is:

The private maritime commercial towing and salvage industry has caused the effect of increased maritime safety.

Research Design (Spector, No. 23; Kidder and Judd)

Three cases were used to determine the effect of the policy. Search-and-rescue cases will serve as the measure of maritime safety and, thus, as the dependent variable for the first two cases. This caseload includes all cases from non-distress to distress type of severity. The Coast Guard monitors and records all requests for assistance. (The Coast Guard admits that its data are slightly skewed as a result of reporting failure by personnel and other factors). The data within this caseload were acquired from the Coast Guard. Data for cases 1 and 2 are given in Table 1. Results of the cases are graphed in Figure 1.

Public Law 97-322 §113 will serve as the measure of the private maritime commercial towing and salvage industry and, thus, as the independent variable for the first two cases. The law, passed Oct. 15, 1982, represents the industry as active for the period since 1983 in this research. However, the industry required a period of development to acquire its resources, to promote its services, and to operate cooperatively with the Coast Guard, Auxiliary, local police and public. Therefore, the treatment effect must be interpreted to require some time lag associated with this development.

Case 1. A one-group interrupted time-series design is applied. This is a quasi-experimental design. The nature of the design is non-experimental since no subject assignment is performed.
The design notation is the following:

$O_1\ O_2\ O_3\ X\ XO_4\ XO_5\ XO_6\ XO_7\ XO_8\ XO_9\ XO_{10}$

Where:

O = observation of search and rescue cases for each year 1980 to 1989
X = treatment of P.L. 97-322 §113 (Oct. 15, 1982)
The group represents the North/Mid-Atlantic Coast
(1st C.G. district + 3rd C.G. district + 5th C.G. district)
Independent variable = P.L. 97-322 §113
Dependent variable = search-and-rescue cases

Case 2. A multiple-group interrupted time-series design is applied. This is a quasi-experimental design. The nature of the design is non-experimental since no subject assignment is performed.
The design notation is the following:

1st DISTRICT= $O_1\ O_2\ O_3\ X\ XO_4\ XO_5\ XO_6\ XO_7\ XO_8\ XO_9\ XO_{10}$
5th DISTRICT= $O_1\ O_2\ O_3\ X\ XO_4\ XO_5\ XO_6\ XO_7\ XO_8\ XO_9\ XO_{10}$

Where:

O = observation of search-and-rescue cases for each year 1980 to 1989

X = treatment of P.L. 97-322 §113 (Oct. 15, 1982)
Independent variable = P.L. 97-322 §113
Dependent variable = search-and-rescue cases

This case serves as a comparison between the two districts to examine any difference in safety considering their respective magnitude of industry. The first district had slightly more firms and earlier development than the fifth district (The "BOAT/U.S. Guide to Towing Companies-1991" reports the first district region to have 48 firms, the fifth district has 42 firms). Due to time and financial constraints, this research cannot express these variations beyond generalization. This research is also limited as no account of comparison between individual firms with respect to size can be made. Therefore, industry in each region must be assumed comparable with respect to service capacity and other qualities.

The two regions are assumed comparable with respect to physical and other variables which affect safety. Such variables are hazard level and Coast Guard, Auxiliary, and local police capacities level.

The direct market for the industry is recreational boaters. Thus, a comparison of regions with similar boating seasons and boating populations offers higher validity than a comparison between regions of dissimilar seasons and populations. The fifth district has a slightly larger number of boats than the first district. The actual number of boaters, a more meaningful statistic, is unavailable. The fifth district has a slightly longer boating season than the first district due to the warmer climate.

Case 3. This case merely reproduces the fatality rate presented by the Coast Guard in *Boating Statistics 1989* (U.S. Dept. Transportation, 1990). According to the Coast Guard, "The best available indicator of safety in recreational boating is the fatality rate, which relates the number of fatalities to the changing boat population" (U.S. Dept. Transportation, 1990).

Analysis

The results of the three cases observing the trends in search-and-rescue cases and fatality rates reflect an increase in safety, as illustrated by continual downward trends. The years following the policy implementation and industry development are slightly more dramatic in decreased search-and-rescue cases and fatality rates. The lack of a statistically significant quantity of data limits more specific observations.

The observations only prove that it is possible that the theory is valid; the industry may have caused increased maritime safety. The high increase in boat population of the later years provides support for this conclusion since such increases did not cause the lower rates of change among the search-and-rescue cases rates which would be expected.

The observations also prove that the policy, and consequently the industry, has probably not caused decreased maritime safety. Therefore, the results of this study support the public policy of private non-distress assistance as worthy of continued implementation and study.

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CASE 1 FYR	Total Search And Rescue (SAR) Cases For North/Mid-Atlantic Coast District 1+District 3+District 5*	TOTAL BOATS NUMBERED NORTH ATLANTIC COAST District 1+District 3+District 5**	SAR Cases Rate Per 1,000 Boats
1980	25,729	1,404,642	18.32
1981	24,855	1,404,976	17.69
1982	24,061	1,418,263	16.97
1983	23,498	1,431,287	16.42
1984	21,273	1,495,984	14.22
1985	23,092	1,555,580	14.84
1986	22,457	1,624,085	13.83
1987	19,665	1,688,631	11.65
1988	18,574	1,821,204	10.20
1989	17,920	1,944,638	9.22

CASE 2	C.G. DISTRICT 1 Adjusted Total SAR Cases* As if 3rd Dist. was split in 1979, not 1987	C.G. DISTRICT 5 Adjusted Total SAR Cases* As if 3rd Dist. was split in 1979, not 1987	Total Boats** 1st DISTRICT	Total Boats** 5th DISTRICT	SAR CASES RATE PER 1,000 BOATS 1st Dist.	SAR CASES RATE PER 1,000 BOATS 5th Dist.
1980	12,843.90	12,885.10	660,070	744,572	19.46	17.31
1981	12,621.48	12,233.52	649,057	755,919	19.45	16.18
1982	11,920.54	12,140.46	651,911	766,352	18.29	15.84
1983	11,210.89	12,287.11	636,663	794,624	17.61	15.46
1984	10,209.37	11,063.63	676,145	819,839	15.10	13.49
1985	10,867.44	12,224.56	692,513	863,067	15.69	14.16
1986	10,312.19	12,144.81	727,537	896,548	14.17	13.55
1987	9,263.71	10,401.29	742,343	946,288	12.48	10.99
1988	10,387.00	8,187.00	802,425	1,005,935	12.94	8.14
1989	10,185.00	7,735.00	921,089	1,036,393	11.06	7.46

Table 1. Data, Cases 1 and 2. (Sources: *U.S. Coast Guard Programs Branch, Search and Rescue Division. **U.S. Department of Transportation, 1990.)

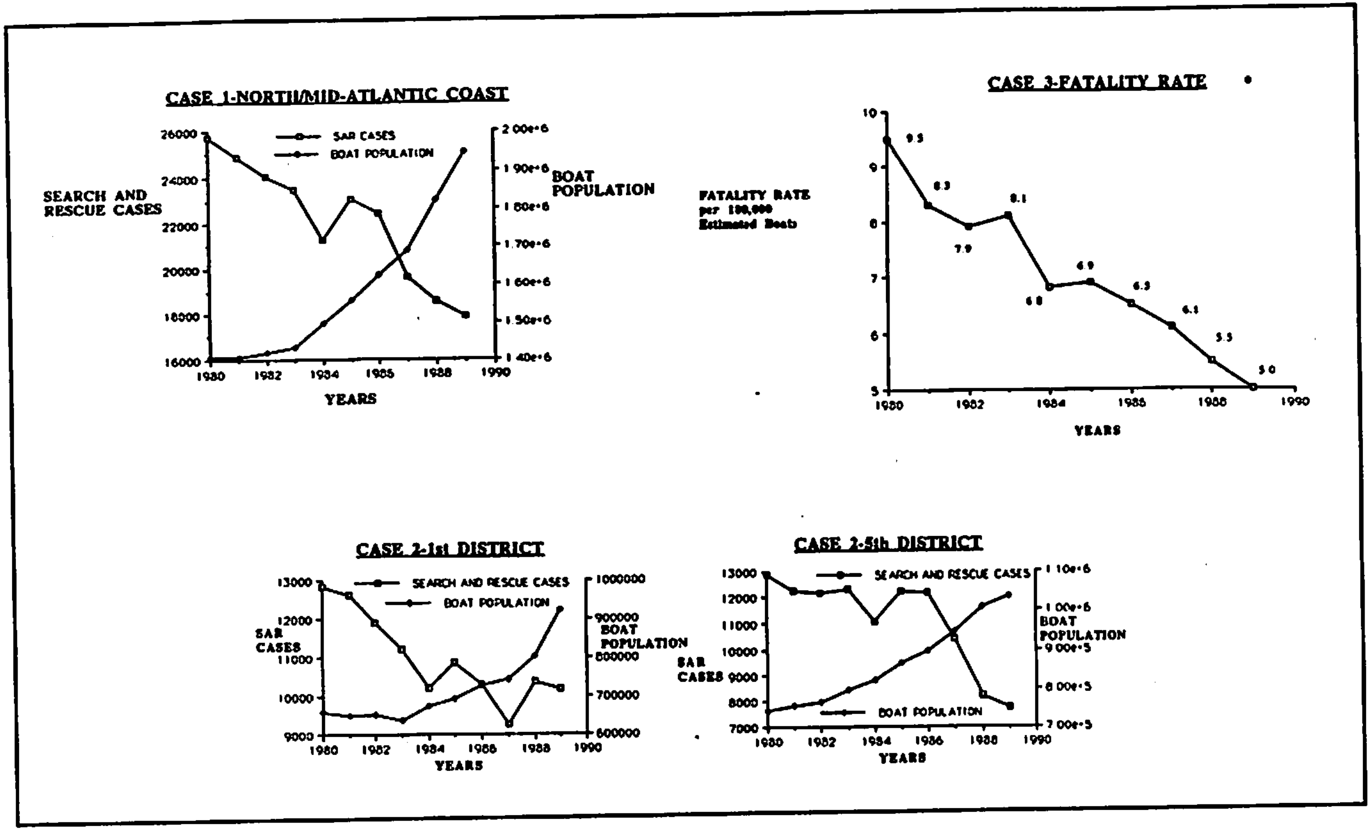

Figure 1. Changes in boat population and number of search-and-rescue cases for cases 1 and 2, 1980-1990.; change in fatality rate for case 3, 1980-1990. (Source: U.S. Department of Transportation, 1990.)

SARGASSUM GRASS BEDS: IS MANAGEMENT NECESSARY?

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Abstract

Sargassum is a free-floating seaweed found in the warmer waters of the globe. Weed patches or lines often form along the interface of two currents moving in different directions. These beds are home for many species of fish, shrimp and crabs. They can also serve as primary nursery areas for several pelagic species.

There are abundant *Sargassum* beds in the North Atlantic Ocean in and along the margins of the Sargasso Sea. These beds are currently being harvested, particularly along the eastern side of the Gulf Stream. The weed is being used as fertilizer and as a nutritional supplement for livestock and poultry.

There is a growing concern over *Sargassum* harvest. While the amount of weed currently harvested does not appear to significantly threaten species habitats, a substantial increase in harvest could be damaging. There has been sufficient concern to prompt the South Atlantic Fisheries Management Council to initiate a fishery management plan for *Sargassum*.

The intents of this paper are to: (1) look at the biological significance of *Sargassum* beds, particularly their significance as nursery areas; (2) assess the impacts to habitats caused by current and future harvests; and (3) examine and assess national and international management options.

Sargassum is a brown alga of the class Cyclosporeae, order Fucales, and family Fucaceae (Costen-Clements et al., 1991). A region of free-floating pelagic *Sargassum* known as the Sargasso Sea is found in the western North Atlantic Ocean. Beds or lines of *Sargassum* are often found in or around this sea along the interface of two currents moving in different directions. It sometimes drifts into inshore waters and occasionally washes ashore in large quantities during storms.

Available estimates of *Sargassum* biomass in the North Atlantic are unreliable and vary widely (Costen-Clements et al., 1991). Estimates of primary production are also questionable (Costen-Clements et al., 1991). One estimate by Carpenter and Cox (1974) placed average production in the western Sargasso Sea at 1.0 mg C m^{-2} d^{-1}. There is also a large contribution from epiphytic cyanobacteria to the primary production of the region (Carpenter and Cox, 1974).

Sargassum beds are home to many organisms, including more than 100 species of fish, more than 100 species of invertebrates (Costen-Clements et al., 1991), and four species of sea turtles (Carr, 1987; Manzella and Williams, 1991). These beds also serve as a primary nursery area for many of these fishes, including billfish, tuna, and mackerel. Several of these fish are also adapted to live exclusively in this habitat. Among these is the Sargassumfish.

Sargassum can be processed for use in industry. The grass is sun-dried, ground into powder, then fermented and extracted. The liquid is separated from the solid at this point. The liquid component is used in fertilizer concentrates and in nutritional supplements for livestock. The solid portion is also used as an animal feed additive. As a fertilizer ingredient, *Sargassum* extracts increase the value and yield of each plant. It eliminates the need for dangerous insecticidal and herbicidal products (SAFMC, 1991a).

Sargassum is harvested by the Aqua 10 Corporation, of Beaufort, N.C. It is harvested with a one-inch-square mesh trawl pulled across the surface down a weed line. The grass is primarily harvested from June to September. According to President William Campbell, Aqua 10 processes *Sargassum* for use as an animal feed supplement and as fertilizer. *Sargassum* supplements produce amazing results in animals. A turkey given 1 cc of supplement per week for 18 weeks will have 26 percent less fat than, but weigh the same as, as a turkey fed normal feed (Campbell, 1992, pers. comm.). The supplement also reduces disease among animals. Similar results are found in hogs, cattle and horses.

Sargassum also exhibits strong antibiotic qualities. Working with the U.S. Department of Agriculture, Aqua 10 confirmed its ability to control *Salmonella*, *Salmonella*-type bacteria in other animals, and microtoxins. Campbell said that it appears to be better than streptomycin in certain respects.

Aqua 10 harvests around 100 wet tons of *Sargassum* per year. Little is known about the impact this could have on the offshore ecosystem. It is not known how much weed is in the Sargasso Sea, or how fast it grows. The exact relationship between the grass and the organisms that depend on it is not yet understood. Many of these organisms are specific to the *Sargassum* habitat, and destruction of the weed beds could be detrimental to them.

Because of the shape of *Sargassum*, as it is caught in the net it creates a mesh of its own, thus preventing even the smallest organisms from escaping through the 1-inch-mesh net.

Occasionally, hatchling or young loggerhead sea turtles are captured by the trawls (Schwartz, 1988). They are returned to the water immediately, but some people question whether they will live after being pulled through the water entangled in the grass.

Many people are pushing for some form of management plan for *Sargassum*. The South Atlantic Fisheries Management Council looked into a plan for *Sargassum*, but it was basically dropped last year.

There have been many proposals for a management plan. Because sea turtles are sometimes caught in the *Sargassum* trawls, some people have called for an end to harvesting, citing the Endangered Species Act (SAFMC, 1991b). Several people have suggested closing the fishery until an in-depth study could be done to determine a maximum sustainable yield (SAFMC, 1991b).

The basic problem to be addressed in management is whether *Sargassum* is a habitat or a resource. In reality, it is both, and it must be managed as both. Many useful products come from *Sargassum*. The utilization of the weed also prompts scientific research by private industry, where the funds are easily available.

Sargassum must be managed, not protected. With the small amounts currently being harvested, a closure of the fishery until it can be studied will be detrimental to Aqua 10 but probably will have a negligible effect on the ecosystem as a whole. Instead, an upper limit should be placed on harvest until a scientific study can be completed to determine a maximum sustainable yield for *Sargassum*.

Methods of reducing bycatch should be studied. A washing system to remove small organisms trapped in the clumps of weed may be a possibility. The possibility of turtle deaths from drowning may be reduced if nets are emptied more often.

Other best management practices must be considered. The possibility of aquaculture may hold promise. *Sargassum* could also be gathered when storms blow large masses of it onto the beaches.

If *Sargassum* is harvested at or below its maximum sustainable yield, and appropriate measures are taken to reduce bycatch, the fishery will continue indefinitely, and may yield products we haven't dreamed of. With a management plan established today, we won't have to worry about emergency closures tomorrow, when the ecosystem is too far gone to save.

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WHAT CAN BE DONE WITH THE DEAD DOLPHIN ON MY BEACH?

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Officials whose local economies are dependent on the tourist trade may view the carcass of a dead dolphin, whale or pinniped that washes up on their beach as, at best, a nuisance, or at worst, a public health problem. Recently, resource management agencies have experienced a different type of pressure as more attention has been given to unusual mortalities. Within the past four years there have been mortalities affecting bottlenose dolphins on the East Coast of the United States, pinnipeds in the North Sea, and striped dolphins in the Mediterranean. Questions have been raised as to the role of environmental factors as a contributing cause for these mortalities.

Any carcass probably represents a problem of disposal. What is less apparent is the scientific value of such dead animals. In each coastal state, the National Marine Fisheries Service (NMFS) has established a marine mammal stranding network constituted of volunteers who respond to strandings of both dead and live animals. Responses to strandings of live animals have received extensive press coverage, but the efforts to collect information from dead animals may be just as important in providing information on marine mammals.

Although strandings are assumed to be rare events, each year a fairly large number of marine mammals strand on our beaches, including some 600 cetaceans (Figure 1). The vast majority of these strandings are of dead animals. Over half of these are normally bottlenose dolphins (*Tursiops truncatus*), but significant numbers of pygmy sperm whales (*Kogia breviceps*), harbor porpoises (*Phocoena phocoena*), and common dolphins (*Delphinus delphis*) also strand. Local officials face a major disposal problem if one of the 60 baleen whales that strand in an average year strands on their beach (Wilkinson, 1991).

Two factors make the stranding data for pinnipeds less accurate. First, NMFS records on stranded pinnipeds are not complete. Second, the response rate for dead stranded pinnipeds is not as high as for cetaceans. The reports on numbers of stranded pinnipeds on the West Coast are contained in Figure 2. The corresponding totals for the East Coast are not available by year, but over a seven-year period network members have reported an average of 138 strandings annually (Early and McKenzie, 1991). Recognizing the limitations of the data, two generalizations can be made. Over 1,000 seals and sea lions strand in an average year, and far more pinnipeds than cetaceans strand live. The majority of stranded pinnipeds are California sea lions (*Zalophus californianus*), but significant numbers of harbor seals (*Phoca vitulina*) and northern elephant seals (*Mirounga angustirostris*) also strand (Wilkinson, 1991).

To scientists, these animals represent an opportunity that might not otherwise be available, and a major portion of the professional literature on marine mammals has been the result of information gained from stranded animals. Some species were originally identified from strandings. There are other species, such as the pygmy sperm whale, that are relatively common but virtually all of our knowledge is the result of examining stranded animals. More may have been learned about the life history of the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) from a single mass stranding than from all of the previous work on this species (Geraci et al., 1978).

Even the most basic information is valuable. The NMFS stranding report form requests only a limited amount of data. In addition to information on the individual responding and the location, it requests the following information: the species, sex, length, condition of animal or carcass, and any evidence of human interaction. These data can provide information to assist the agency in its management responsibilities.

Just knowing the species and the location of the stranding can provide information on species distribution. Recently, stranding data indicate that both harbor seals and some species of arctic seals may be expanding their ranges to the south. The West Coast population of bottlenose dolphins appears to have extended its range to the north following the 1983 El Niño.

Perhaps more important, the data provide a baseline for normal mortality rates that can be used to detect unusual mortality events. Without information as to what is normal it is difficult to detect the abnormal.

As demonstrated in Figures 1 and 2, the number of animals stranding can be an indication of such a mortality event. The 1987 peak for cetaceans corresponds to the die-off of bottlenose dolphins on the East Coast. The higher figures for pinniped strandings in 1983 and 1984 correspond to two events—El Niño in 1983 and an outbreak of leptospirosis in California sea lions in 1984. As the baseline data have improved, we are able to detect even relatively localized mortality events. As an example, last September and October, an unusual number of bottlenose dolphins stranded in Sarasota, Fla. The strandings occurred at a time of year when stranding rates are normally low. One of the possibilities being investigated is that the mortalities might be related to an algal bloom occurring just before the mortality began. The biotoxin produced by red tide, brevetoxin, was previously implicated as a causal factor in the massive dolphin mortality that occurred on the east coast in 1987-88 (Geraci, 1989).

Changes in the length and sex distribution of stranded animals may also be an indication that something unusual may be occurring. Although there are better ways of making the determination, length can provide a rough indication of age in most marine mammals. The normal mortality distribution curve is U-shaped. Mortality rates are highest among young and old animals. Normal stranding rates reflect this model. The peak stranding season for bottlenose dolphins is during calving when young animals are most likely to strand. Reflecting a mortality rate as great as 50 percent in the first year of life, the most commonly stranded pinnipeds are yearlings. A change in the age distribution of stranded animals is an indication that something may be affecting the population.

In the same manner, a change in the sex distribution of stranded animals may be cause for concern. As an example, when the leptospirosis epizootic occurred, a disproportionate number of male California sea lions stranded.

From a management perspective, NMFS is interested in human interactions that may be contributing to marine mammal mortality. Studies of stranded pinnipeds on the West Coast have shown that a significant number of animals had been shot (Hansen, 1983; Stroud and Roffe, 1979). In at least two instances, data from strandings have provided information on human interactions with serious management implications. In the mid-1980s, stranding data alerted management personnel to a potentially serious interaction between harbor porpoises and a halibut gillnet fishery off the central California coast (Seagars et al., 1986). Similarly, stranding data have shown that ship collisions may cause a significant number of deaths of the critically endangered northern right whale (Kraus, 1990).

With sufficient baseline data, therefore, it is possible to detect the changes that require some sort of management action. The loss of the information from stranded animals reduces the reliability of baseline data.

Many of the members of the stranding networks are themselves researchers, and they work beyond the basic data on the stranding report form. They have generated data that have given us a much clearer picture of particular species, population dynamics, and the threats that are common in the environment.

Perhaps the most obvious value of dead animals is that they provide information about their diseases and parasites. Some stranding network members routinely conduct necropsies and histopathological analyses of tissues (Dailey and Walker, 1978; Geraci and St. Aubin, 1987; and Ridgway and Dailey, 1972).

Although the length of an animal can provide information on whether an animal was immature, there is a more accurate means of determining actual age in odontocetes. By counting growth layer groups in teeth, a relatively accurate determination of age can be made (Hohn, 1980). It also may be possible to determine the age at which a female became sexually mature using the same technique (Hohn, 1991).

Similarly, the reproductive status of a cetacean can be determined by examination of the gonads. Although it is only possible to determine if a male is sexually mature, the examination of corpora in ovaries may help reconstruct the reproductive history of a female (Collett, 1981).

To show how such data can be used in making management decisions, a combination of the data from tooth sections and gonads might provide an indication of the status of a particular stock. One of the indications that a stock may be under stress is a reduction in the age at sexual maturity.

Stranded animals also provide information on the prey species of marine mammals. Fish otoliths and squid beaks are collected and identified (Clarke, 1986; Fitch and Brownell, 1978; and Barros and Odell, 1990). Information on prey species can provide indirect evidence of potential fisheries interactions. A change in the composition of prey may indicate environmental problems. Although the studies were not conducted on stranded animals, scat analysis of pinniped prey during the 1983 El Niño reflected the changes in fish populations (Trillmich and Ono, 1991). Although the implications are uncertain, the decline in Steller sea lion abundance on the West Coast has been accompanied by a change in prey species from capelin and herring to pollock (NMFS, 1991).

Collection of tissues can also provide genetic information and information on contaminant loads and biotoxins. A piece of skin or muscle tissue can be used for DNA analysis. In order to determine the degree of inbreeding, the right whale recovery team identified such genetic research as a priority (NMFS, 1991a). A great deal of concern has been raised over the ecological impacts of algal blooms on ecosystems generally, and the biotoxins they can generate have been implicated in four marine mammal mortality events in the past 15 years: ciguatoxin and maitotoxin in a mortality of endangered Hawaiian monk seals in 1978 (Gilmartin, 1987); brevetoxin in a mortality of endangered manatees in 1982 (O'Shea et al., 1991);

saxitoxin in a mortality of humpback whales in 1987 (Geraci et al., 1989 and Anderson and White, 1989); and brevetoxin in the 1987-88 die-off of bottlenose dolphins (Geraci, 1989).

Similarly, concern has been raised over the impact of anthropogenic contaminants on marine mammals. In addition, such animals may be used as indicator species for the condition of our environment. Marine mammals are relatively long lived and feed at high trophic levels. Although high levels of organochlorines have been found in the tissues of some animals (Geraci, 1989; Massé et al., 1986; O'Shea et al., 1980), conclusions as to how individual animals are affected are uncertain. A series of investigations in Europe has shown a correlation between reproductive failure and PCB levels (Helle, 1980; Reijnders, 1986). Although there has been considerable speculation that anthropogenic contaminants may have an impact on marine mammal immune systems and be related to recent mortality events, a cause-and-effect relationship has not been established. The lack of such a link should not be surprising. It is difficult to establish such a link even in human epidemiology.

One of the real problems in determining the impact of contaminants on marine mammals has been the lack of baseline information for comparison and lack of standardization in collection methods, methods of analysis, and necessary subsidiary information. When high levels of contaminants were found in bottlenose dolphins that died in the 1987-88 mortality, it was difficult to determine the significance because of a lack of comparable information (Geraci, 1989). Some studies have not had adequate controls or have omitted important life-history parameters (Addison, 1989). As an example, information on age and reproductive status of animals often has not been included. One study indicated that female bottlenose dolphins may dump up to 80 percent of organochlorines during a first pregnancy and subsequent lactation (Cockcroft et al., 1989). Without life history information, the conclusions that can be drawn from data are much more limited.

From the perspective of management, the second level of information collected can often provide information that helps to differentiate stocks. To properly manage marine mammals, it is often necessary to identify discrete population stocks. It may make a significant difference if the population affected by a fishery is a relatively small population or part of a much larger population. Obviously, genetic analysis can provide useful information, but other information also can help differentiate stocks. Differences in species of prey may differentiate inshore and offshore stocks. In a related area, differences in parasites may be an indication that animals are feeding in separate areas or on different prey species. It may be a tragic commentary on conditions in our world, but even ratios of contaminants may be an indication of geographic isolation. Studies done on harbor porpoise on the West Coast indicate that the ratio of DDT metabolites to PCB is higher in California than in Washington and Oregon (Calambokidis, 1986). Such results may indicate differential exposure and spatial segregation of populations.

After the 1987-88 die-off, NMFS recognized that better baseline information was needed and that the full potential of the stranding networks was not being utilized. Beginning with a comprehensive review of network operation, a series of steps were taken to upgrade stranding network operations, our response to unusual mortality events, and to establish baseline information on contaminants in marine mammals.

A series of administrative measures was taken to increase the consistency of data from different areas of the country. To improve the reliability of information from strandings, NMFS is in the process of preparing a field guide to be used by stranding network members. The guide will provide a range of information, including species identification, handling of live stranded animals, collection of basic information, and protocols for tissue collection. In addition, NMFS' Southeast Science Center is preparing a laboratory forensic manual for autopsies of small cetaceans. The forensic manual will cover a series of scientific disciplines, including life history, histopathology, collection of samples for viral and bacterial analysis, and collection and preparation of tissues for contaminant and biotoxin analysis.

To improve the response to unusual marine mammal mortalities, NMFS has set up a task group to provide guidance whenever there is an indication that an unusual mortality event may be occurring. The task group has set up a series of criteria to initiate consultation. The criteria are based on the basic information routinely collected for all stranding responses. By establishing criteria and the task group, NMFS has increased the probability of an expeditious response to such events. The task group has been consulted four times within the past year and has provided useful information on the course of investigations.

Analysis of tissues from bottlenose dolphins indicated high levels of organochlorines, but it was difficult to determine the significance of these findings because of the lack of baseline information with which the results could be compared. To respond to this gap in data, NMFS initiated a program to establish a National Marine Mammal Tissue Bank. The concept was to establish a bank of archived tissues of high quality that could be examined retrospectively for comparative analysis. The tissues are stored in liquid nitrogen freezers at the National Institute of Standards and Technology (NIST). Portions of the tissues are made available to independent researchers who can demonstrate a need for such tissues. As a condition of access, researchers will be required to share results of analyses.

After establishing a rigorous protocol for tissue collection and preservation, a pilot project was conducted in the Northeast to collect blubber and liver from harbor porpoises incidentally taken in fisheries and mass-stranded pilot whales. Having determined that the protocol could be met, the project has been expanded to include other species and other areas of the country.

Ultimately, it is hoped that single-stranded animals may be a source of tissues for the bank. Stranded marine mammals are the most readily available source of such tissues. In addition, some species of marine mammals do not mass-strand and are not commonly taken in fisheries. Before the dead dolphin on your beach can be used for such a purpose, however, some questions need to be answered. Because such animals usually have been ill, the question of whether such animals are representative of populations should be addressed. Stranded animals are also likely to be in varying states of decomposition, and the question of how tissue degradation affects contaminant levels needs to be determined.

To address these issues, NMFS has initiated two projects. As part of a real-time monitoring program, NMFS is conducting research on stranded bottlenose dolphins in the Gulf of Mexico. In addition to analyzing contaminant levels, medical information from gross necropsies and histopathological analysis, life-history data, and biotoxin information will be collected. By developing a complete picture of an animal, we hope to develop baseline data and to determine whether such animals can be utilized for the tissue bank in the future. NMFS will also conduct a tissue degradation study to determine which animals might be acceptable as a source of banked tissues.

Finally, to ensure comparability of results on contaminant levels from various laboratories, NIST and NMFS have set up a quality assurance program. In addition to providing a degree of standardization to accommodate different methodologies, this component of the tissue bank program also is developing standard reference material that can be used by researchers for calibration. Currently, NIST is processing blubber from mass-stranded pilot whales as a standard reference material.

To a researcher, the dead dolphin on a beach potentially is a source of a range of information. Even the most basic data can provide information that can help in species management. The value of such information is reduced, however, if the baseline is inadequate and there are gaps in the data. A mechanism has been set up to respond to strandings, but the members of the stranding network can only respond if those who observe such strandings report them. A stranded marine mammal is much more than a disposal problem.

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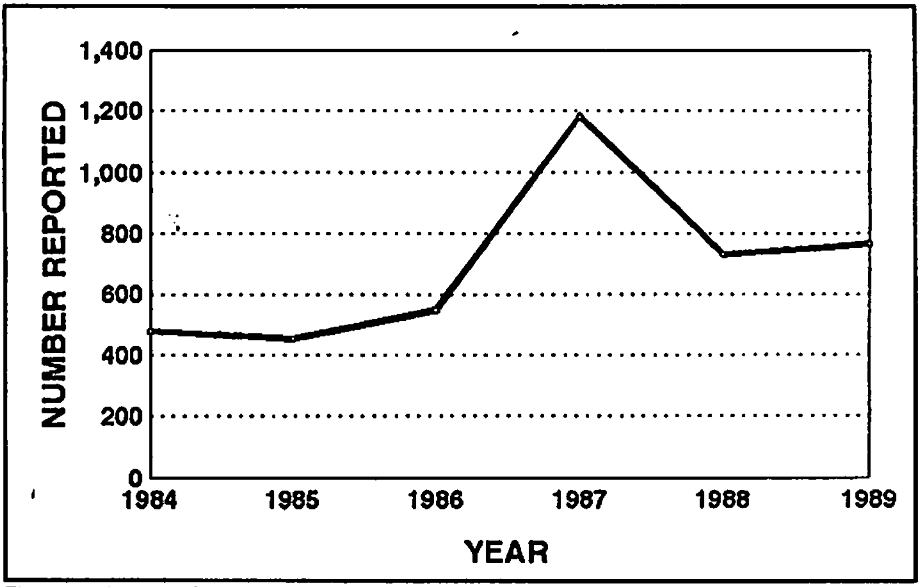

Figure 1. Number of reported cetacean strandings annually, 1984-1989.

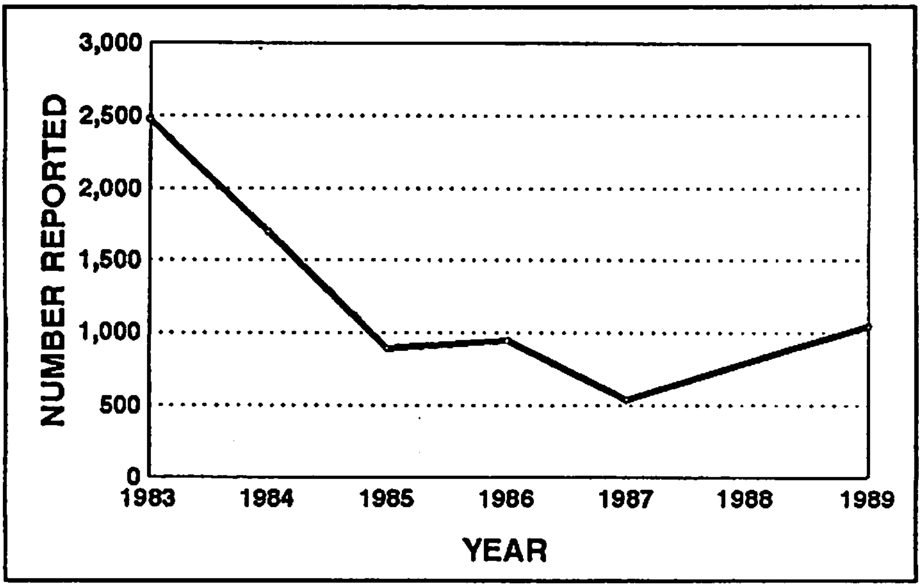

Figure 2. Number of reported pinniped strandings annually on the West Coast, 1983-1989.

Knowledge and Uncertainty in Coastal Management

HOW TO PROTECT WHOLE MARINE ECOSYSTEMS

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Marine ecosystems, such as salt marshes, mangrove swamps, seagrass meadows, coral reefs, intertidal zones, estuaries and coastal waters, continue to experience mass die-offs of fish and plants, hypoxic events, unusual algal blooms, declining water quality, and decreasing biological diversity. This degradation is continuing despite numerous attempts to protect marine ecosystems with federal and state environmental laws. The Clean Water Act of 1972 provides a case in point. The massive amounts of money expended to control conventional pollutants and dramatically reduce the discharge of phosphorus from wastewater treatment plants and industrial outfalls have resulted in improved water quality in some of the nation's rivers and lakes over the last two decades. However, rivers continue to discharge pollutants into estuaries and other coastal ecosystems.

Levels of suspended sediments (from nitrate and total nitrogen from acid rain, sewage, and fertilizers), and toxic metals (for example, arsenic and cadmium from fossil fuel combustion, metals manufacturing, pesticides, fertilizers and detergents) increased in U.S. rivers from 1974 to 1981 (Smith et al., 1987). These pollutants are delivered by rivers, streams and winds to estuaries and salt marshes. Many water bodies have levels of pollutants in excess of water quality standards, even though most major industrial dischargers are in compliance with their discharge permits.

Sewage treatment plants continue to release heavy metals and nutrients into estuaries and other coastal waters and to sequester toxins into sewage sludge, despite heavy regulation including discharge permits, toxicity testing and monitoring requirements. Combined sewer overflows contribute contaminated runoff from urban areas and overwhelm the capacity of sewage treatment plants during storms, resulting in releases of raw sewage. Toxins escape from industrial facilities and sewer lines into the atmosphere and are then deposited into waterbodies and their watersheds, posing serious threats to the Great Lakes and other lakes and estuaries throughout the country, despite the existence of air quality criteria.

The destruction of river bank habitat, wetlands, and other buffer areas between the land and water due to logging, mining, road building and development results in the runoff of sediment, pollutants, and excess nutrients (Water Quality 2000, 1991). The coral reefs of the Florida Keys have decreased in vitality and water quality (Dustan and Halas, 1987) despite the designation of the surrounding waters as "Outstanding Florida Waters" (ostensibly prohibiting the degradation of water quality) and of the Keys as an "Area of Critical Concern." Many factors have contributed to ecosystem degradation. Increased levels of sediment loading, nutrients and toxins are due in part to a lack of standards, lack of effective mechanisms for ensuring compliance with best land management practices, and lack of aggressive toxic-use-reduction strategies. Monitoring programs have to a large extent failed to provide the information necessary to identify threats or incipient damage (NRC, 1990). Water quality standards are seriously flawed, and standards for sediment quality and bioaccumulation are lacking, allowing pollutants to cross unchecked into various ecosystem compartments. Pollution is not managed at appropriate spatial scales, and within appropriate ecological boundaries. Policy-makers prefer to "wait-and-see" whether development or discharges of pollutants will result in degradation, rather than commit funds or risk being labelled "anti-growth" while uncertainty exists. Meanwhile, degradation proceeds and few incentives exist to reduce uncertainty in a timely manner. In this paper we propose new policy and analytic tools that will result in greater protection of whole ecosystems by institutionalizing the precautionary principle.

Wait-and-See or Do-No-Harm? Scientific Uncertainty and Decisionmaking

Most examples of marine pollution and habitat degradation can be attributed to the application of the "wait-and-see principle." According to this principle, toxic discharges, nutrient pollution, habitat alterations, introductions of exotic species, harvest of organisms, water supply manipulations and all manner of other environmental insults are allowed if the resulting environmental damage is uncertain, but the costs of preventing degradation are known. Application of the principle is particularly pervasive where future environmental damage is being weighed against current costs.

The wait-and-see principle has been reflected in environmental policies, programs and regulatory systems in the United States and in international arenas. This has occurred notwithstanding the fact that the wait-and-see principle is generally not formally acknowledged in environmental law. In fact, legislative language often purports to place the burden of proving that pollution is harmless on the polluter. In practice, however, laws are often applied in ways that place the burden of proof on regulatory agencies, citizens and environmentalists; they must show that pollution and habitat destruction/alteration are harmful to trigger regulatory action. For example, language in the Toxic Substances Control Act attempts to shift the burden of proof to dischargers of toxics, but regulators have interpreted this law in a way that actually requires *more* information to trigger action than before the law was written. Under the Clean Water Act, the flexibility afforded to local regulatory agencies to design compliance schedules or develop site-specific standards has often been manipulated to provide lengthy implementation delays; this puts environmentalists in the position of demonstrating the environmental damage incurred by the delay.

The prevalence of the wait-and-see principle is, in large part, a simple reflection of human nature. When faced with the prospect of requiring expensive environmental controls or forestalling development and thus having large—and quantifiable—effects on local economies, decisionmakers often want more proof of ecological harm than the equivocal analyses preferred by scientists. Scientists often respond to requests of policy-makers for advice with hedging on the value of available data, presumably to protect their credibility in the likely event that conclusions about the causes and effects of ecosystem degradation will change in the future. This hedging paves the way for the verbal minimization of threats to ecosystem integrity or human health, and the utilization of scientific disagreement and uncertainty to justify inaction.

A substantial literature exists on modelling and statistical techniques to support decisionmaking under conditions of uncertainty. Applications of such techniques may prove useful in rendering more transparent the assumptions, facts and logic used to reach decisions. Water resource professionals have devised rules of thumb and statistical criteria that make it possible for them to deal with uncertainty systematically as they plan and build water supply systems, flood control projects, and so on. Uncertainty inherent in the hydrologic cycle and other natural phenomena can be *quantified* (not necessarily reduced) and handled in a consistent fashion by using historical records in conjunction with concepts such as maximum probable flood, drought return period, safe yield, etc. (Wagonner, 1990). Unfortunately, water resource professionals often embrace the wait-and-see principle; many of them lobbied against the passage of the Safe Water Drinking Act and the Federal Water Pollution Act (Clean Water Act) and resisted their mandates after enactment. Methods to systematize uncertainty should be applied whenever appropriate, but with caution, especially as the past rapidly becomes the prologue to an uncharted future of climatic change (Luecke, 1990).

The uncertainty inherent in predicting the harm that will result to ecosystems, particularly marine ecosystems, from specific pollution or habitat alteration practices is unlikely to change substantially in the near future. Scientific uncertainty is the rule in marine environmental issues due to the complexity of marine ecosystems (e.g., estuaries vary tremendously on various time scales, from tidal cycles to seasons to years, and differ substantially from one another because of different geomorphology, riverine input, watersheds, circulation patterns, etc.), a general lack of powerful marine ecological theories that would allow generalization, and a lack of long-term monitoring and research sites. Inadequate monitoring protocols also do not allow the early identification of problems and do not supply the information necessary to assess threats to and the status of the marine environment (NRC, 1990).

Scientific uncertainty often persists even after intensive research has been conducted because of natural variability, because effects cannot often be related to single causes in complex ecosystems, and because the levels of importance of various factors are difficult to quantify. Rather than narrowing the suite of contributing factors, research has tended to broaden the context of environmental problems, forcing scientists to examine phenomena on different spatial and temporal scales.

The water quality and other standards that are supposed to serve as benchmarks against which potential damage can be assessed are fraught with inadequacies and uncertainty. Standards are based on the notion that the capacity of ecosystems to assimilate wastes and recover from physical alteration can be quantified and predicted; however, little evidence exists to support this assumption. More often, relevant standards simply do not exist. Standards currently exist for only a few of the thousands of potentially toxic constituents that are discharged into water bodies. Few standards for toxin and/or nutrient concentrations in the tissues of organisms and sediments, major sinks for toxins, are currently in use. The development of standards is usually slow, in part due to a lack of incentives resulting from the wait-and-see principle; if, for example, discharges of unregulated toxins are allowed to continue until a standard is set, the only advocates for a policy of rapid standards development are affected citizens and environmentalists.

Scientific uncertainty surrounding the causes, extent, and future evolution of ecosystem degradation, combined with very real and quantifiable costs to prevent projected degradation, has resulted in many examples of the application of the wait-and-see principle and of the placement of the burden of proof on regulators and citizens. First, we present a few examples in which decisionmakers waited for evidence to accumulate (obviously degraded ecosystems) and then acted to try to reverse the degradation:

(1) Nutrient loading from septic systems and sewage discharges continue despite good evidence that many estuaries, coastal embayments, coral reefs, etc. respond to nutrient additions with excessive growth of opportunistic algal species, simplification of communities, and sometimes anoxia or hypoxia. Macroalgal blooms in Kaneohe Bay (Hawaii) (Smith et al., 1981), the nearshore waters of the Florida Keys (Lapointe et al., 1990) and Bermuda (Lapointe and O'Connell, 1989), and the subestuaries of Buzzards Bay, Long Island Sound, and the Chesapeake Bay are examples. Only after these impacts became obvious were potential solutions explored. Recently, tertiary treatment of sewage prior to discharge and bans on phosphate-containing detergents have been used successfully to reduce these effects. In the Chesapeake, Buzzards Bay, and Long Island Sound regions, comprehensive plans to address point and non-point sources of nutrients and nutrient loading standards are being developed. A ban on phosphate-containing detergents and other ways to reduce nutrient loading (e.g., improved on-site disposal systems, small-scale and alternative technology-based sewage treatment plants, etc.) are being considered in the Florida Keys. Cost-effective remedial measures have been identified to address the problem of excessive nutrient loading at a variety of different scales and under a variety of different geological and hydrological conditions. Financing for new sewage treatment works on the appropriate scale and using appropriate technology to remove nutrients effectively will be required. This is especially true for important marine habitats in less affluent regions of the United States and in developing countries.

(2) In 1968, Swedish scientists elucidated the theory that sulfur oxide gases could be transported over long distances and transformed into acids, explaining the phenomenon of acid rain. In the mid-1970s, evidence indicating that the same phenomenon could be occurring in the United States began to accumulate. However, U.S. policy-makers allowed utilities and other dischargers to continue the use of tall smokestacks, resulting in the acid rain problems documented over the last decade. Recently, another problem was recognized: acid rain also deposits nitrogen into the watersheds of estuaries such as the Chesapeake Bay, contributing to eutrophication (Fisher and Oppenheimer, 1991). Legislation to control acid rain by cutting SOx emissions was finally enacted in 1990. EPA's NOx criteria documents are currently in review; ideally, new NOx criteria will protect sensitive marine ecosystems from atmospheric nitrogen deposition.

(3) The depletion of the stratospheric ozone layer and the recent increase in the amount of ultraviolet (UV) radiation reaching the earth's surface resulted from the unexpected effects of chlorine and bromine (delivered by chlorofluorocarbons, or CFCs, and halons), sulfur, and nitrogen oxides. After evidence of negative effects appeared in mid-1970s, consumers boycotted CFC propellants despite considerable scientific uncertainty. CFC producers adopted

the wait-and-see principle, arguing that CFC production and release should continue because uncertainty existed. The discovery of the ozone hole over Antarctica prompted agreements to cut production and release. The rate of CFC phase-out depends on the best available evidence, according to international agreements on this issue. Newer evidence indicates that stratospheric ozone is declining more rapidly than expected, and that enhanced UV flux results in decreased marine primary productivity.
Other issues could be resolved with modifications to legislation and regulation:

(4) Discharges of toxic metals and organic compounds have been allowed while effects were uncertain, despite evidence that these compounds have negative effects on marine organisms in laboratory tests. The Clean Water Act promotes the goal of "zero discharge" of toxics, and directs regulatory agencies to require discharge permits with adequate allowance for uncertainty. Most urban harbors, the Great Lakes, and most U.S. estuaries are victims of toxic discharges; diseased fish, contaminated shellfish, and "hot spots" with high residual concentrations of metals and organic toxins are the result. Discharge permits for individual sources may not protect water bodies from the cumulative effects of many point sources and non-point sources. Community-level indicators of the incipient adverse effects of toxic discharges are needed. Biological criteria based on such indicators may help to prevent the contamination of relatively pristine water bodies (EPA, 1990). Standards are needed for sediment loading and for toxins and nutrients in sediment and the tissues of organisms (e.g., bioaccumulation) in order to identify sites in need of remediation and to protect *all* components of marine ecosystems. Mandatory programs for reducing the use of toxic substances, aided by mechanisms which establish economic incentives for pollution prevention and recycling, are needed to reduce exposure of workers to toxic substances and to reduce loadings of toxic pollutants to the atmosphere and to waterbodies.

(5) Destruction of habitat and buffer zones. Mangrove chipping in the Caribbean region, dynamiting of coral reefs in the Phillipines, and the use of coral reef limestone as construction material in Indonesia are all examples of habitat destruction (Wells, 1988) taking place despite the obvious detrimental effects and despite uncertainty about the full value of these ecosystems. Natural ecosystems allow us to avoid costs such as artificial breakwater construction (which coral reefs provide free of charge) and contain large unrealized economic potential from sustainable fisheries, pharmaceuticals, ecotourism, etc. Compelling data on the full value of marine ecosystems managed in ways that protect biological diversity and the resource base are needed, along with a popular mandate to do so. Comprehensive land use plans, sanctuaries, and sustainable harvest practices must be implemented with the full participation of local resource users. Federal oversight, interagency cooperation, and land acquisition will be needed to implement measures to protect habitat in the United States Development assistance will be necessary to implement this kind of management in less developed countries.

Finally, we present two examples in which decisionmakers are still waiting to see what degradation results from ongoing practices and where little impetus for corrective action exists:

(6) Fish, shellfish, liverock and other marine organisms are harvested without certain knowledge of the effects of harvest on individual stocks, let alone the effects on ecological integrity. For example, removal of grazing fishes could trigger eutrophication in coral reefs. Selective removal of large fish could result in selection for small spawning size, and hence lower fecundity. Ecological impacts must be ascertained, harvest limits should be based on the minimization of these impacts, and refugia for big fish will probably be needed to keep fecundity high, by protecting highly fecund stocks. The lack of ecologically based fisheries management is the rule in most nations, be they industrialized or less developed.

(7) The U.S. policy on global warming represents one of the best examples of the wait-and-see principle. Although warming has occurred over the last century, the causes of the historical temperature increase remain uncertain (with greenhouse gas accumulation the most likely cause). There is a high degree of scientific uncertainty concerning the potential impacts of climate change on ecosystems, although circumstantial and experimental evidence strongly indicate that mass coral reef bleaching is linked to anomalously warm *local* temperatures (and that these localities have spread around the globe during the last decade), and that many terrestrial species appear to have shifted their ranges northward. Increased greenhouse gas concentrations are expected to increase ocean temperatures generally; continued ocean warming would in turn be expected to result in increased temperatures near coral reefs, and to trigger more frequent and severe mass coral bleaching events. Climate change poses a threat of very large magnitude (extinction and range reductions; collapse of coral reef ecosystems; physical destruction of wetlands, etc.) and of a long duration (in some cases irreversible on ecological time scales).

A threat with these characteristics should clearly result in action to reduce risk despite a large degree of uncertainty. The effects of greenhouse gas accumulation on ecosystems will be very difficult to demonstrate until long-term (perhaps 30 year) temperature records are compiled (unusual in marine systems); even then, the evidence will be circumstantial. The lag time between reductions in greenhouse gas emissions and the effects on climate may be about 40 years (due to the thermal inertia of oceans). Hence, action to reduce effects taken when the effects are obvious and demonstrable will be too late. Some solutions: gradually increase global energy efficiency, gradually increase the cost of fossil fuels to reflect total costs (social and environmental) so as to provide a level playing field for renewable sources of energy, remove subsidies for highways and provide incentives for construction and use of mass transit facilities, reforest deforested land, provide economic incentives for conserving carbon reservoirs (e.g., forests), and provide environmental technologies on a concessionary basis to less developed countries.

In each of these examples (with the exception of global warming, for which past and current effects are uncertain), the wait-and-see principle has resulted in ecosystem damage and health risks, as well as costly clean-up operations, and sometimes irreversible degradation: loss of species, destruction of irreplaceable habitat, continuing toxicity of toxic metal "hotspots". Since the nature of scientific uncertainty and of equivocal scientific judgements is unlikely to change, the pervasive use of the wait-and-see approach is also unlikely to change unless a clear attempt is made to design policies, programs and laws to counteract the tendency to wait and see. The wait-and-see principle should be replaced at every level with the do-no-harm principle. The do-no-harm, or precautionary principle would require polluters, developers and other users to demonstrate that their activities are not harmful to individual species and/or to whole marine communities and ecosystems, both local and remote, prior to engaging in them.

The implementation of the do-no-harm or precautionary principle will require new analytical tools. Monitoring protocols capable of predicting threats to the marine environment and of providing the information necessary to determine the causes of degradation are urgently needed (NRC, 1990). Threats analysis, or risk assessment, is a promising analytical tool but still appears to be very sensitive to input assumptions, and hence very easy to manipulate in order to rationalize preconceived results. Less quantitative, more transparent methods may be more useful, such as jury-like deliberations based on the best available evidence to prioritize threats, assign responsibility, and determine remedies.

New policy tools must also be incorporated into legislation and regulations if environmental degradation is to be prevented, rather than merely dealt with when crises arise. Regulators, scientists, and policy-makers must be inculcated with the precautionary principle, so that well-intentioned attempts to shift the burden of proof or prevent degradation in the face of uncertainty are not subverted by poor or even damaging implementation. Discharges of currently unregulated toxins and nutrients should be frozen at present levels if the best available evidence indicates that they pose a risk to the environment. The freeze would be lifted only if sufficient evidence to the contrary is provided, or when protective standards are developed. Such emissions freezes are needed to at least preserve the status quo while uncertainty exists, and to provide incentives for the timely development of standards. Flexibility will be needed to provide for new evidence and for the fact that freezes are being imposed on the basis of incomplete evidence. For example, enforceable timelines for standards development could be established.

Standards should be designed to prevent degradation. In many cases, the concentration of a toxin at which adverse effects (including subtle behavioral changes and other sub-lethal effects) are likely is much lower than the concentration at which adverse effects are clearly demonstrable. Standards should prevent relatively pristine waters from degrading; here, a premium must be put on the *sensitivity* of the standard, so the standard should be low enough to reduce or eliminate the *risk* of degradation even if degradation is not clearly demonstrable. Another type of standard (such as the concentration of a toxin which yields statistically significant declines in organism abundance or viability) may be required when a high degree of *demonstrability* is needed to justify, for example, a costly clean-up. Deviation of water, sediment and/or tissue concentrations of nutrients and toxins from values characteristic of pristine ecosystems should trigger emissions freezes if, as is usually the case, the present and future capacity of a given ecosystem to assimilate toxins and nutrients cannot be quantified.

New analytical tools, new kinds of precautionary standards, and new policy ideas like the emissions freeze should be used in the context of a comprehensive view of threats, interactions between ecosystems, and ecosystem boundaries. Cross-media pollution caps will be necessary to ensure that air quality, surface water and groundwater standards are stringent enough to prevent pollution in marine ecosystems. Caps on pollution that shrink over time present opportunities to use tradable emissions reductions credits or other economic incentives to decrease the cost of pollution reductions (Tripp and Dudek, 1989; Project 88, 1988). Care should be taken to ensure that such trading schemes do not result in harmful concentrations of pollutants in some sites. Sediment, water, and tissue bioaccumulation standards should be used together to prevent the movement of pollution into these ecosystem compartments and to ensure that, for example, water quality does not remain high at the expense of sediment quality. Circulation patterns and interactions between ecological communities, drainage basins and airsheds should be used to define boundaries that reflect ecological realities and to implement comprehensive pollution reduction strategies that protect all interacting components, transcending if necessary jurisdictional boundaries. Marine ecosystems must also be protected from global warming and ozone depletion, and may prove to be sensitive indicators of these stresses (e.g., coral reef bleaching), helping to define maximum tolerable rates of climate change and increases in ultraviolet radiation.

In conclusion, it seems clear that the wait-and-see principle is prevalant in our society. It probably results from the perception of a dichotomy between economic interests and environmental protection, and from the contrast between the readily quantifiable costs of pollution prevention and control and the less tangible costs of ecosystem degradation. These factors provide a basis for the historical bias on the part of decisionmakers to protect economic interests at the expense of environmental interests. However, a new understanding of the importance of ecological integrity to economic interests and quality of life, and a new focus on *sustainable* resource use and the need to provide a quality environment for future generations, are emerging. These new understandings are eroding the false dichotomy between economic interests and environmental protection, and should make the implementation of the do-no-harm principle more tractable. Scientific uncertainty should not be an excuse for inaction, but rather should result in prudent measures to prevent degradation due to ignorance.

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Monitoring and Assessment

THE ENVIRONMENTAL MONITORING COMMITTEE: SOLVING THE PUZZLE OF COMPREHENSIVE MONITORING

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Regional Citizen Advisory Councils

On March 24, 1989, the *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound, Alaska, and spilled more than 11 million gallons of crude oil into these resource-rich coastal waters. The national and international repercussions of that single event are still being felt.

One major outcome of this oil spill was passage by the 101st Congress of the Oil Pollution Act of 1990 (OPA90). The most significant provisions are:

Expand federal role in response to an oil discharge;

Establish an Oil Spill Liability Trust Fund administered by the U.S. Coast Guard;

Require owners or operators of individual vessels and facilities to prepare response plans for worst-case oil and hazardous substance discharges;

Increase the liability of tanker owners and operators in the event of a spill;

Require newly constructed tankers over certain size limits to have double hulls or other double-containment systems;

Mandate establishment of an interagency committee to coordinate efforts to improve oil spill response technology;

Require formation of industry funded citizen advisory groups in Prince William Sound and Cook Inlet.

Although the last provision (actually Article V of OPA90) is not well known outside of Alaska, it has very important long-range implications for all oil-producing areas of the United States. OPA90 created two demonstration citizen advisory groups in Alaska, the Prince William Sound Regional Citizens Advisory Council (RCAC) and the Cook Inlet RCAC.

As a member of the Cook Inlet RCAC I am here to tell you about the formation of this council and about the work of one of its committees. If these councils are effective in Alaska they could serve as models for other states.

My comments are specific to the Cook Inlet RCAC; however, the Prince William Sound RCAC functions in a similar manner. The Cook Inlet RCAC serves as a regional resource to assist the local oil industry and state and federal oil industry regulators in developing and implementing oil spill prevention and response strategies in Cook Inlet. It also serves in an independent and proactive manner to scrutinize and oversee oil activities and provide recommendations when improvement and changes are desirable.

Cook Inlet RCAC's area of responsibility includes the public and private properties, beaches, harbors, bays, estuaries and waters in Cook Inlet. Oil facilities subject to oversight by the council include oil terminal complexes, tanks, vessels, tankers, docks, pipelines and platforms. The oversight can include exploration, development, production or transport of crude oil or refined crude oil products.

The council consists of 13 citizens from throughout Cook Inlet, including Kodiak Island, an area that is geographically outside the inlet but within the influence of Cook Inlet waters. The people on the council represent cities, boroughs and special interest groups from Anchorage to Kodiak, a diverse cross-section of the 300,000-plus population. About 60 percent of the state's population is contained in this area.

Cook Inlet RCAC Members
City of Kenai
City of Homer
City of Seldovia
City of Kodiak
Kenai Peninsula Borough
Kodiak Borough
Municipality of Anchorage
Alaska State Chamber of Commerce
Recreational organizations
Environmental organizations
Alaska native corporations
Aquaculture associations
Local commercial fishing industry organizations

The Environmental Monitoring Committee

OPA90 required that each RCAC create committees to carry out the tasks assigned it by the act. In the case of the Cook Inlet RCAC, we have two task-oriented committees: the Prevention, Response, Operations and Safety Committee and the Environmental Monitoring Committee (EMC, created in June 1991). Both committees are made up of council and public members.

The EMC has the following membership:

Council Members
City of Homer (University of Alaska Sea Grant Marine Advisory Program)
City of Kodiak (City council member and seafood processor)
City of Seldovia (public school teacher)

Public Members
Faculty member, Alaska Pacific University
Alaska Center for the Environment
Private citizen, City of Kenai
Kenai River Guide
Commercial fisherman

Public school teacher, Beluga, Alaska

According to OPA90, the EMC is required to "devise and manage a comprehensive program of monitoring the environmental impacts of the operations of terminal facilities and crude oil tankers." One of the first acts of the EMC was to develop a mission statement to give it some direction in meeting that purpose. The mission of the EMC is to ensure that the environmental quality of Cook Inlet is not compromised or degraded by the operations of oil facilities and vessels.

With a mission statement in hand the EMC began to tackle the most perplexing question in its assigned task. What does *comprehensive monitoring* mean?

The EMC invited presentations by environmental consultants, scientists, regulators and industry officials to describe their ideas on comprehensive monitoring, as well as prior and ongoing programs in Cook Inlet. Out of these discussions came definitions of *compliance monitoring* pursuant to regulatory permits; *baseline monitoring*, collecting data before an event takes place; *event monitoring*, such as tracking the impacts of an oil spill; and *resource and scientific monitoring*. However, no one had a ready definition of comprehensive monitoring.

While preparing for this presentation I found another definition of monitoring that I would like to share with you: Monitoring is

> The continued, systematic time-series observation of pre-determined pollutants or pertinent components of the marine ecosystem over a period of time, sufficient to determine the:
>
> Existing level,
> Trends, [and]
> Natural variations of measured components (Federal Plan for Ocean Pollution Research, Development and Monitoring—Fiscal Years 1992-1996, p. 76.)

This gives as succinct a definition of monitoring as I have seen and might even be stretched to mean comprehensive monitoring.

With at least a rudimentary understanding of what comprehensive monitoring meant, the EMC proceeded to develop a work plan for 1992. It consists of the following objectives:

To develop and implement an ongoing scientific research program to detect, identify and assess environmental impacts to the Cook Inlet ecosystem;

To become familiar with the operation of oil facilities and vessels with special emphasis on type, source and quantity of material released into/onto the air, land, sediments and waters of Cook Inlet;

To assess the adequacy and effectiveness of federal and state laws and regulations, including the performance of regulatory agencies as it pertains to protection of the Cook Inlet ecosystem;

Accumulate information useful for managing spill impacts (sensitive area mapping; dynamic flow models); and determine possible environmental impacts of spill cleanup (in situ burning; dispersants; bioremediation; mechanical).

Developing the above work plan generated three questions that the EMC felt needed immediate attention. Near the end of 1991 we awarded three contracts that we hope will answer these questions.

The first contract, EMC 91-003, deals with the history and current status of oil development and production in Cook Inlet.

EMC 91-003 ($14,000)

Compile a comprehensive directory of Cook Inlet oil operations, including: history of Cook Inlet oil; identification of Cook Inlet petroleum operations and facilities; petroleum fields; oil storage; oil transportation; products produced; permits; discharges; and maps.

The second need that the EMC felt had to be addressed was a source of existing information on the Cook Inlet ecosystem. The contractor for this task was asked to search state and federal regulatory libraries, stacks of industry assessments, and numerous academic studies and compile a computer-based bibliography.

EMC 91-002 ($14,000)

Compile a comprehensive annotated bibliography of environmental literature on Cook Inlet: post-1970; computerized format; availability and cost; and search all available sources.

The final reports for EMC 91-002 and 91-003 are due to be in the committee's hands by the middle of April 1992; these are two important pieces of the puzzle. The third and, we hope final, piece is a model monitoring program specifically for Cook Inlet.

EMC 91-001 ($50,000)

To design a model comprehensive environmental monitoring program for Cook Inlet: examine Cook Inlet at the ecosystem level; meet or exceed regulatory compliance monitoring; collect baseline information and monitoring data; detect chronic and acute impacts; comprehensive including air, water, land, sediment, biota; measure toxicity levels and risk; be practical (cost-effective) and applicable to the study area.

By mid-1992, the EMC hopes to be in a position to consider the next phase of the puzzle—implementation. We hope that portions of the model comprehensive monitoring program will already be in place as a result of state, federal and industry compliance monitoring. We expect to establish specific monitoring objectives that build on existing monitoring and will lead toward the fulfillment of our assigned task of a comprehensive monitoring program.

We are also considering using citizen volunteers to keep down the costs of what we expect to be a long-term program. We would exercise great care not to compromise monitoring quality with this kind of effort.

In some ways we see our comprehensive monitoring program as being analogous to a home smoke detector. You may have used the best materials and followed every code in constructing your house. You may even have a safety specialist audit your home for any deficiencies and certify it as meeting all known standards. But in all likelihood you will still sleep better at night knowing one or more smoke detectors are in place and functioning.

The result, we hope, will be something that fills the cracks between existing programs and adds additional structure and support to the environmental monitoring of Cook Inlet. With this information the Cook Inlet RCAC can make well-balanced, concrete recommendations to industry and government about protecting our marine environment. In doing so, we will establish a firm foundation for citizen participation in environmental protection for the rest of the nation to build upon.

STATISTICS IN COASTAL MONITORING AND ASSESSMENT: WHAT MANAGERS NEED TO KNOW

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Tetra Tech Inc.

The Value of Statistics in Coastal Monitoring and Assessment

There is a need for greater use and understanding of statistics in the management of coastal environments. Statistical analysis has many applications in coastal monitoring and assessment, including estimation of the current status of ecosystem parameters, detection of differences in parameters of interest between study areas and reference sites, detection of spatial and temporal trends, assessment of data quality, and assessment of regulatory compliance decisions made under a risk-based regulatory approach. Statistics play a vital role in providing managers with a quantitative basis for their decisions.

The extent of areas involved in coastal monitoring and assessment programs make it necessary to base management decisions on limited information obtained from sample data. Therefore the use of statistical analysis is necessary in order to obtain the information needed to support management decisions, to extract the appropriate information from sample data, and to determine how well the data support the decision to be made. With basic knowledge of the fundamentals of statistics, managers can effectively interact with those involved in the design and evaluation of a study to ensure that the results will provide them with adequate information on which to base their decisions. In addition, basic knowledge of statistics will allow managers to properly evaluate the results of a study, the uncertainty associated with the results, the implications of the uncertainty, and the adequacy of the data in meeting the objectives of the study. Another important benefit is that managers will gain understanding of the resources (personnel, level of expertise, computer hardware and software) required to meet the objectives of a study.

There are several reasons why a study may not be adequate to meet management objectives. They include improper design, inadequate sample size, lack of statistical expertise resulting in the use of an inappropriate form of analysis, inadequate data quality control, and inadequate data management. With properly focused, application-based training, key staff members can be brought to a level of expertise necessary to avoid these problems. To ensure that a study is successful in meeting management needs, managers and statisticians must work closely together during all phases of the study. This is as important during the design phase as it is during the implementation and analysis phases. Unfortunately, too often statisticians are consulted only during the analysis phase of a study and often they must work with data that are not adequate to answer the questions of concern. The purposes of this paper are to provide managers with a basic overview of the application of statistics to coastal monitoring and assessment and to give them insight into their role in statistical analysis.

The Study Design Process

Proper study planning and design are crucial to ensure that a study is successful in providing the information needed by management in a useful format. Allocating adequate resources to the design phase will ensure that the resources allocated to the remaining phases are used effectively. An overview of the study design process is presented in Figure 1.

Development of Study Objectives and Performance Criteria

The first steps in the design process are to develop clear objectives for the study and to define a set of performance criteria to be used in determining if the objectives are met. As an example, the objective might be to determine if the disposal of dredge material at a site will have a significant adverse impact on the benthic organisms. Based on this objective, one or more parameters will be measured at both the proposed dredge site and at a reference site to determine if the difference between the samples from the two sites is significant.

Two types of significance are used as performance criteria: ecological significance and statistical significance. An ecologically significant difference is one that is judged to be large enough to result in a measurable ecologic effect. A statistically significant difference is one that is so large that it is very unlikely that you would observe a difference of that magnitude due to random chance of sample selection alone and therefore it is assumed that an actual difference exists between the two sites. A statistically significant difference is not necessarily ecologically significant.

By stating the study objectives and required performance criteria in the beginning of a study, a clear set of goals will be developed and a set of objective criteria will be available to measure success in meeting the goals. An example of a study objective and performance criteria would be to be able to detect a difference of 10 percent or more in a given parameter between a proposed dredge site and a reference site, with a probability of 80 percent of detecting a difference of that magnitude or greater given one exists (the statistical power), and a probability of 10 percent of concluding that a difference of this magnitude exists when in fact it does not (the statistical significance).

Establish Testable Hypotheses

In order to arrive at an objective conclusion, it is necessary to apply an appropriate statistical test to the sample data. The first step in this process is to translate the study objectives into testable hypotheses. The hypotheses represent a formal structuring of the key questions to be answered in a manner that allows a specific statistical test to be used to arrive at a conclusion. The general approach is to formulate a null hypothesis that no difference or trend exists, and that any that is observed is due simply to random chance of sample selection. The null hypothesis can be thought of as the default hypothesis. When the test is conducted, the null hypothesis will be assumed to be true unless there is enough statistical evidence to reject it (similar to a defendant in a criminal trial being presumed innocent unless the prosecution presents evidence of guilt beyond a reasonable doubt). Therefore it is possible to accept the null hypothesis even when it is not true, simply because there was not enough evidence (data) to reject it.

If the objective is to determine if there is a difference of a given magnitude in the concentration of a chemical of concern between two areas, samples are collected from both areas and a comparison is made between the average concentrations. An appropriate null hypothesis would be that there is no difference in the average concentration between the two sites. The alternate hypothesis would be that the average concentrations are not equal. Due to the natural variability in the parameter being measured, it is possible for the averages to differ solely due to random chance. The question then becomes, "How big a difference must be observed in order for the probability of it occurring due to random chance to be sufficiently small that it can be concluded that the true averages at the two sites differ?" In order to answer this, it is necessary to understand the types of errors that can occur when conducting a statistical test.

A difference might exist between the average concentrations in two areas, but the samples collected may result in estimates of the averages that are not significantly different; the reverse may also occur. These situations lead to the possibility of two types of errors, which are illustrated in Figure 2, concluding that there is a difference when there is not, and concluding that there is no difference when in fact there is one. The probability of the first type of error represents the risk to the producer, which is also referred to as the significance level of the test. The probability of the second type of error represents the risk to the consumer. The probability of correctly concluding that there is a difference when one exists is referred to as the power of the test. Traditionally, significance levels of 5 to 10 percent have been used and values of 80 percent or more for power have been considered sufficient. These values are by no means cast in stone and the manager should be involved in selecting values that reflect reasonable risks of committing the corresponding types of errors. Because there is an interdependency between the significance level, the power and the minimum detectable difference of a test, it will be necessary to arrive at a balance that best meets the objectives of the study. The minimum detectable difference should be set at a level that is considered to be ecologically significant, then the significance level and power must be balanced to reflect the acceptable producer and consumer risks. The power of a test can be difficult to calculate and therefore it has often been overlooked, however it is crucial that a study have sufficient statistical power if the results are to be conclusive. If the power of a test is low, then there will be a tendency to accept the null hypothesis (conclude that there is no difference or trend) simply because there is a lack of statistical evidence.

Select Methods

Once the testable hypothesis has been formulated, the specific statistical test to be used must be selected. The test selected will have a set of assumptions associated with it as well as particular data needs. Both factors must be taken into account when selecting the sampling design (number of samples to be taken and their spatial and temporal distribution), the physical method of sample collection, the method of analysis and the method of managing the data to be used.

A variety of sampling designs is available. While simple random sampling is one of the most commonly used designs, other designs can result in more efficient sampling (more information or less uncertainty for a given cost). Systematic sampling uses samples collected at fixed intervals over the entire study area, and therefore equal representation is ensured. Stratified sampling allows the study area to be divided into strata based on key criteria, and each strata is sampled independently. This allows the sampling effort to be allocated optimally among the strata to increase the efficiency. Multi-stage sampling involves selecting a number of large primary samples, which are then subsampled, again resulting in increased efficiency. Figure 3 provides a brief overview of these designs.

When an appropriate method of statistical analysis has been selected, methods of sample collection and analysis must be chosen with care to make sure that key assumptions of the analysis are not violated. Using consistent sample collection and laboratory analysis methods throughout the study is preferable in order to minimize variation in the results due to methods.

Another key point to address is the handling of non-detects. If possible, the laboratory used should report all concentrations measured, even if some criteria cause the result to be reported as a non-detect. This will allow greater flexibility in the handling of non-detect values and result in a more thorough analysis.

How the data are managed is as important as how they are collected. The design of the data management system should take into account the major uses of the data, including the types of analysis to be performed and the types of reports to be generated. Flexibility is an important feature of a data management system, because data requirements can change, particularly in long-term monitoring studies. An efficient data management system will help reduce the cost of data analysis and data quality control.

Evaluation of Expected Performance

The next crucial step is to evaluate the expected performance of the study to ensure that the performance criteria will be met. If inadequate data are used, the study may fail to reach a valid conclusion. It is important to determine the expected minimum trend or difference that the study will be able to detect based on the environmental variability and the proposed sampling plan and to compare this value with the performance criteria based on ecological significance. Statistical power analysis is useful in determining the minimum difference or trend that a study will be able to detect with a specified probability.

Interpretation of Study Results

When interpreting the results of a study based on sample data, the exact results obtained can vary due to random chance of sample selection and the natural variability of the ecological parameters being measured. Therefore, it is important to put the results into the proper perspective by understanding the level of uncertainty that is associated with them.

When the objective is to estimate a particular ecological parameter, such as the level of a contaminant within a specific area, it is typical to collect samples from several locations within the area and calculate an average as a representative value for the entire area. Because the concentration will likely vary throughout the area, the concentration of the samples you collect and therefore the average can vary depending on the exact location of the samples you collect. The distribution of all possible sample outcomes (averages) is referred to as the sample distribution of the mean. If your sampling method is unbiased, then the most likely value in this distribution will be equal to the actual average concentration in the study area. Figure 4 illustrates the relationship between the distribution of an environmental parameter and the distribution of sample outcomes. The amount of spread in the sampling distribution (and hence the uncertainty in an estimate) will depend on the variability of the parameter, the sample size and the sample design. The common measure of the variability in the sample outcome is the standard deviation of this distribution which is referred to as the standard error of the estimate. This value can be used to assess the uncertainty of the result, usually in the form of a confidence interval. A typical way of expressing a result would be as an average concentration of 12.5 parts per million (ppm) with a 95-percent confidence interval of ± 5 ppm. The confidence interval can be interpreted as follows, if repeated sampling were conducted, and each time an average was calculated, along with a 95-percent confidence interval, then 95 percent of the intervals would contain the true average concentration. If the confidence interval is narrow, then the estimate is likely to be close to the actual value of the environmental parameter. If on the other hand, the confidence interval is very wide, perhaps even containing zero, then the estimate is of little or no value and additional sampling must be done.

This paper has presented only a very basic overview of the statistical issues that a manager should address when conducting a monitoring or assessment study. However, with a minimum amount of training that is properly developed to focus on a particular groups needs, the manager and support staff can effectively address the key statistical issues required to ensure the attainment of the study objectives in a cost-effective manner.

Figure 1. The study design process.

Develop Study Objectives
and Establish Performance
Criteria

↓

Establish Testable Hypothesis

↓

Select Methods
·Analytic
·Sampling
·Data management

↓

Evaluate Expected Performance

Conclusion	Truth: No Difference	Truth: Difference
No Difference	Correct	Error P = Risk to Consumer
Difference	Error P = Risk to Producer	Correct P = Power

Figure 2. Types of errors associated with testing for a significant difference between two averages.

Simple Random:	Samples are independently located at random	
Systematic:	Samples are located at regular intervals	
Stratified:	The study area is divided into nonoverlapping strata and samples are obtained from each	
Multistage:	Large primary units are selected which are then subsampled	

Figure 3. Sampling methods.

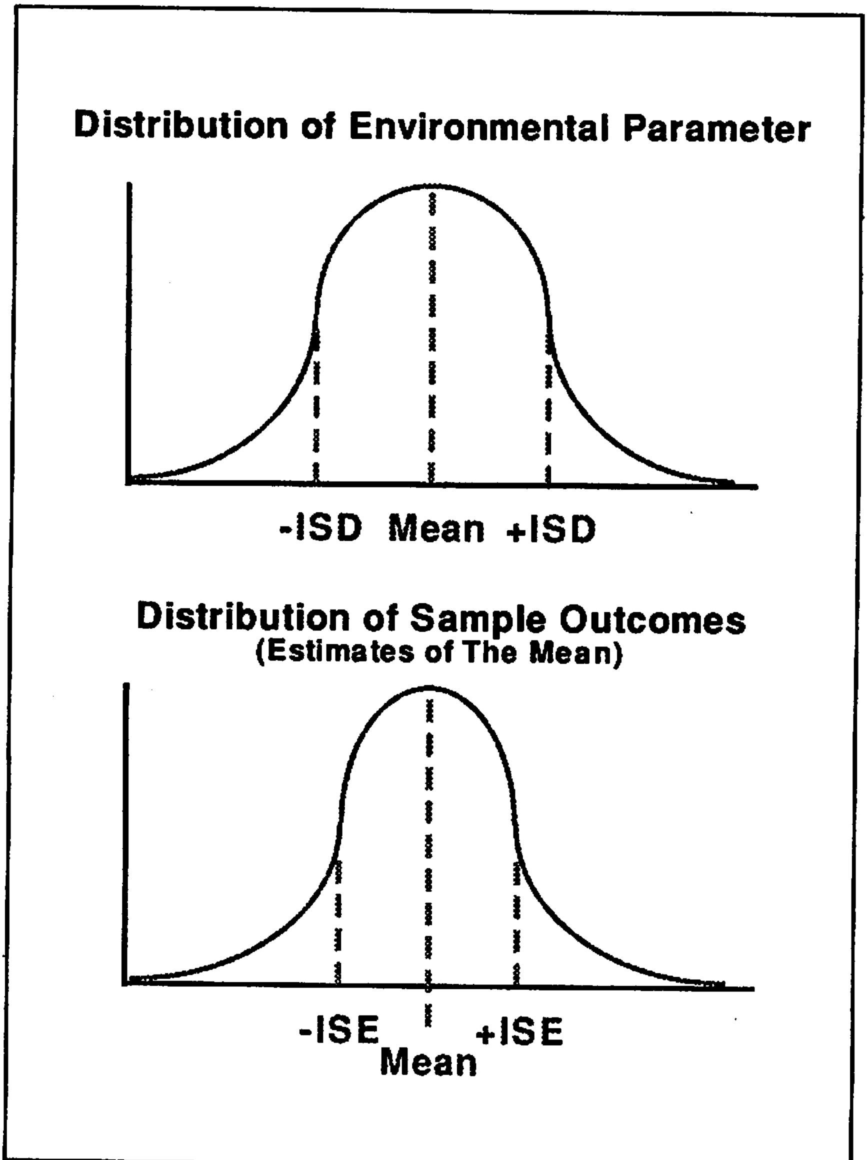

Figure 4. The uncertainty associated with estimates.

ENVIRONMENTAL CONCERNS ASSOCIATED WITH BOTTOM SEDIMENTS AND DREDGE SPOIL DISPOSAL IN HALIFAX HARBOUR, NOVA SCOTIA, CANADA

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Introduction

Halifax is the capital of the province of Nova Scotia, Canada, and is located in the Maritime Provinces bordering the Atlantic Ocean, centered roughly, latitude 44°36'N longitude 63°34'W (Figure 1). Halifax Harbour is a major inlet extending inland from coastal headlands more than 19 km to its head, where the Sackville River enters Bedford Bay. The harbor is oriented northwest to southeast, consistent with ice movement during the last Wisconsin glacial period. The harbor is flanked on the east side by the smaller city of Dartmouth. The harbor extends north of a headland from Hartlen Point across Chebucto Head, which includes Inner and Outer Halifax Harbour, Northwest Arm, Eastern Passage, The Narrows, Bedford Basin and Bedford Bay. Areas seaward are designated as the approaches to Halifax Harbour. The Inner Harbour includes the areas extending from and including The Narrows in the north, to a line extending from Maugher Beach in the east, across the harbor to York Redoubt. The Outer Harbour occurs south of this area and extends to the boundary with the approaches to Halifax Harbour (Figure 2).

Due to the stress on water quality created by sewage effluent entering the harbor, several major studies have been performed that have produced a prolifera-tion of data, making Halifax Harbour one of the most closely studied confined water bodies in the world. In 1988, 1989 and 1990 data consisting of a regional grid of echosounder data, sidescan sonograms, mid- to high-resolution seismic reflection profiles, gravity cores, piston cores, grab samples, epibenthic dredge hauls, bottom photographs and remotely operated vehicle (ROV) video information were collected by scientists of the Bedford Institute of Oceanography. Sampling was targeted to define the characteristics of previously identified sediments. Prouse and Hargrave (1987), collected an additional 135 samples in 1988 from the harbor bottom sediments employing general grid patterns, without the aid of geophysical data.

History of Halifax Harbour

Halifax was founded in 1749 as a military outpost. Along with Dartmouth it has transcended into the main eastern Canadian seaport offering services and shelter to North Atlantic cargo vessels and passenger liners. The harbor is ice-free during winter thus providing year-round facilities for the container trade and gypsum export. It is also the east coast homeport for the Royal Canadian Navy, hence it harbors ships and submarines, has major docking facilities and provides sheltered

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sea space for naval exercises. Present military facilities include ship repair, degaussing ranges, anchorages and seabed installations for acoustic studies. In the early years of its existence fortifications were erected around the harbor; they remain as tourist attractions. During the world wars, the harbor was the demarcation point for North Atlantic convoys that anchored in Bedford Basin. The most memorable event in harbor history took place when two wartime ammunition ships collided in the harbor Narrows and exploded in 1917, leveling a large section of the city. The harbor has also been extensively used for boating, swimming, diving, tour boating, private fishing, waste dumping and research activities. The Outer Harbour supports an important commercial lobster and finfish industry.

The harbor has been employed as a repository for raw sewage for almost 250 years with the first consolidated sewage outfalls being constructed in the 1850s. The present system consists of approximately 50 combined sewage and stormwater outfalls serving Halifax and Dartmouth with only 20 percent receiving primary treatment (City of Halifax, Engineering Department, pers. comm.) (Figure 3). Intensive studies of the physical and chemical nature of the harbor were conducted in recent years to facilitate prediction of the dispersion and fate of contaminated sediments under present conditions so remedial action could be taken, such as constructing a sewage treatment system and major outfall. These efforts have produced data indicating the extent and potential toxicity of sediments and spoil sites along the harbor bottom and shorelines (Fournier, 1990).

Geological and Oceanographic Character of Halifax Harbour

Initial work by Faribault (1908) suggested that Halifax Harbour was surrounded by Lower Cambrian metasediments with intrusive granite along its western side. Slates and quartzites were mapped as being folded into a series of southwest-northeast trending anticlines and synclines continuing under the harbor. Cameron (1949) identified a major fault (Chain Lakes—Sheenan Cove) confirmed to run beneath the harbor to more than 32 km offshore. It is postulated that the origin of the harbor is not due to structural control within the bedrocks, but to the distribution of bedrock type. A large resistant intrusion, South Mountain Batholith (Faribault, 1908), influenced the location of fluvial drainage systems in preglacial time, confining their locations to areas east of the batholith, which extends to more than 30 km offshore. Prior to glaciation, the present Sackville River continued on its course across a gently dipping Cretaceous peneplain through the present area of the basin and out the harbor (King and Fader, 1986). Recent evidence suggests another drainage system that existed in the present location of a series of lakes running northeastward through the city of Dartmouth. Glacial ice flowing through this system may have met ice moving south along the Sackville River Valley and continued a southerly flow. Halifax Harbour is a remnant of an ancient river valley drowned by rising post-glacial sea level and reworked by the erosional action of water and ice during several glacial periods (King, 1970; Fader and Miller, 1991).

The Inner Harbour and Bedford Basin act as a trap for sediments eroding from the surrounding land mass. Bottom sediment thicknesses determined from side-scan sonar, high-resolution seismic and sedimentological studies by scientists at Bedford Institute of Oceanography range from a few centimeters to more than 20 m, with the composition varying from gravel and sand to silt or clay (King, 1970).

Surficial sediments are remnants of the Wisconsin glacial period, Holocene deposition during sea level rise, and recent sediment additions from watercourses entering the harbor (Figure 4). Saltwater circulation is characterized by a typical estuarine two-layered flow consisting of saltier, heavier, incoming tidal waters moving along the bottom, while lighter, outgoing freshwater flow moves in an envelope at or near the surface. Outgoing movement is driven by river discharge and overland flow. Thus, surface and bottom waters form two separate layers of differing densities, with mixing occurring at the interface (Figure 5) (Fader and Petrie, 1991). Currents were measured to range between 0.06 and 0.22 km/hr at the Narrows, with the higher velocities near the bottom. These increase to 0.12 to 0.35 km/hr at the outer harbor. Currents change rapidly in velocity and direction due to variations in wind or tidal effects. Meteorological events can temporarily reverse the circulation pattern (Hurlbert et al., 1990). Sediment deposition is controlled by current patterns. Bedform features suggest that sediments generally move in a northerly direction, the same as near bottom circulation. It is feasible to make predictions regarding the resting place of contaminants carried by sewage effluent based upon sediment transport and water circulation data (Fader and Petrie, 1991).

Anthropogenic Features of Halifax Harbour

Human-induced features documented on the harbor bottom include anchor furrow and pitmarks, borrow pits, shipwrecks, oil rig and seabed impressions, propeller marks and scour, bridge abutment debris, pockmarks, unidentified debris, sewage outfall banks, dredged areas and dredge spoils. Locations and interpretations are derived from public archive searches, sidescan imagery, seismic reflection profiles and occassionaly by using ROVs.

Sewage outfalls pour basically untreated sewage and stormwater runoff into more than 50 locations on both sides of the harbor. This inflow is considered to be the main source of the high metals content detected in sediments throughout the harbor. Anchor furrow marks formed as long linear depressions flanked by side berms are widespread across the floor of the inner harbor. They range up to 3 m in depth and 5 m in width. Anchor impact often produces pits that can become enlarged when anchors pass through gas-charged sediments and volume is displaced as methane gas escapes. Anchor deployment acts as a widespread sediment turbator such that sediments and their associated contaminants are continually being exhumed, resuspended and redeposited in the inner harbor. Borrow pits are circular seabed depressions from which material has been mined for aggregate and fill. Many such pits averaging 15 m in diameter and up to 3 m in depth are found north of McNabs Island. Many shipwrecks have been located on the seabed of Halifax Harbour. They are not considered to be hazards to navigation but could represent obstacles to underwater cables and pipelines.

Dredge spoils located throughout the harbor are defined as circular deposits of material dumped on the seabed. They range in diameter to 30 m and may exist as expressions several meters higher than the surrounding seabed, or as coarse debris in depressions several meters in depth. Particularly notable are spoils dumped on Holocene mud near the Northwest Arm that have compressed and displaced the mud into features resembling pockmarks on sidescan sonar. The weight of the foreign sediments has resulted in the venting of methane-charged sediments in zones directly beneath the spoils.

Dredge spoils are recognized on sidescan imagery by their acoustically rough scattering surface and blocked texture (Figure 6). Spoils are known to consist of materials such as construction debris, discarded wood docks, gravel, boulders, muddy sediments, garbage, contaminated sediments and unidentified debris. Years of commercial shipping, industrial activity and naval exercises suggest that some debris may be dangerous. Old rusting drums have been identified but not closely examined since their contents could prove detrimental to diving teams.

Dredge spoils consisting of coarse debris often resemble borrow pits, since the heavy, dense material displaces the mud at the seabed, creating a depression. Large circular pits in a few locations are inferred to be spud-can depressions in Holocene mud created by jack-up oil rigs. They represent only minor resuspension of possible contaminated sediments. Directly adjacent to many docks the seabed appears eroded up to two-meter depths in scallop-shaped depressions. The interpreted cause is propeller wash associated with large vessels. The violent action resuspends sediments and permits possible movement of contaminants into the water column (Fader et al., 1991). Throughout the harbor many sidescan sonar high-intensity backscatter targets have been identified. They are thought to represent various types of unidentified debris, presenting minimal obstacles to underwater construction activities. Many areas near berths have been dredged to provide deeper draft for large vessels (Figure 7). They appear to result from dragline and clam-shell dredging operations. The dredge spoil has either been jettisoned nearby or dumped at other harbor locations. This practice raises considerable concern since sewage outfall settlement zones are usually found adjacent these docks and the highly contaminated materials are exposed to previously relatively clean areas with metals being resuspended in the water column tending to present a hazard to finfish. Consequent plumes also may interfere with photosynthesis and stability of the benthos and biota.

Marine Waste Disposal Regulations

In 1975, Canada signed the London Dumping Convention and its parliament passed the Ocean Dumping Control Act whereby disposal of wastes at sea became regulated by a system of permits. Prior to this statute, an ad hoc system of regulation existed under which uncontrolled dumping activities prevailed, since there were ineffective rules, limited monitoring and inconsequential fines. Permits govern such activities as timing, handling, storing, loading and placement at the disposal site. The permit system was subsumed under the Canadian Environmental Protection Act in 1988 and is presently administered by the Environmental Protection Service (EPS, 1991). The requirements deal with three categories of substances. Category one includes substances that can seriously harm the marine environment; non-compliance carries a fine as great as $100,000. The second category deals with substances that are potentially harmful with the possible fine being $75,000. The third category covers all substances not listed in one and two, with a potential fine up to $50,000.

Physiochemical Characteristics of Dredge Spoils and Sediments

Pollutants conveyed to Halifax Harbour come from either point sources, such as domestic and industrial waste from sewage outfalls (Figure 3), or non-point sources, such as urban runoff and atmospheric additions. Rough estimates suggest that greater than 151,400 m^3/day of raw sewage is pumped into the harbor from more than 50 outfalls. It includes human and chemical wastes from residences, institutions and commercial and industrial facilities. Only about 20 percent of raw effluent is treated at the Mill Cove secondary facility. Side-scan sonar data near the plant discharge zone suggest there is sufficient energy in local circulation patterns to disperse sludge. Urban runoff and stream discharge adds salt, fertilizers and industrial chemicals to harbor waters (Fournier, 1990). Atmospheric pollutants involve mainly ash and acidity transported from industrialized centers in Eastern Canada and the United States. The U.S. Environmental Protection Agency (U.S. EPA, 1976) has set standards (Puget Sound Standard) for maximum acceptable levels of metals in a marine environment, based upon total metal content. They are displayed in Table 1 along with similar standards developed by the Canadian Federal Department of Environment, Protection Division (DOE, 1992).

Sewage particles and non-point-source additions reaching the surface, if retained near surface, are normally carried to sea, but as they sink they are picked up by the deeper inflow and transported back up the harbor. In strongly stratified waters, the plume may not reach the outflowing surface layer and particles would be carried directly into the harbor (Fader and Petrie, 1991).

Halifax Harbour bottom sediments have undergone periodic oxidation-reduction of various metals, dependent upon the weight, compaction and organic loading of sediments. Oxidation effects have been measured as occurring from 0 to 5 cm into bottom sediments throughout the Outer Harbour and 0 to 1 cm around the Inner Harbour. Reducing conditions prevail beneath these zones. The probable cause is the heavy organic loading by large volumes of effluents combined with the compaction of sediments and subsequent expulsion of oxygen. Iron and manganese are oxidized and then move back into the water column, whereas magnesium, zinc and cadmium (Figure 8) tend to form sulfides under reducing conditions. Copper is an organic complexor and thus tends to attach to sediment particles, but if released by agitation it tends to oxidize and move into the water column (Winters et al., 1991). Since the reducing environment is deep in the sediments, contentious metals will normally be contained and will not present a threat to the surrounding environment by entering the water column. Thus, these noted potentially deleterious metals will not readily enter the environment inhabited by fish and shellfish unless disturbed by extraneous activities. Dredging represents such an activity and the effects of normal harbor maintenance have been documented at several locations.

Chemical analysis of samples from Queen's Quay (Figure 9), indicate that the mobilization of sediments by dredging activities has produced a considerable increase in the level of heavy metals in the upper sediment column and conceivably the water column, where they may be oxidized and pose a threat to the food chain (Buckley et al., 1991).

A 1987 study involving an attempt to re-introduce a common species of mollusk into Halifax Harbour after many years' absence proved disastrous. The new entrants died before measurements could be taken in a 96-hour bioassay, attesting to the prohibitive state of harbor sediments for shellfish habitation (Buckley, 1992). Flounder from the harbor contained tumors and lesions (Tay, 1992). Historical data indicate a drastic change in benthic species over several decades with numerous benthic organisms being replaced. One exception is the lobster which remains a contented scavenger in a domain abundant with sustenance. Tests suggest that harbor lobster is still edible if the head is discarded (Buckley, 1992).

Conclusions and Recommendations

The scientific and engineering database for Halifax Harbour is one of the most comprehensive in the world. Many years of raw sewage input has virtually deprived the harbor sediments of oxygen and thus limits biological habitat. Halifax is in dire need of primary sewage treatment facilities. As presently recommended by the task force, effluents from the planned sewage outfall will remain in the confines of the Inner Harbour and will not create additional contaminant buildup and a threat to fisheries and human activities in the Outer Harbour. Numerous hazardous chemicals enter the harbor due to commercial activities being conducted along the shoreline. Sediments in many parts of the harbor are contaminated with heavy metals; thus disturbance of these sediments could pose a threat to water quality. The sediments may be covered by particles from the proposed sewage treatment plant and reduce the potential for release. Remedial action to dredge the contaminated sediment should be avoided.

A comprehensive management approach to handling all wastes discharging to Halifax Harbour should be established. It should include:

Land, seabed and water use controls;

Reduction of the volume and toxicity of wastes through a source control program;

Recovery of materials where possible;

Treatment and stabilization of unrecoverable wastes;

A non-point source identification and control program; and

Adequate dispersion of wastes that can safely be assimilated into the environment.

An environmental quality monitoring program should be developed to:

Investigate the frequency and impact of combined sewer overflows near recreation sites; and

Determine contaminant levels and additions to biota and sediments with special emphasis on heavy metals and hazardous compounds

Consideration should be given to adapting the UNEP guidelines for environment harbor management. The dredging and dumping guidelines under the Environmental Protection Act should be strictly enforced for the harbor to limit remobilization of contaminated sediments. Shoreline activities, such as ship repair, boat painting, creosoting pilings and ship loading, should be investigated and monitored.

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Table 1. Maximum acceptable levels (mg/l) of metals.

Metal	Pudget Sound	Canadian Environmental Protection
MgO	0.21	0.75
Cd	0.96	0.60
Cu	80	45
Pb	70	45
Zn	160	169

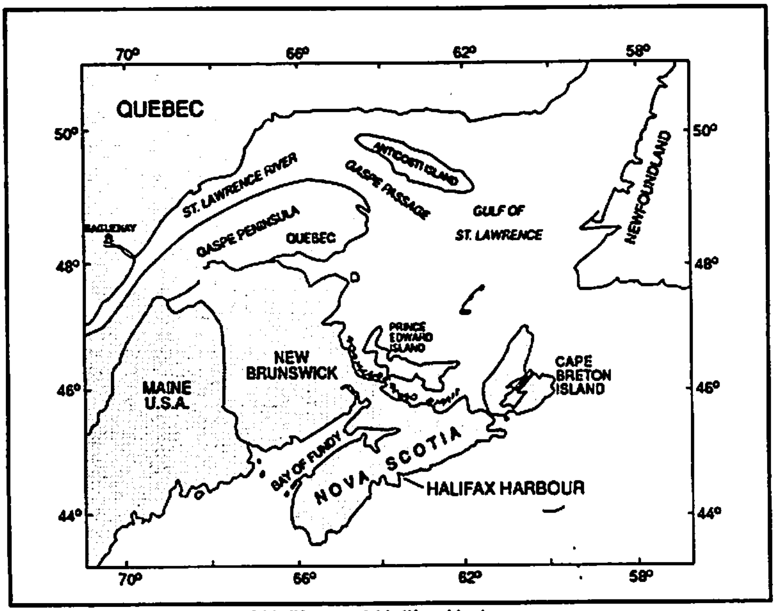

Figure 1. Location map of Halifax and Halifax Harbour.

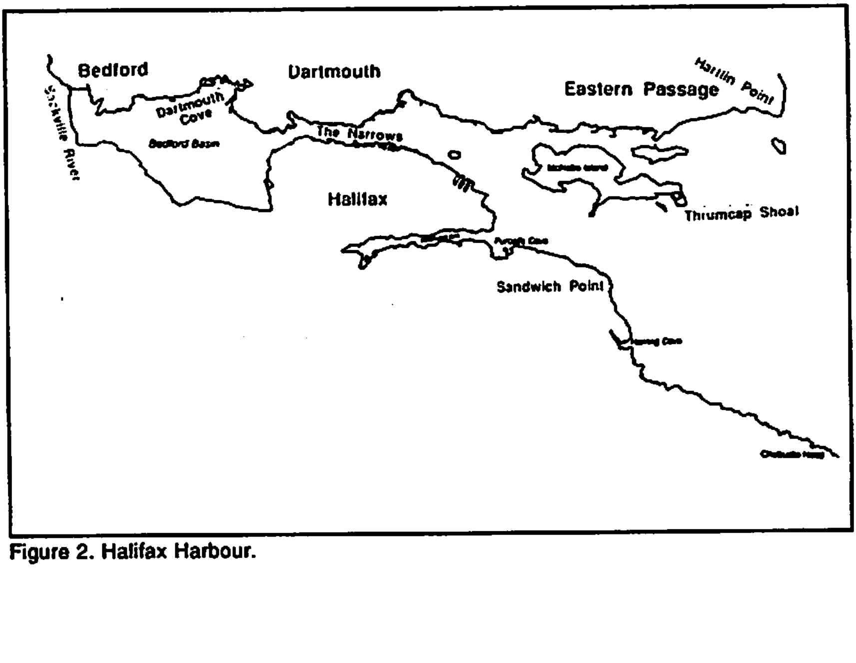

Figure 2. Halifax Harbour.

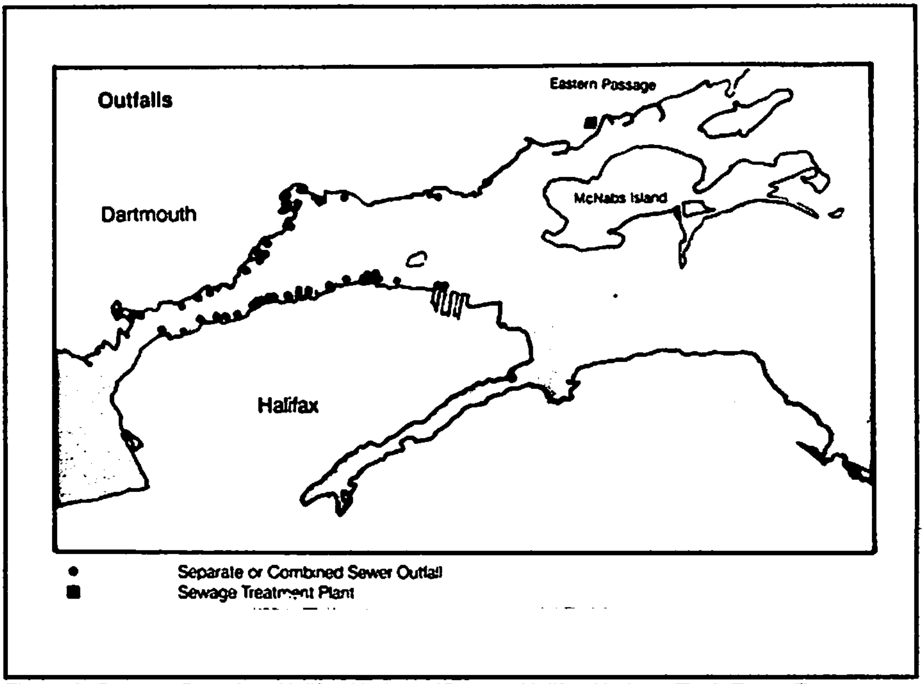

Figure 3. Sewage flows into Halifax Harbour (Source: Halifax Harbour Task Force Report, 1991).

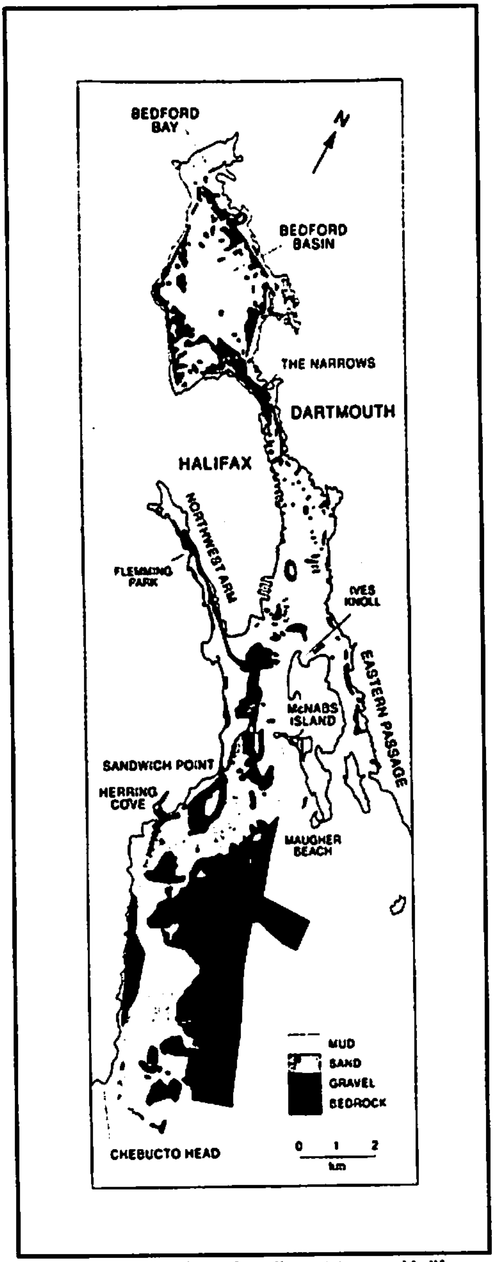

Figure 4. Distribution of sediment types, Halifax Harbour (Source: Fader et al., 1991).

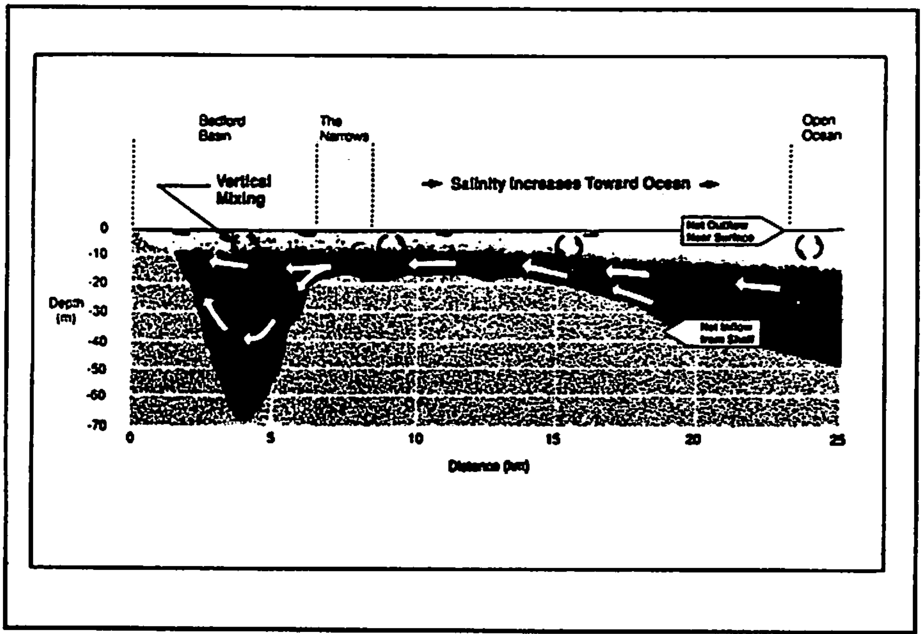

Figure 5. Circulation in Halifax Harbour (Source: Halifax Harbour Task Force Report, 1991.

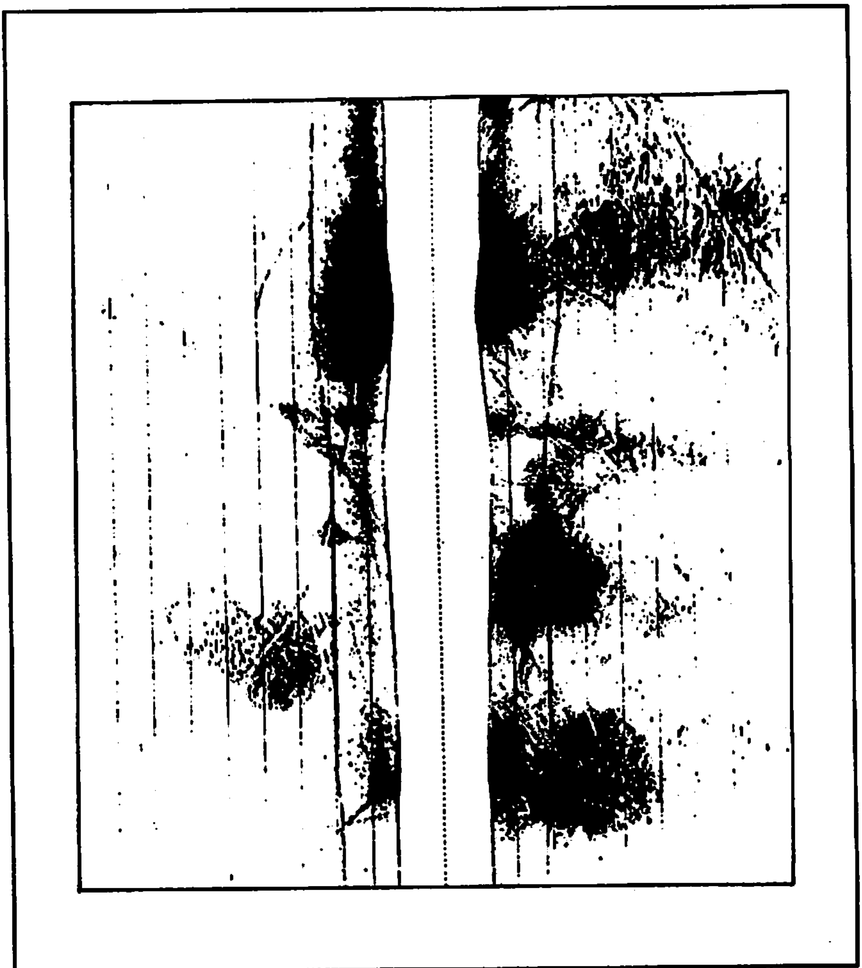

Figure 6. Dredging activities and other anthropogenic features, Halifax Harbour (Source: Fader et al., 1991).

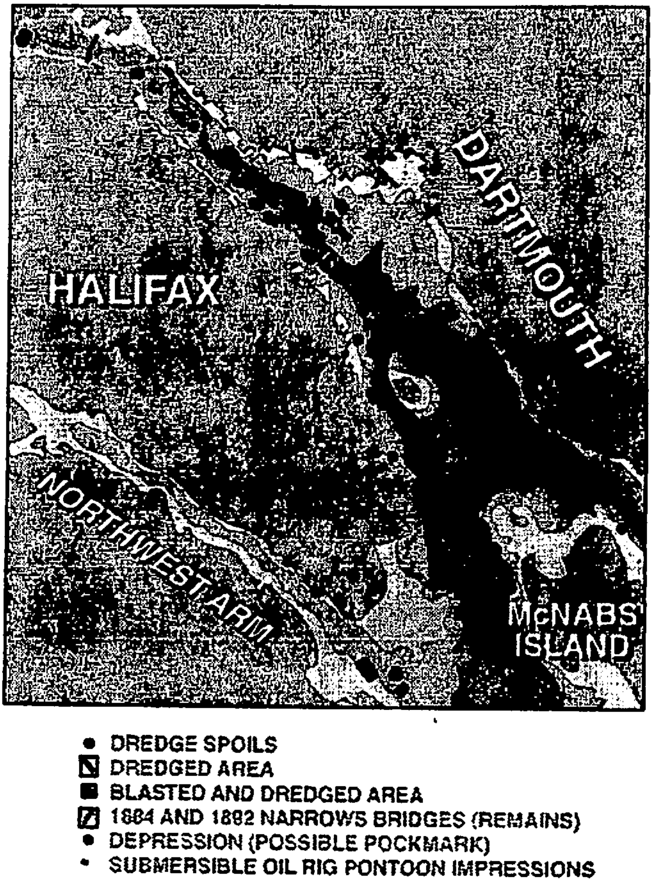

Figure 7. Side-scan sonar depicting large dredge spoils in Halifax Harbour (Source: Fader et al., 1991).

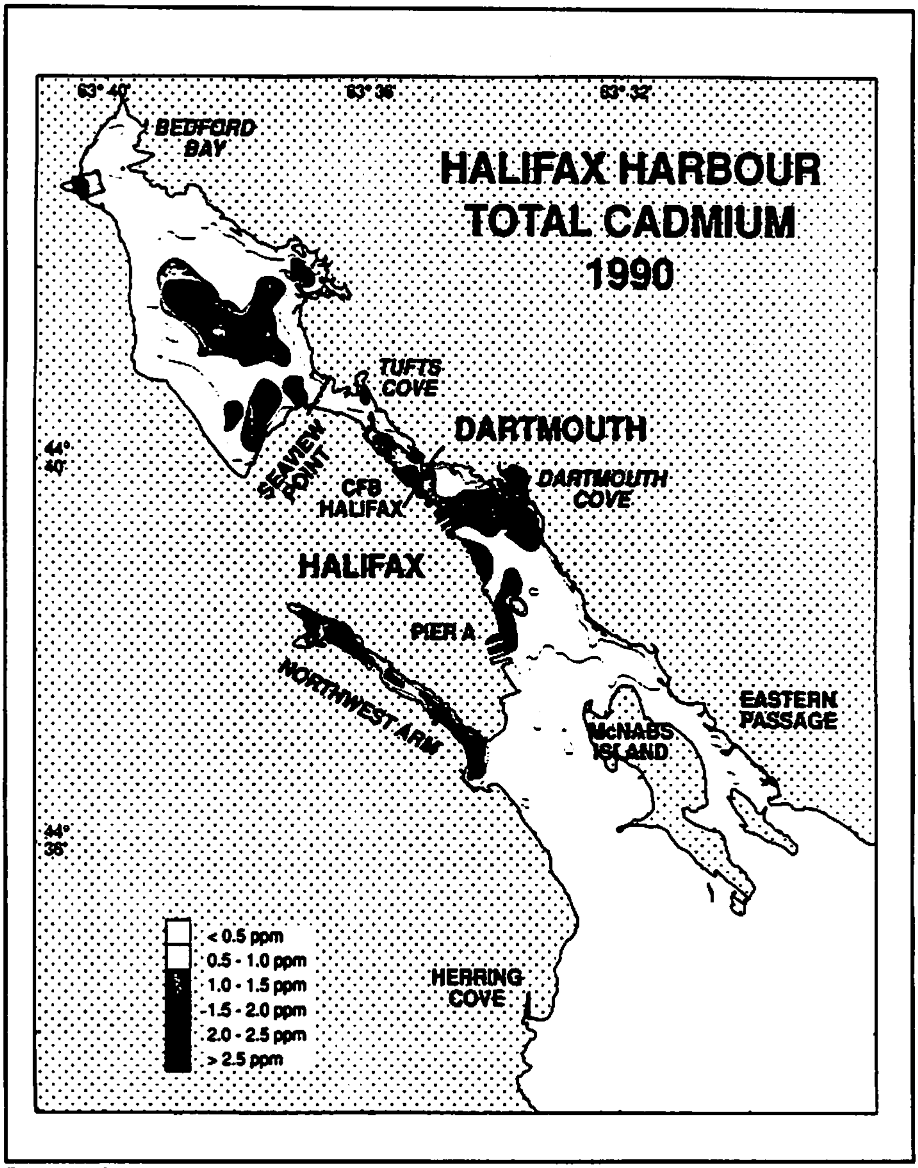

Figure 8. Cadmium distribution in Halifax Harbour (Source: Winters et al., 1991).

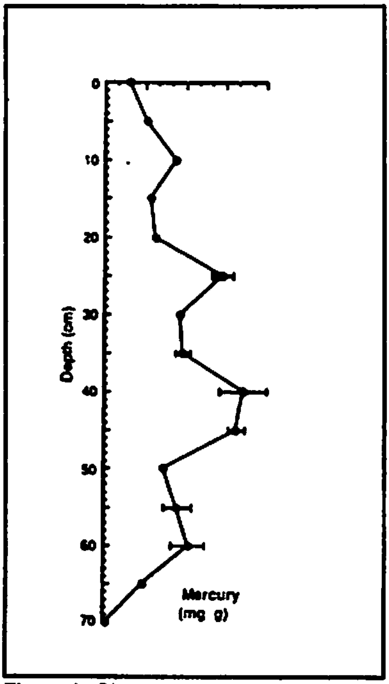

Figure 9. Chemical core analysis, Queen's Quay, Halifax Harbour. (Source: Buckley et al., 1991.)

Shoreline Management

THE NEW WAVE OF COASTAL EROSION MANAGEMENT

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Introduction

Increased congressional concern about coastal erosion prevention and management is evidenced by three recent developments.

First, in 1990, when Congress reauthorized the Coastal Zone Management Act of 1972 (CZMA)(Pub. L. 92-583), provisions were made for awarding enhancement grants as an incentive to states with innovative ideas about how to address such coastal hazards as erosion.

Second, by inserting Section 309 into the Water Resources Development Act of 1990 (Pub. L. 101-640), Congress required the secretary of the Army and the Corps of Engineers to consider whether it is desirable to plan and implement shoreline stabilization and beach renourishment projects in states that do not have certain types of restrictions on development in areas subject to erosion.

Third, a bill that would limit availability of federal flood insurance in coastal communities identified as erosion-prone was passed by the House of Representatives in 1991 and is in committee in the Senate.

In addition to these federal developments, the 30 coastal states, 24 of which have federally approved coastal management programs, are exhibiting increasing interest in addressing erosion problems. This paper summarizes the results of my recently completed research on pertinent state laws and regulations.

Principal Federal Erosion Management Programs

Coastal Zone Management Act. The Coastal Zone Management Act of 1972 (CZMA), as amended, established the voluntary federal/state partnership under which the coastal states were given financial incentives to develop and implement federally approved coastal management programs. CZMA is administered by the Office of Ocean and Coastal Resource Management (OCRM) within the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Although the original 1972 CZMA did not require that state management programs consider coastal erosion, a 1976 amendment required participating states to address coastal hazards such as erosion in their programs.

The Coastal Zone Act Reauthorization Amendments of 1990 (Pub. L. 101-508), by which CZMA was extended, provide a further incentive to the states with regard to managing erosion problems. This legislation authorizes special grants to states to achieve various "coastal zone enhancement objectives," including [p]reventing or significantly reducing threats to life and destruction of property ... in high-hazard areas. ..." As of this writing, OCRM is reviewing proposed strategies from the states seeking such grants.

Army Corps of Engineers Projects. The U.S. Army Corps of Engineers administers both federally financed shoreline stabilization and beach nourishment and renourishment projects, as well as the regulatory programs established under the Rivers and Harbors Act of 1899 and the Clean Water Act.

Stabilization and nourishment projects are authorized under periodically enacted legislation, such as the Water Resources Development Act of 1990. Section 309 of that act requires the secretary of the Army to report to Congress on the desirability of limiting such projects to states having four categories of restrictions and provisions relating to land use and activities in coastal areas subject to erosion. As of this writing, the secretary of the Army has not yet submitted a report to Congress.

In 1991, under contract to the Corps, I researched the extent of the state laws and regulations that are pertinent to Section 309. The results of my research are summarized later.

National Flood Insurance Program. The National Flood Insurance Act of 1968 (Pub. L. 90-448), which created the National Flood Insurance Program (NFIP), did not originally relate to coastal hazards such as erosion. The Flood Disaster Protection Act of 1973, however, expanded the NFIP to include flood insurance coverage for wave- or current-caused shoreline damages.

More than 16,000 communities participate in this voluntary program under which insurance for improvements in hazardous areas is available if certain conditions are fulfilled. The NFIP is administered by the Federal Emergency Management Agency (FEMA).

A significant change in the program occurred in 1987 when the Upton-Jones Amendment was added to the law. To encourage relocation or demolition of a structure in an erosion-prone area, this amendment authorized payment of claims before damage occurred.

Availability of insurance under the NFIP will be substantially reduced in erosion-prone areas if Congress passes the proposed National Flood Insurance, Mitigation, and Erosion Management Act of 1991 (U.S. House of Rep., 1991). The House of Representatives passed its version of the proposal in May 1991 by a vote of 388 to 18. Currently, a virtually identical bill is being considered by a subcommittee of the Senate Committee on Banking, Housing and Urban Affairs.

As passed by the House, the proposed act would require FEMA to identify erosion-prone coastal communities and to certify 10-, 20- and 60-year setbacks based on average erosion rates. The Upton-Jones Amendment provisions would be repealed, and availability of new flood insurance would be limited within the setback areas. Although communities designated as erosion-prone would not be required to participate in the revised NFIP, there would be surcharges on all existing policies in non-participating communities, and those communities would not be entitled to any mitigation benefits within the 60-year setback.

In communities choosing to participate, the owner of an existing structure waterward of the 10-year setback line would have a two-year grace period to decide whether to accept relocation benefits of as much as 40 percent of the structure's value. Such benefits would not be available in non-participating communities.

In both participating and non-participating communities, the revised NFIP would make only one payment on a future claim, not to exceed 40 percent of value, for loss of or damage to a building located within the 10-year setback, and then the policy would be canceled.

There are already some limitations on the NFIP. For example, issuance of flood insurance is prohibited within the Coastal Barrier Resource System, which is administered by the U.S. Fish and Wildlife Service, Department of the Interior. This system of undeveloped barrier islands and other features along the Atlantic and Gulf coasts was created by the Coastal Barrier Resource Act (Pub L. 97-348) and expanded by the Coastal Barrier Improvement Act of 1990.

State Coastal Erosion Management Provisions

Most coastal states, including those without federally approved coastal management programs, have statutes, administrative rules and regulations, or other legal authorities that address at least some aspects of coastal erosion. A few of these laws and regulations were in place before the United States began offering the states incentives under CZMA to develop management programs, but many of them have been approved recently by state legislatures and administrative agencies.

During my research for the Corps of Engineers in 1991, I examined various state restrictions and provisions relating to coastal erosion. The research focused on the four categories of restrictions and provisions referred to in paragraphs 1-4 of Section 309 of the Water Resources Development Act of 1990. The results of my research, which demonstrated a wide variety of pertinent state laws and regulations, may be summarized as follows:

Paragraph (1): "Restrictions on new development seaward of an erosion setback line . . . of at least 30 times the annual erosion rate." Ten states prohibit or restrict much, but not all, new development within designated portions of their coastal zones waterward of setback lines defined in terms of annual erosion or recession rates for 30 or more years. These states are Florida, Michigan, Minnesota, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island and South Carolina. Eight other states have state-mandated setback lines that either are not defined in terms of 30-year erosion rates or are based on different tests. These states are Alabama, Delaware, Hawaii, Maine, Maryland, Oregon, Virginia and Wisconsin. All other coastal states, except Illinois and Indiana, have some type of state restrictions on use of coastal lands.

Paragraph (2): "Restrictions on construction of new structural stabilization programs, such as seawalls and groins, and their reconstruction if damaged by 50 percent or more." Virginia prohibits construction of new stabilization projects on its barrier islands, and each of the 29 other coastal states has some type of state-imposed restriction on such construction. As for reconstruction of badly damaged stabilization projects, only three states, Minnesota, Rhode Island and South Carolina, appear to have state-mandated restrictions. In at least eight other states it is arguable that such reconstruction is restricted under state regulatory mechanisms. These states are Alabama, California, Delaware, Florida, Georgia, Hawaii, New York and North Carolina.

Paragraph (3): "Provisions for the relocation of structures in erosion-prone areas." Only North Carolina and South Carolina have state-imposed provisions specifically requiring relocation of structures under certain circumstances in designated areas. Arguably, in at least 12 other states there are state provisions requiring, or at least encouraging, limited relocation of structures under particular hazardous circumstances. These states are Delaware, Florida, Georgia, Massachusetts, Michigan, Minnesota, New York, Ohio, Pennsylvania, Rhode Island, Virginia and Wisconsin.

Paragraph (4): "Provisions to assure public access to beaches stabilized or renourished with Federal funds after January 1, 1991." No coastal state appears to have any provision expressly meeting this standard, but North Carolina has a statutory provision having such an effect. In each of at least nine other states there are provisions arguably ensuring public access to future federally funded beach stabilization or renourishment projects. These states are Alabama, Connecticut, Florida, Georgia, Illinois, New Jersey, Rhode Island, South Carolina and Virginia.

Conclusion

Collectively, three recent developments in Congress—enactment of the Coastal Zone Act Reauthorization Amendments of 1990, insertion of Section 309 into the Water Resources Development Act of 1990 and introduction of the proposed National Flood Insurance, Mitigation, and Erosion Management Act of 1991—indicate that there may be a new wave of coastal erosion management at the federal level.

While these developments are significant, most of the 30 coastal states are already addressing various erosion management issues by means of a variety of laws, regulations and coastal management program provisions.

Federal and state erosion management efforts should be coordinated. The federal government, in legislating and administering federal programs, should take into consideration the diversity of state coastal problems and solutions.

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Pub. L. 101-640, 104 *Stat.* 4604.

Pub. L. 101-508, 104 *Stat.* 1388-299.

Pub. L. 90-448, 82 *Stat.* 572. That act was amended by the Flood Disaster Protection Act of 1973, Pub. L. 93-234, 87 *Stat.*. 975. These laws, as amended, are codified at 42 *U.S.C.* § 4001 *et seq.*

Pub L. 97-348, 96 *Stat.* 1653. This act, as amended, is codified at 16 *U.S.C.* § 3501 *et seq.*

U.S. House of Representatives. May 1, 1991. Proposed act, H.R. 1236. (The senate version, S. 1650, has not been approved as of this writing.)

FACTORS INFLUENCING COASTAL EROSION IN DELAWARE

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Abstract

Wind-induced wave heights were calculated using directional wind speed and frequency data recorded over a 10-year period at Dover Air Force Base, average water depth along different fetches, and fetch distances for eight directions (only N, NE, E and SE were pertinent to this study) from four locations along the estuarine and oceanic coasts of Delaware. The calculated wave heights were then converted into wave energy, which was further subdivided into directional shore-normal and shore-parallel wave energy components for each of the locations. The rate of coastal erosion and the preservation potential of the marginal marine sediments (defined by the ratio of the thickness of inland to the thickness of offshore marginal marine deposits left behind after such shoreface retreat) for each location were graphically compared with dynamic parameters such as shore-normal and shore-parallel energy component, fetches, and maximum wave height in order to determine their interrelationships. The individual contribution of these parameters to the factors influencing coastal erosion and preservation were determined.

All of the wave parameters except the shore-parallel wave energy component increase from north to south, toward the oceanic coasts. Although the easterly components of shore-normal energy are prominent at each location, they seem not to have a direct affect on coastal erosion. The data suggest that the shore-parallel energy component plays a vital role in coastal erosion and preservation. There exists a logarithmic relationship between the rate of coastal erosion and the net shore-parallel wave energy components. This suggests that erosion rates increase rapidly once the amount of net shore-parallel wave energy reaches the threshold limit for a particular shoreline. Changes in preservation potential and rates of coastal erosion parallel each other, implying that a rapid shoreline retreat leads to a better preservation of stratigraphic record in the nearshore zone.

Introduction

The Delaware coast is predominantly transgressive, acting in response to local relative sea level rise (Kraft, 1971). In a few areas at Cape Henlopen, parts of Broadkill, and Slaughter beach, limited progradation has resulted from construction of groins, jetties, and breakwater harbor (Maurmeyer, 1978). The depositional environments of the Delaware coast have evolved within and upon the valley and interfluves of a trellis-dendritic drainage system of the ancestral Delaware River (Knebel and Circe, 1988; Fletcher et al., 1990). As a result of the local relative sea level rise, sedimentary environments in a low-lying coastal zone with low sediment inputs, such as Delaware, migrate in a landward direction, as a part of the process of coastal erosion (Brunn, 1962). The rate of shoreline retreat during the last few decades has varied for different portions of the Delaware coasts from 0.25 m/year to 6.9 m/year (Kraft et al., 1976; Maurmeyer, 1978). The underlying factors responsible for such variation in coastal erosion are not yet well understood. Only a better understanding of these factors can enable us to design a coastal management method to plan land use in a way which will mitigate coastal erosion while safeguarding the environment.

Wind-induced wave energy is the primary cause of coastal erosion in Delaware (Pizzuto, 1986). Storm-induced waves do most of the erosional work (Galgano, 1989; French, 1990). A better understanding of the directional distribution of wave energy components can help us to understand the sediment dispersion pattern and the direction of sediment movement. The amount of wind-induced wave energy depends on average water depth along the direction from which the wind is blowing, fetch distance and wind speed (U.S. Army Corps of Engineers, 1977).

Landward retreat of the shoreface and adjacent nearshore environments driven by transgression causes erosion of previously formed marginal marine deposits such as beaches, coastal wetlands and lagoons. This erosional process destroys pre-existing strata and creates contemporaneous stratigraphic records in the nearshore zone. The degree of preservation of marginal marine sediments probably varies as a function of many interrelated parameters such as: antecedent topography on which the transgression is taking place, wind-induced wave energy, shoreline orientation, sediment supply and wave height. Their interplay and their individual contribution to erosion and preservation potential of marginal marine sediments are not well-documented for the Delaware coast.

This study attempts to document the factors influencing coastal erosion and preservation potential of marginal marine sediments in the nearshore zone along the estuarine and oceanic coasts of Delaware. The directional wave energy components for four locations along the estuarine and oceanic coasts of Delaware were calculated in order to establish a relationship between the wave energy components and the rate of coastal erosion and preservation.

Study Area and Methods

The location of the study area is the barrier-nearshore zone of western Delaware Bay and the Atlantic coast of Delaware. Four stretches of the coast, with different geomorphic, geologic, and dynamic settings, were selected for this study (Figure 1). Three of the four study sites (South Bowers, Big Stone and Broadkill) were selected along the estuarine coast of Delaware from a point where barriers are very thin or absent to a point where they are well developed. The fourth site was along the oceanic coast of Delaware (Dewey Beach).

The NOAA navigational charts for the Delaware estuary and the Atlantic coast of Delaware were used to determine directional fetch distances, average water depth along those fetches, and the shoreline orientation for each study area. An arbitrary fetch of 50 km was chosen for an infinite fetch distance along any direction (the E and SE directional fetches for Dewey, and the E directional fetch for Broadkill), and an average water depth of 15 m was used for such infinite fetches. Directional wind speed and frequency data recorded over a 10-year period at the Dover Air Force Base were used to calculate 99.9 percentile values for wind speed (wind speed that is greater than 99.9 percent of the wind coming from a particular direction) for all fetch directions. Wave height was calculated using the Forecasting Curves for Wave Height (U.S. Army Corps of Engineers, 1977) for a constant water depth (average water depth was used). The values for the wave height (H) were then converted into wave energy (E) using the relationship: $E = 1/8 \rho g H^2$, where p is the density of water and g is gravity. The values for calculated energy were multiplied by the frequency of respective wind directions in order to obtain the weighted wave energy produced by wind coming from a particular direction. The weighted wave energies were then converted into directional shore-normal and shore-parallel wave energy components for the four study sites.

The rates of coastal erosion for the last two decades were calculated using computer generated historical shoreline maps of Delaware prepared by Galgano (1989) and French (1990), and the average preservation potential of the marginal marine sediments for the study area which were calculated using a series of vibracores taken from both marginal marine environments (marsh/lagoon) and the nearshore zone.

Results

The results of total wave energy (E), shore-normal energy (SNE) and shore-parallel energy (SPE) components, maximum wave height (H), fetch distances (F) for different directions, erosion rate (R), and preservation potential (P) of the marginal marine sediment in the nearshore zone for the four study locations are shown in table 1 and in figures 2-4.

All the wave related parameters (E, SNE, H, and F), except the shore-parallel wave energy components, increase from north to south towards the oceanic coast (Figures 2, 3, and 4). The easterly components of shore-normal energy are prominent for each location (Figure 4). The data also suggest that the shore-parallel energy components show parallelism with coastal erosion rate and preservation potential of marginal marine sediments (Figure 3). There exists a logarithmic relationship between the rate of coastal erosion and the net shore-parallel wave energy components (Figure 3). Apparently, erosion rates increase rapidly once the amount of net shore-parallel wave energy reaches the threshold limit (in this case, the value of $10m^2$ is the threshold limit) for a particular shoreline.

Discussion

The spatial variation in the rates of coastal erosion along the Delaware coast cannot be explained only by variations in the amount of sediment supply and by the amount of total wind-induced wave energy available for a particular stretch of the coast. For example, the amount of sediment carried by the longshore current decreases from the Atlantic coast toward the estuarine coast (Maurmeyer, 1978). The rate of coastal erosion, however, does not parallel this trend (Figure 2). The results of this study show that no significant relationship exists between total wave energy and rates of coastal erosion. The data also suggest that the shore-normal components of wave energy do not parallel the rates of erosion. This discrepancy can be attributed to the fact that shore-normal energy has a maximum affect outside of the breaker zone, and is dissipated within the breaker zone (Holman, 1983). As shore-normal energy is directed perpendicular to a shoreline it can disintegrate sediment, but cannot remove the loosened sediment from the shoreline. It is the shore-parallel wave energy component that transmits the energy along a shoreline and, therefore, can cause erosion by removing sediment in the direction of net shore-parallel energy movement. The rate of coastal erosion is at a maximum at

South Bowers where the net shore-parallel energy is also at a maximum, and erosion rate is at a minimum at Dewey where the net shore-parallel energy is at minimum. This finding is compatible with the idea suggested by Holman (1983) that the shore-parallel edge wave is the primary mechanism for coastal erosion.

The wave base or depth of erosion (h_b), and wave height (H) have the following relationship: H/h_b = 0.75 - 1.2 (Komar, 1983). This implies that a large wave is capable of eroding sediment from a relatively greater depth. Therefore, the areas that experience lower maximum wave height such as South Bowers and Broadkill are likely to have a shallower depth to erosion and thus a better preservation potential in the nearshore zone. A rapid rate of erosion along with a greater tidal range and low wave height, which has a shallow wave base, in the estuarine coast of South Bowers and Broadkill are probably responsible for the better preservation of marginal marine sediments in the nearshore zone.

Conclusions

The orientation of a particular shoreline, which is the factor responsible for variation in the amount of shore-parallel wave energy, is certainly one of the most important parameters in coastal erosion. Shoreline orientation along with fetch and water depth determine the amount of wave energy produced by the wind. While the net shore-parallel wave energy components control the rate of coastal erosion, the shore-normal wave energy components and wave height are responsible for vertical erosion (depth of erosion). This latter factor controls the preservation potential of marginal marine sediments in the nearshore zone. Coastal management plans designed to mitigate coastal erosion need to take into account the factors influencing shoreline retreat in order to prevail.

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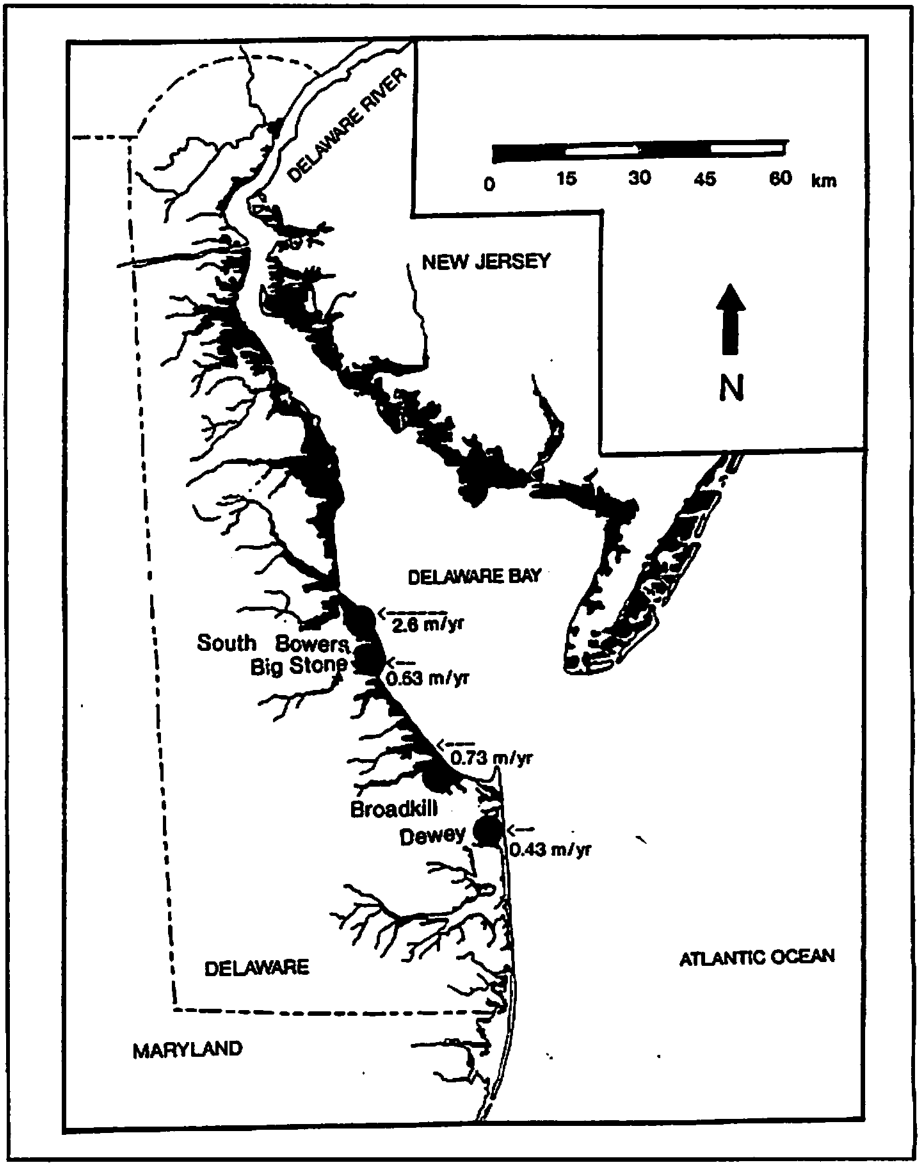

Figure 1. Map of Delaware showing the study area.

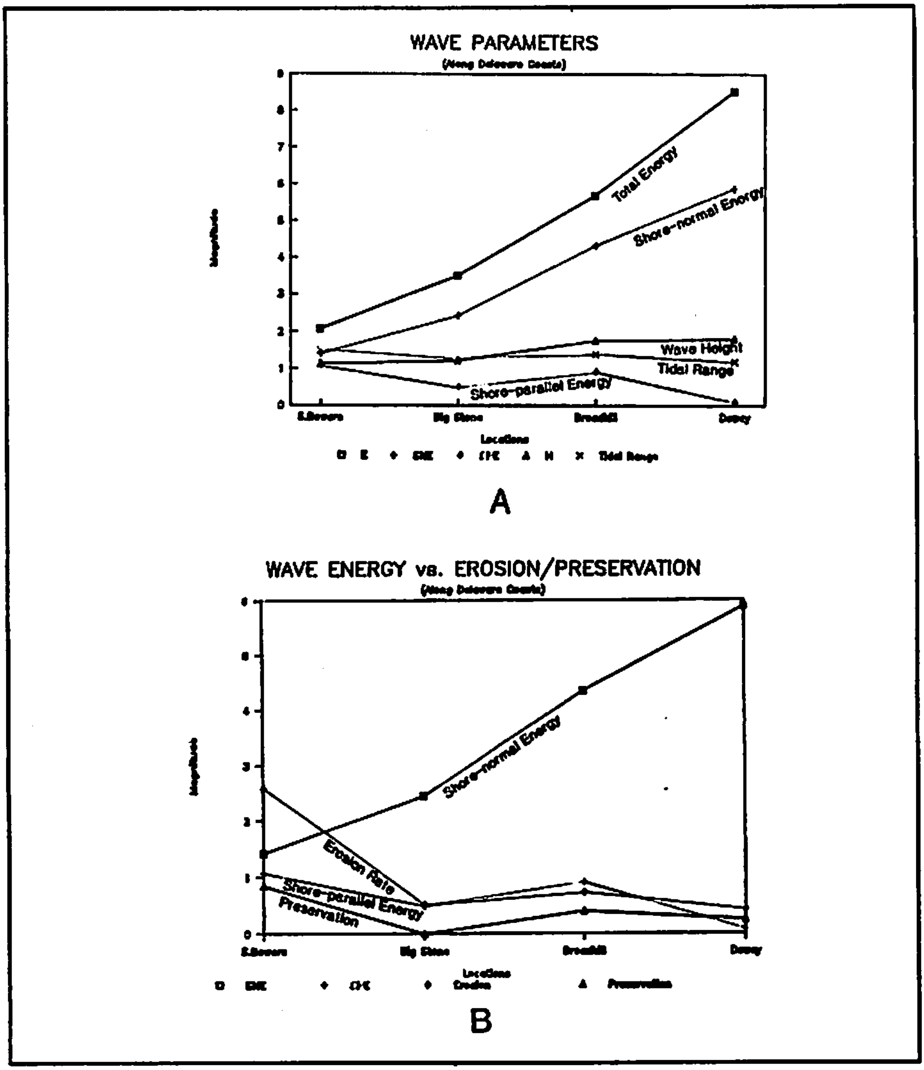

Figure 2. *A:* Graph showing wave parameters for the study area. All parameters increase from the estuarine coasts toward the oceanic coast, except for the shore-parallel wave energy and the tidal range. *B:* Graph showing spatial variations in the coastal erosion rates (R), preservation potential (P), shore-normal energy (SNE), and shore-parallel wave energy (SPE) components for the study area. All parameters, except SNE, parallel each other.

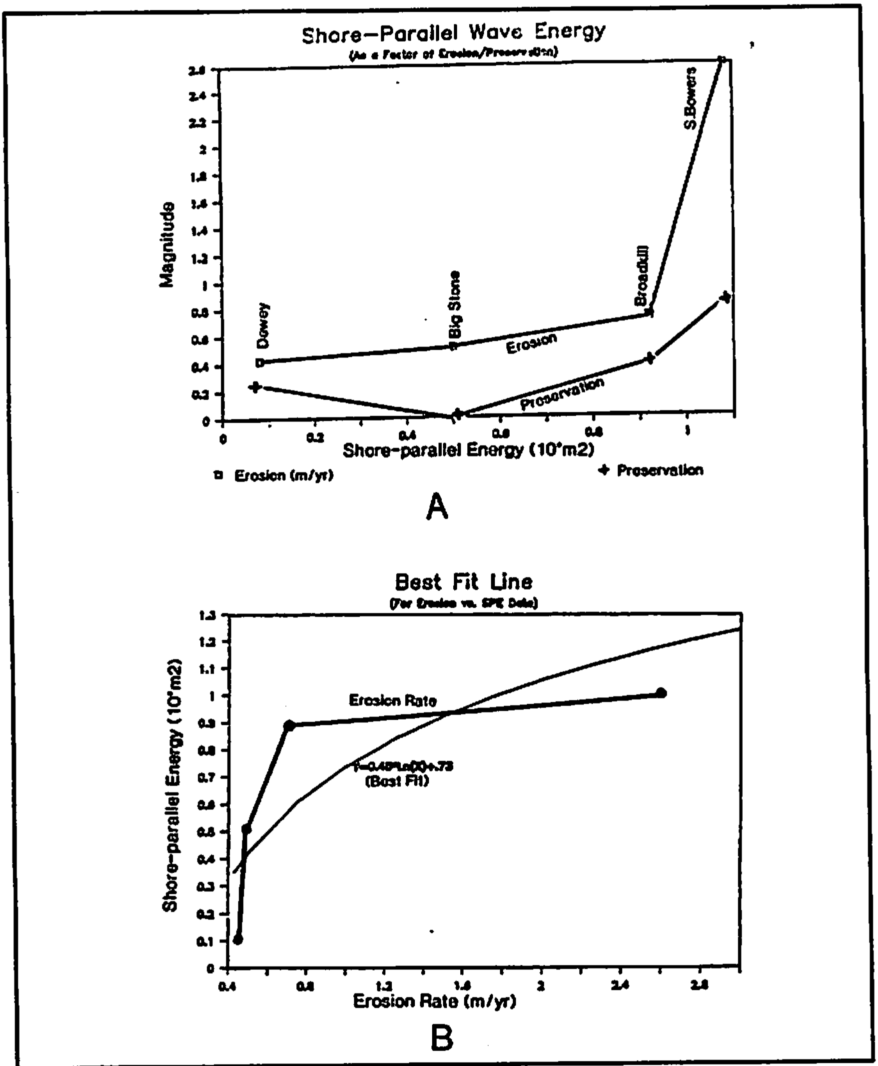

Figure 3. *A:* Graph showing relationships between coastal erosion rates and preservation potential as a function of shore-parallel wave energy. *B:* Graph showing relationship between coastal erosion rates and shore-parallel wave energy (SPE). A logarithmic relationship exists between the parameters with the best-fit logarithmic line $Y = 0.45 * Ln(X) + 0.73$.

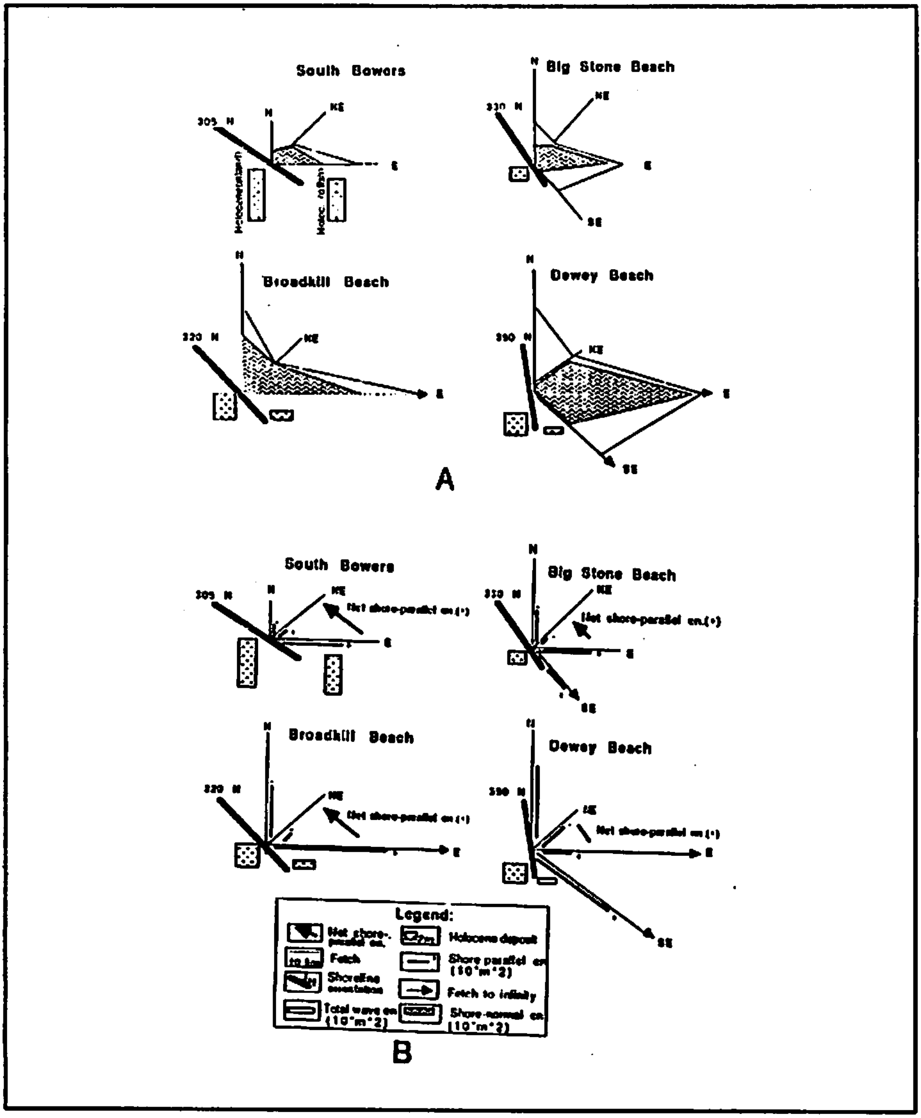

Figure 4. *A:* Rose diagram showing distribution of directional fetches, total wave energy, and shore-normal wave energy components for the four study areas. Preservation of marginal marine deposits for each of the study locations is also shown. *B:* Rose diagram showing distribution of directional shore-parallel wave energy components and net shore-parallel wave energy vectors.

Table 1. Wave-related parameters for different fetches and rate of erosion and preservation potential for four study sites. The northbound and southbound SPE are assigned a positive and negative sign respectively. The difference between positive and negative SPE is the net shore-parallel wave energy component. Abbreviations are discussed in the text.

Location	Direction	H (m)	E (m^2)	SNE (m^2)	SPE (m^2)	R (m/yr)	P (%)
South Bower	N	0.43	2.49	2.04	-1.42	2.6	0.85
	NE	0.83	4.11	4.05	0.71		
	E	1.14	14.12	8.1	11.5		
Big Stone	N	0.79	8.39	4.2	-7.26	0.52	0.0
	NE	0.90	4.91	4.74	-1.27		
	E	1.23	16.3	14.11	8.15		
	SE	0.79	5.55	1.43	5.36		
Broadkill	N	1.07	15.37	9.88	-11.77	0.73	0.4
	NE	1.15	7.91	7.88	-0.69		
	E	1.77	33.61	25.75	21.61		
Dewey	N	1.26	17.00	2.95	-16.74	0.43	0.25
	NE	1.07	12.34	10.10	-7.07		
	E	1.77	33.62	33.10	5.83		
	SE	1.44	22.36	12.82	18.82		

A MODEL FOR THE DEVELOPMENT OF A LANDOWNER'S SHORELINE MANAGEMENT PLAN: THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY EXAMPLE

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Introduction

The University of Rhode Island (URI) owns approximately 900 m (one-half mile) of waterfront on Narragansett Bay which is managed in a very relaxed, laissez-faire manner by the URI Graduate School of Oceanography (GSO). Despite Rhode Island's more than 400 miles of scenic coastline, this small area continues to attract more water enthusiasts from the general public with each passing year. The increased use has begun to create conflicts among the public users, and between public use and GSO operations. In response to these conflicts, and with concern over campus security and growing liability risks, the Dean of the Graduate School of Oceanography established an Ad Hoc Committee to review the circumstances and to make recommendations for a shoreline management plan. This situation, attempting to develop a coastal access and management protocol after extensive use by the public, is now common among private, state and federal coastal landowners. The GSO committee, despite good intentions, began by making common errors and controversial recommendations. Fortunately, with a little timely research and expanded membership, these evolved into a series of less controversial, better considered and more easily implemented recommendations. Although still in progress, the GSO experience identifies a path of information gathering, prioritization and policy-making that can serve as a general model for resolving both simpler and more complex disputes between public and private interests in shoreline access and use.

The GSO shoreline area consists of a course sand and cobble beach approximately 25m wide accessible via a town road to the waterfront, a wooden pier used by the University for small boat and ship operations, and several private boat moorings in front of the beach area (See Figure 1). Although concentrated during the summer months, the following coastal activities are enjoyed by the public regularly at the GSO: children's wading, adult swimming, kayaking, wind-surfing, scuba diving, sunbathing, volleyball, launching and mooring of small boats, and fishing (primarily recreational). GSO activities in the same areas include scientific scuba diving, maintenance and mobilization of scientific operations on various research vessels, both episodic and on-going experiments from the shore and pier, and seawater intakes and discharges for the aquarium facilities.

Conflicts include competition for space (especially for parking and between GSO operations and the fishermen on the pier), and cultural conflicts between local and immigrant (primarily non-English-speaking Asian) fishermen. Public-use impacts include fishing gear tangled in GSO mooring lines and experiments; increased attention by GSO security and maintenance in response to conflicts, vandalism, alcohol violations, unauthorized vehicles blocking emergency and operations access, schoolchildren and others playing unsupervised on the pier and among equipment stored near the beach, sanitation problems (there are no public rest rooms on the beach), public use of the lab's showers, rest rooms and vending machines, trash cleanup and damage to landscaping. More specifically, the summer GSO beach attendance has risen to 20 to 100 people weekdays, and 50 to 200 on weekends. In one instance, over 90 fishermen were trying to casts their lines from the approximately 100-foot-long pier. Grounds staff spend 30-60 minutes per day cleaning up the beach and pier after the public. Campus security responds almost daily to some incident on the shore or pier during the warmer months.

The Ad Hoc Committee on Public Use of the GSO Shoreline and Pier consisted of the following GSO personnel: marine superintendent (chair), director of security and operations, dean's office representative, chair of the landscaping committee, aquarium operations supervisor, head of maintenance, university legal counsel, a faculty representative and a graduate student representative. The predominance of GSO facilities interests was intentional in that these were the groups most affected by the public use and would eventually be responsible for handling the impacts. After assessing the extent of utilization and impacts of the public use of the shore, the committee was mandated by the dean to determine the legal ramifications of the situation under status quo laissez-faire management and under other recommended management policies, attempting to maintain public access if possible. In a memo to the Ad Hoc Committee date July 30,1991, Dean Duce wrote, "We have always maintained that these facilities are open to the public, and indeed this has been a very positive side of our public relations effort with people in the local area. This is important and we want to maintain this as much as possible."

At the committee's first meeting the overwhelming consensus (with the sole dissent coming from the student representative) was that marine operations and public use of the pier area were incompatible. There was a strong sense that increasing public access would threaten GSO's "peace and charm." The committee recommended that pier access by the public be totally eliminated, and a fenced area be constructed surrounding and isolating the pier and adjacent upland from public access. Although controversial, the committee felt the liability risk and conflicts warranted drastic measures, and that the University had the preeminence and legal grounds to withstand the public dissent of an unpopular policy. The legal counsel's advise included that restrictions be phased-in since the public may have some rights to access due to "historic use and adverse possession." Other recommendations considered included deeding the beach area to the Town in order to remove management and liability responsibilities from GSO. Further discussion of the beach area was postponed until the second meeting, as the committee felt it needed more information before continuing, particularly on the legal aspects of public access.

The subsequent process of information gathering at this point was the key to successfully identifying errors in these early recommendations and to determining additional constraints that prevented creation of further bad policy recommendations. Although closure of the pier to the public was consistent with increased ease and safety of marine operations at GSO, analysis of the full facts made it very clear that non-facilities perspectives needed to be included in prioritizing use of the GSO shoreline in order to avoid other forms of legal jeopardy and a public relations fiasco. The following section outlines five legal aspects of shoreline management that were reviewed in this case and are applicable to many similar situations. The next section outlines the perspectives of five major public and private interest groups investigated in this case; these could serve as example reference sources for other public/private conflict resolution cases. The section after that summarizes the actions and recommendations of the GSO Ad Hoc Committee, and the final section presents suggestions for applying this model to other instances of public/private interest conflicts and the development of shoreline management policies.

Legal Aspects

Several legal facts need to be determined and considered before any effective policy or management plan can be designed or implemented. These include the laws regarding landowner liability, public access rights to private and public areas, the definition of mean high water, land title restrictions, and the responsibilities of the landowner.

Liability. Landlord liability laws are generally defined by the state and interpreted by its courts. Unimproved property (e.g., a beach) usually generates less liability than improved property (e.g., a pier). Court decisions on cases with similar characteristics can indicate the level of liability risk for the landowner. For instance, a recent R.I. case supports a landowner's rights to operate a functional dock (without numerous safety barricades) (*Banks v. Bowen's Landing Corp*, 1987). Some states have Landowner Liability Laws; if a landowner dedicates a public right-of-way and access over his/her private property, these laws remove liability from the landowner, and vest it in the state who is traditionally free from suit under the doctrine of Sovereign Immunity. GSO properties are owned by the URI board of governors, not by the state per se, and therefore are not immune from liability suits at this time. In Rhode Island, such a law exists for wooded trails, and although recommended to be extended for coastal access, has not yet been amended by the legislature (Rhode Island, 1989). It is not clear, whether an amended Landowner Liability Law would release the landowner over developed parts of their property opened to the public.

Access. There are three principal doctrines that define the public's rights to access coastal lands in all states: the Public Trust Doctrine, easement by prescription, and dedication (Kalo, 1990). Coastal and submerged lands from the Mean High Water Line (MHWL) to the three-mile limit are given to the state in trust for the public to use. In Rhode Island the rights reserved for the public along the shore and over Public Trust Lands are described by the R.I. Constitution and include "fishing from the shore, gathering seaweed, leaving from the shore to swim in the sea, and passing along the shore" (Nixon, 1990). In 1971, the Rhode Island Coastal Resources Management Council (CRMC) was given the authority to manage Rhode Island's Public Trust lands. CRMC, therefore, has jurisdiction over the submerged public trust lands upon which the GSO pier rests.

Easement by prescription occurs when the public use is "open, notorious and adverse," (*Seaway Company v. Attorney General*, 1964) continuous (i.e., not seasonal), without permission or challenge by the landowner, and (in Rhode Island) for 10 years or more. At GSO, the public has been given permission to use the shoreline and pier, and since the pier is closed to the public during ship mobilization, there is no easement by prescription. Public access to upland beaches and the piers is more often governed by the doctrine of dedication which may provide the public with access once an intent, implied or expressed, is shown by the owner to allow public use (Kalo, 1990). In the GSO case, there is clear evidence (e.g. the dean's mandate to the Ad Hoc Committee) that there has been an intent to dedicate use to the public whenever possible.

Mean High Water Line (MHWL) and Riparian Rights. The legal definition of the MHWL, which defines the shoreward extent of the Public Trust Lands, was established by a U.S. Supreme Court decision as the U.S. Coast and Geodetic Survey's definition of the average height of all the high waters over the astronomical cycle of 18.6 years (the meteoric cycle) (*Borox Consolidated Ltd. v. City of Los Angeles*, 1935). As this is a dynamic boundary and not readily identifiable by the casual observer, several states have modified their definition (e.g. "vegetation line" or "dry sand"). Rhode Island has supported the 18.6 year definition (*State v. Ibbison*, 1982), and more recently chose to leave the term "shore" undefined in the state constitution but to included the four privileges of the shore described above (Nixon, 1990). Lands above the MHWL belong to the riparian or coastal landowner whose rights vary between states, but usually include the right to fill and to wharf out from the shoreline (Nixon, 1990). These rights have diminished significantly in recent years, and in Rhode Island the only riparian "rights" that remain include the right to apply for permits from the CRMC for improvements or alterations along the coast.

Title Histories of the Coastal Property. Often there are restrictions that limit a property's use put on a property deed when it is transferred. For this reason, the recent title histories of URI's GSO seven coastal parcels were researched, resulting in the identification of several small exclusions, easements and conditions of use. These included restricted use of two parcels for research or educational purposes only, evidence for implied dedication of another ("as now used in common by his grantees and the general public"), federal uranium mining rights on another, permanent rights of access across a parcel for the land donor and his heirs, etc. Most importantly, it became clear that the town road (South Ferry Road) is a public right-of-way and public road down to the high water mark. This implies that GSO has no rights other than those accorded to the general public in the approximately 50-foot-wide stretch of the road and shoreline.

Responsibilities of the Landowner. A landowner has a responsibility to manage all of his or her property. This includes making a reasonable effort to foresee reasonable activities on the property (*B. Mariorenzi v. J. DiPonte*, 1975), maintaining it accordingly, and controlling activities on the property. In addition, the landowner is responsible for enforcing the regulations for public access without prejudice (i.e., off-duty GSO personnel would be bound equally by the restrictions). Although specific constraints vary by state practice, generally, periodic enforcement of closures of the pier or beach uplands and of the posted regulations must be maintained for property not to become dedicated to the public.

Private and Public Interests in the GSO Shore

Several coastal interests and/or agencies had helpful information and insights on many issues concerning the GSO shoreline; in some cases these groups, either as allies or as adversaries, would play a key role in the overall design, approval and execution of the management plan. At least five interest groups should be contacted for input into a public/private coastal access management plan: the state Coastal Zone Management Act authority and other related state land/water use agencies; the town or city planner; the landowner's own user groups;

non-governmental and volunteer coastal organizations; and coastal recreational interest groups (boaters, fishermen). Consideration of these perspectives and suggestions before designing policy could result in a stronger plan, with many of the potential conflicts being resolved before implementation of a shoreline management plan.

State and Coastal Land Use Agencies. Most coastal states have agencies that have jurisdiction over shoreline and coastal issues. The CRMC is the Rhode Island state agency delegated to execute the Coastal Zone Management Plan and is the protector of the Public Trust in regards to the coasts, state waters and submerged lands. CRMC's assistance and guidance on what would or would not be acceptable restrictions at GSO was so valuable that a CRMC representative was formally added to the GSO Ad Hoc Committee. This was a significant development, as it was the first time CRMC was able to join in the early planning stages of a private entity's shoreline management process. Another state agency, the Rhode Island Department of Environmental Management (DEM), also had input for GSO. They handle the practical aspects of access, including marking the rights-of-way to sites, and surveying the shoreline for state properties that could support recreation and access. GSO's site and aquarium discharges were evaluated by DEM and considered to be non-hazardous and compatible with public access. DEM also provides small grants to municipalities to assist in improving public access. Most importantly, their guidelines on the state's mandate to open more state-owned land to public access implied that on this issue GSO did not have preeminence over the public, as the Ad Hoc Committee had originally predicted. A third state entity, the Rhode Island Attorney General's office, was also asked to comment on GSO's options for access limitations.

Town or City Planner. Most coastal towns have a harbor planning or management commission that oversees local coastal activities. In the case of GSO, the town Harbor Commission is responsible for the control and operation of South Ferry Road down to the MHWL, as well as the moorings, and the beach areas beneath MHWL (i.e., between the high and low tidal levels). The Town Planner was supportive of some restricted access to the GSO pier and shore as it would reduce the number of GSO incidents to which the town police would have to respond. He was very negative about the possibility of the town accepting the ownership or management of the GSO shoreline area as their resources were already oversubscribed.

Landowner User Groups. Naturally, the interests of the landowner will be well represented in planning the management protocol, however at least three aspects should be examined in order to maximize the policy benefits. First, the landowner's activities and methods should be reviewed to determine better and/or alternative ways of accomplishing and of funding the stated goals. Flexibility and creativity can often resolve major conflicts. Second, the objectives and interests of the landowner's immediate neighbors should be considered, such as the National Oceanic and Atmospheric Administration and Environmental Protection Agency labs near GSO. Conferring with neighbors can add resources and good will to any resulting policies. Third, similar case histories should be reviewed in order to learn how other landowners resolved (or failed to resolve) their conflicts and coastal problems. In this example, the marine superintendents at Scripps and Woods Hole Oceanographic Institutions were contacted to discuss their situations and policies.

Non-Governmental and Volunteer Organizations. There are many non-governmental and volunteer groups that support certain academic, preservation and stewardship activities along the shoreline. These groups can often provide assistance with funding of small projects, annual beach clean-up programs, public awareness and information to the landowner. The URI Coastal Resources Center has a list of all the coastal volunteer organizations, and publishes a statewide list of descriptions of beaches and coastal access which could include guidelines from the landowner about various restrictions. Some of these groups might also represent a landowner's adversary in a suit for public access, and it is worthwhile to understand their concerns in order to determine if a policy could be adjusted in order to achieve the goals of both parties.

Recreational Fishermen and Boaters. Recreational interests have grown in importance in the coastal zone, and simply can not be ignored. It has been estimated that there are 250-550 thousand recreational anglers in Rhode Island, many of whom fish from the shore or from artificial structures (jetties, piers, etc.) (*Environmental Impact Assessment*, 1988). They were instrumental in getting a local bridge converted, with funding, into a public fishing pier. Other well-financed and organized interest groups include the recreational boaters. Despite the obvious conflicts between these groups and the coastal landowner, they are often willing to contribute time and money to maintain and enhance local facilities. At GSO, the local sailboard association has volunteered to install a low fence to keep vehicles off the grass near an area used by the wind-surfers to handle their equipment. This is a win-win situation and leads to shared community interests instead of antagonism.

Recommendations of the GSO Committee

After assimilation of the research results by the committee, it was clear that its original understandings, priorities and recommendations were naive, possibly illegal, and doomed to failure during implementation. The scope of the complexities and the conflicts, although better identified and constrained by this information, was beyond the policy backgrounds or authority of the facilities-oriented committee. It was decided to present the dean, university president and legal counsel with a range of policy options for the management of the GSO shoreline in general, and for the divergent public access spectrum of total closure to open access for each geographical area (the boat mooring area, the beach and the pier). Each option would identify the constraints and possible ramifications of the policy. This would give the decision makers, who must also consider other factors (such as budgetary constraints, the risk of lawsuits, public image and relations during the university's centennial celebration, and the "mission" of the university) the best available information on which to base their decisions, and some degree of flexibility as circumstances changed.

General Recommendations. The Coastal Resources Management Council is clearly the most powerful entity whose approval would be required on any GSO shoreline management plan. They expressed concerns that the GSO community not become too proprietary about resources which were located on the campus, but not strictly theirs to control. Under any public access scenario, however, the committee felt that certain minimal steps should be taken. These included clearly identifying with signs the extent of the university's property versus the town property and the guidelines for public access to the area; invoking parking restrictions necessary to preserve emergency access; and widely publishing guidelines, use restrictions (where to park, etc), and conservation ethics to the public and user groups who visited the property. In addition, every effort should be made to get the landowner liability laws extended to include coastal access.

Moorings. The town controls all aspects of this area of responsibility. GSO's only duty or concern is to inform the town harbor planning commission of any operational constraints that might limit the number or location of moorings off the shore of South Ferry Road (e.g., ship operations, research experiment sites), and to act as a good neighbor to the boat owners during storms, etc.

Beach and Shoreline. Since the town road provides public access to the GSO shore, the beach area has almost certainly been dedicated for public access through memoranda and property title easements, and the state's political environment favors public access over state and private property ownership, it seems clear that public access and use of the GSO beach is assured indefinitely. No obstruction could be erected along the shore that would impede the four privileges of the shore listed in the state constitution. The university could still significantly impede or enhance the access and facilities along the GSO shore, so the committee presented three policy options (with specific logistical details omitted here) which represented a spectrum of management and access to the shore and beach area. They were: (1) maintaining the present level of support, parking and services resulting in a similar level of public attendance and impacts; (2) reducing the level of support and access by limiting parking, establishing a curfew, etc., resulting in lower attendance and fewer impacts; and (3) enhancing access and services (increased parking, rest rooms, nature trails), resulting in increased attendance and impacts. Naturally, the cost of the support effort is directly related to the level of attendance and good will of the public, a choice that ultimately, the dean and URI president must make.

GSO Pier. The presence of the GSO pier on public trust lands, the moderate level of operational activity at the pier (fewer than 150 days per year), the possibility of implied dedication of the facility, and the strength of the recreational fishermen's interest groups lead the CRMC representative to suggest that complete closure of the pier to the public would not be approved at this time, although reasonable restrictions related to operations would be acceptable. The committee developed a range of policy options and ramifications for access to the pier, including in all cases a fenced staging area on the pier upland area and a gate across the pier at some point which could be closed when needed for security or operations. The three policy options were (1) access open to the entire pier except during ships operations, resulting in the least public dissent and the greatest nuisance impacts; (2) access limited to the pier shoreward of the gate at all times, with closure of the entire pier during ship operations, resulting in some dissent but fewer impacts; and (3) closure to the public of the entire pier at all times, resulting in a struggle with CRMC, a possible lawsuit by the fishermen, but increased GSO operational ease.

The GSO coast, albeit small, represents a complex area of conflicting interests and rights. Due to early information-gathering efforts and the inclusion of the perspectives of outside interests and regulators, a controversial, probably illegal policy with the associated public relations nightmare was avoided. In its place, a range of sound, well-researched policy options have been presented to the decision makers. Based upon the recent surge in public access advocacy, budget constraints, the university's centennial year celebrations and GSO's marine educational mission, it is probable that the public access policy at GSO will remain as favorable to the public as possible, implementing for now only minimal alterations or restrictions. Despite the fact that minimal restrictions in access provide only minimal improvement for operational staff, through discussions, this process has generated greater tolerance and understanding towards public access and other interests. The worst possible scenario would be to implement a URI/GSO policy for enhanced public access without allocating the necessary resources to manage the situation.

Conclusions and Model Implications

This paper follows one pathway towards the development of a well-informed set of recommendations for the public access management of a popular, privately owned shoreline area. The extent of the information-gathering and liaison work with outside interests was not burdensome—each committee member contributed within their expertise and through their contacts; the graduate student representative (and author) researched the balance of inputs. This early effort proved well worthwhile in identifying sensitive issues and negative outcomes before significant time or momentum was lost, and while opportunity remained for incorporating modifications in the policy.

Information that should be reviewed in developing a shoreline management plan include five legal aspects (landowner liability, public access, mean high water line definition, title history restrictions and the responsibilities of the riparian landowner); the perspectives and constraints of at least five general interest groups (state coastal authorities, town or city planner, landowner user groups, non-governmental and volunteer coastal organizations, and recreational interests); and finally the priorities, financial limitations and public relations ramifications of these factors to the overall objectives of the landowner and coastal area in question. The committee membership should extend beyond the members of the landowner's facilities staff, consisting of representatives of those who must execute and implement the policy, as well as those who have regulatory jurisdiction in the area, those who are responsible for making the broader institutional-wide policy decisions, and perhaps even those who have conflicting interests from the landowner.

The model just described has some resemblance to the greatly maligned "synoptic" or "scientific" policy-making process, but should provide greater success. Due to the small scale research effort implemented here, (simply identifying conflicting perspectives and focussing on key constraints,) better policy formulation, whether incremental or sweeping in nature, can result. By incorporating several perspectives at an early stage, landowners can reduce the level of conflict between public and private interests, which leads to better understanding, tolerance and amenity among user groups.

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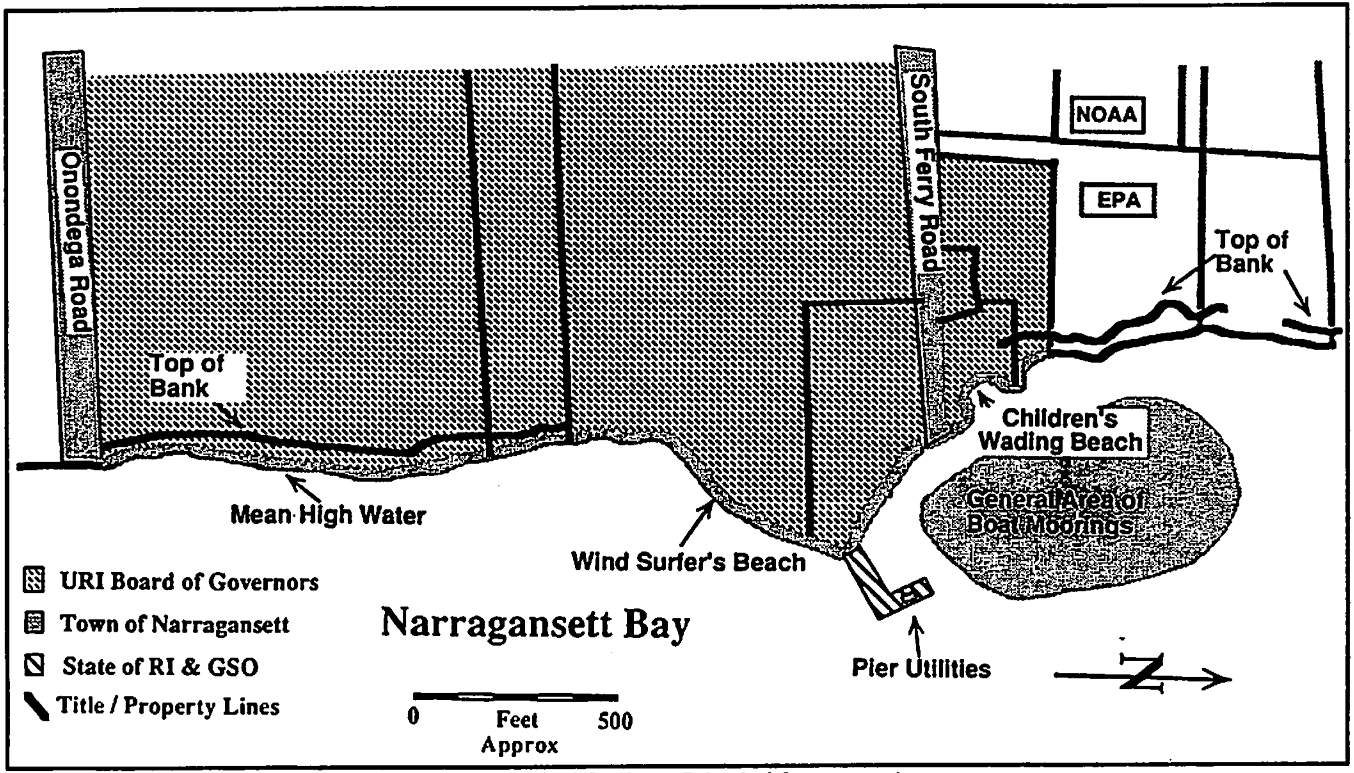

Figure 1. Coastal property of the University of Rhode Island Graduate School of Oceanography.

Marine Education

THE AQUARIUM PHENOMENON: THE CHANGING ROLE OF MARINE AQUARIA IN THE URBAN WATERFRONT ENVIRONMENT

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Abstract

The primary role of marine aquaria in urban waterfront environments has evolved from being a catalyst in the revitalization process to being a marine resource. In developing a plan for waterfront revitalization, many municipalities sought to include a large marine aquarium. City planning departments were primarily interested in the ability of such facilities to draw both local citizens and visitors to the waterfront area. As a consequence, it was believed that the public would become more aware of and patronize adjacent businesses.

Today's aquaria are being built with greater emphasis on their educational value instead of an expectation of economic salvation of waterfront areas. Indeed, many facilities are being built or planned in landlocked locations. Most modern aquaria offer a wide range of research and marine educational programs. Additional benefits provided by these facilities include their new emphasis on local ecosystems, including coastal and upland areas; the knowledge gained through their research efforts; and the new hope for endangered species achieved through their breeding and conservation efforts.

Introduction

Urban waterfront areas have undergone a continuous pattern of changing uses and recycled space. The first episode of recycling appeared in the wake of the "container revolution" for cargo transported by ships. Large tracts of waterfront property were redeveloped for non-water-related uses, such as raised highways, airports and parking areas. This trend continued until public outcry in the 1970s resulted in efforts to clean up the waterfront areas, making them safe and accessible to the public for recreational uses. These efforts, known as the waterfront revitalization movement, were characterized by renewed interest in productive and attractive uses for the urban waterfront.

Today's waterfronts are still participating in this revitalization movement. Greater attention is being paid to water-dependent and water-enhanced uses, with priority being given to the former due to the limited space available in the now extremely popular urban waterfront areas. The concept of mixed-use areas (containing light industry, residential, retail and recreational areas within a relatively small space), has become the waterfront planning method of choice. Beneficial tax climates and the plethora of historic structures available for adaptation to new uses have led to a trend of retaining the historic flavor of the waterfront districts while returning them to a productive status within the city.

Out of these fertile circumstances, the aquarium phenomenon emerged. Many cities became interested in the potential benefits associated with the addition of a public aquarium. It was widely believed that the inclusion of aquaria as anchor facilities in revitalization plans would increase tourism, obtain recreational and educational opportunities for nearby communities, and encourage local business to re-invest in the city's waterfront area. Aquaria were expected to draw both residents and tourists to the waterfront area, providing potential customers to adjacent businesses. The value of the facility would be as a catalyst—they were not expected to produce money but were meant to draw people to an area where they would be provided the opportunity to spend money. The success of this plan depended upon each aquarium's sustaining a high level of public interest. In response to this challenge, aquaria moved beyond simple entertainment goals, evolving into a public service role far beyond that envisioned by city planning departments.

Historical Perspective

The use of an aquarium in waterfront revitalization became quite popular following a series of remarkable success stories. The New England Aquarium, which opened in 1969 on the Boston waterfront, was the first. Taking advantage of new technology and knowledge about marine species, this facility was a novelty and drew record crowds. The success of the New England Aquarium was remarkable enough to draw interest by itself, but the subsequent development of the Quincy Marketplace near Faneuil Hall resulted in a partnership that was even more interesting to city planning departments. The aquarium provided a destination for tourists and residents who then, by virtue of being nearby, spent more time (and money) in the adjacent shops and restaurants.

The success of this combination on the Boston waterfront influenced the decision to build the National Aquarium at Baltimore. This aquarium is a sister facility to the New England Aquarium and echoes many of its features, most notably the large central tank and temporary exhibit space. The Baltimore Aquarium is also paired with an adjacent commercial area. When Baltimore's Inner Harbor Project also became an economic and social success, the aquarium boom was almost inevitable. City planners could, and did, justify the inclusion of an aquarium in their waterfront development plans by virtue of their potential value in creating tourist appeal, especially when combined with a marketplace. By the mid-1980s aquaria were expected to help rejuvenate the urban waterfronts. They were essential elements in many revitalization plans.

The classic example of how aquaria were viewed and designed during this period is seen in the Monterey Bay Aquarium. The waterfront revitalization effort in Monterey, along Cannery Row, involved the adaptation of existing abandoned buildings to the familiar aquarium/marketplace plan. The Monterey Bay Aquarium was built on the former site of Cannery Row's largest cannery. The building was designed to preserve the historic flavor of Cannery Row, and the exterior is a faithful reproduction of the Hovden Cannery that inspired it. Inside the aquarium, visitors can see old boilers and a pumphouse, which were restored for display. Other canneries along Cannery Row have been adapted by local business for retail use, taking advantage of the popularity of the aquarium. The area appears almost exactly as it did to John Steinbeck when it inspired his book *Cannery Row*. Today however, the air smells of the sea rather than of sardines, and the streets and shops are crowded with people coming to enjoy the view and visit the aquarium.

By 1986, the aquarium phenomenon was in full swing. Kashdan (1986) reports that as many as 30 cities were in various stages of planning aquarium installations. By 1990, however, the economic role of aquaria had been more thoroughly analyzed. City planners began to understand that circumstances and location were also vital elements in developing a successful revitalization project. While there were no examples of spectacular failures, it became clear that not every city could support the construction and maintenance of an expensive aquarium. In addition, there was no guarantee that an aquarium could save every waterfront. In order for an aquarium to succeed, it had to focus on educational and entertainment goals, and it needed to be special. In efforts to be unique and to appeal to local communities, many newer aquariums have been designed around local species and ecosystems. While many of the earliest facilities took advantage of the public's love of marine mammals, later facilities have found that this approach was not really necessary. Exhibits of upland and coastal areas, such as wetlands, swamps, bogs, rivers, estuaries and even lakes, have been created inside aquaria located near these types of ecosystems. Monterey Bay Aquarium began this trend by presenting visitors with recreations of plant and animal communities of Monterey Bay. The Aquarium of the Americas in New Orleans features the Mississippi River Delta, emphasizing the losses of the Louisiana marshlands. The opening of facilities at Chattanooga and Charleston continued the message. The Tennessee Aquarium will depict the course of the Tennessee River from its Appalachian beginnings through rivers and lakes until it empties at the Mississippi Delta into the Gulf of Mexico. The South Carolina Aquarium will contain exhibits devoted to river, swamp and marsh-estuary systems. Ironically, the trend toward emphasizing local ecosystems has highlighted the interdependencies of all marine ecosystems. Public aquaria are passing this information on to their visitors.

Many facilities are also getting involved in projects involving local wild animal populations. The New England Aquarium implemented a stranded animal rescue program for marine mammals that responds to the frequent whale strandings on Cape Cod. This program has grown into a network that involves all the facilities on the East Coast and has provided most of the physiological data used in developing medical treatment for captive cetaceans. Similarly, research projects that increase the success rate of maintaining specific animals in captivity provide information for wild population management programs. Breeding programs, originally intended to decrease the need to capture additional animals, may lead to re-stocking projects releasing endangered animals back into the wild.

Perhaps the expanded role of modern aquaria can explain the interest that so many communities have in building one of their own. Kagan (1990) estimates that 30 to 70 cities are planning to construct aquaria. Indeed, the trend seems to have grown into a global phenomenon, with large aquaria located in or planned for Japan, Taiwan, France, Monaco, Mexico, China, Canada, Bermuda, New Zealand, Australia and Scotland. This is not by any means an exhaustive list, it is merely meant to illustrate how widespread the phenomenon has become. Table 1 contains a list of the opening dates of aquariums in the United States. The table is followed by a map that shows the location of each facility. Note that the earliest facilities are all located near the coast, while later facilities are located further inland.

Inside a Modern Aquarium

What is it that makes these new aquaria so irresistible to the public? Modern aquaria have abandoned the old idea of displaying one or two species in small tanks. Simplistic displays lined up like paintings in an art gallery have become obsolete. Advances in acrylic technology allow construction of large tanks, while innovative habitat fabrication methods and increased experience with marine species make it possible to develop realistic recreations of natural settings. The impression a visitor receives on the initial visit is carefully designed and created with the educational as well as recreational value in mind. Every detail, from tank size or style to interpretive and interactive elements, are geared to present the visitor with information. Even the gift stores have an educational orientation. Other innovations include the use of temporary exhibits that are changed periodically, the use of interactive elements within displays, and an active interest in providing research and educational opportunities to as many people as possible. Modern aquaria, well aware that the public possesses high levels of general knowledge (due to television or magazine exposure), aim to provide access to unusual species and more obscure facts.

The New England Aquarium was the first example of this new "modern aquarium" genre. The Great Tank at the New England Aquarium contains a spectacular coral reef display complete with sharks, sea turtles, moray eels, several different species of fish, and, at feeding time, even a scuba diver or two. The 24-foot-high exhibit is viewed from a spiral walkway surrounding the tank, allowing visitors to see the reef at different depths and from different angles. At the Aquarium of the Americas visitors walk through an acrylic tunnel surrounded by a Caribbean coral reef. The Monterey Bay Aquarium presents a live kelp forest and attending animals seen through acrylic panels big enough to do justice to a 28-foot-high, 66-foot-wide tank, the tallest in the country. The Vancouver Aquarium offers spectacular underwater views of killer and beluga whales in naturalistic habitats. Most new aquaria boast at least one large tank, and some facilities use this exhibit as a signature display, providing a focal point for their theme.

The sizes of these exhibits are impressive, but their real value lies in their realism. Larger tanks allow these facilities to maintain mixed animal and plant species in a single tank. Aquaria are now able to give visitors and scientists a view of marine communities that is surpassed only by putting on scuba gear and getting wet. The message is even more powerful when the exhibit depicts a local marine system. Interpretation of native habitats encourages both the tourist and the resident to develop an even greater appreciation of their surroundings. Local teachers and school children may benefit from these exhibits by participating in field trips to the aquarium, where these displays are enhanced by aquarium-provided educational packets and curriculum guides.

An aquarium's interpretive efforts are as important as the exhibits to successful education of visitors. Interpretive elements must be appealing, memorable and readily available in order to be effective. Tilden (1957) provides a comprehensive discussion of traditional techniques. Classic examples are signs placed on or near exhibits giving information about the animals or plants on display, and providing volunteers to answer questions. Advances in technology allow modern facilities to add elements such as videos showing rarer behaviors, or other species with an important relationship to the displayed animals. Some videos even show the environment from the perspective of the animal being displayed. These are all valuable in obtaining greater understanding of the animal on exhibit and would be difficult or impossible to convey in any other way. External elements, such as lighting, sound tracks and even the introduction of appropriate smells, are used to help the visitor better understand the animal and its environment. A major difference seen in the approach to interpretation taken by modern aquaria is their willingness to be more aggressive in their attempts to influence attitudes and behavior, steering visitors towards a conservationist point of view. Interpretation has evolved beyond the mere presentation of facts. Boyle (1989) states that aquaria have an obligation to use interpretive elements that challenge the visitor to take an active role in protecting the environment, and then provide information on how to do so.

The use of interactive displays is also becoming quite popular. Jenkins (1985) provides an excellent review of interactive displays in use at zoos and aquariums. Graphics inviting visitors to compare themselves to the animals, exhibit features that can be directly manipulated by visitors (who then observe the results directly), and three-dimensional depictions of footprints or outlines of animals used to make souvenir rubbings are a few examples. More high-tech examples are computer-based systems that ask and answer questions, and the very successful Live Link exhibit at the Monterey Bay Aquarium. Live Link is a real-time live video from a remotely operated deep-sea camera that is transmitted directly into the aquarium's auditorium. The live video is complemented by a video encyclopedia on a laser disk controlled from the lecturn. The aquarium provides a guide who can switch between live and video segments or still pictures from the disk. The guide is also given textual data on a computer screen to assist him or her in interpreting the pictures stored on the disk.

One of the most important educational features of an aquarium is its gift store. Here the aquarium has the opportunity to offer take-home messages. Books and publications offer more in-depth information than is possible to convey through the interpretive activities of the aquarium; stuffed animals can be used to prolong feelings of closeness to animals enjoyed by children during their visit; and posters or T-shirts may provide lasting impressions that appeal to teenagers.

For anyone fortunate enough to live near an aquarium, multiple opportunities for marine education become available. Many aquaria offer educational programs to the general public. These may include formal programs, requiring a fee or advance registration; informal, walk-in programs; off-site programs; or special one-time events in celebration of environmental or conservational events such as Earth Day or Arbor Day. Some aquaria offer teacher training or curriculum guides for marine-related topics. They may offer college-level classes for credit in cooperation with nearby academic institutions. Internship and research opportunities may also be available. Age-appropriate workshops, field trips, conservation programs and lectures on marine topics have all been offered. A few facilities have taken to the road with mobile animal shows, bringing their message to people unable to visit the aquarium. These aquaria seem determined to bring new information to as many people as possible by whatever means they can.

The specific programs offered will vary according to the priority given to these programs by each institution. The author is involved in a study designed to measure the level of effort seen within each facility to undertake research projects and provide educational programs. This research should provide information on the specific educational programs offered by these facilities as well.

Discussion and Conclusions

Aquaria continue to appeal to city planners because they offer recreational and educational opportunities to residents and have strong tourism potential. The primary value these facilities serve in economic terms is their ability to draw visitors to an area. In order to take advantage of the catalytic nature of these facilities, they must be located close to a marketplace or commercially oriented district with easy access to related food and hotel services. A large aquarium, with strong drawing power, can be a significant addition to a waterfront revitalization plan, but in order for such a plan to succeed, the aquarium must continue to draw crowds over long periods of time. Getting the surrounding community actively interested in the continued success of the facility is also vitally important.

Considering the limitations inherent in the economic role played by an aquarium, and the expense of building and maintaining this type of facility, the ongoing interest shown by cities must be based on additional benefits associated with a public aquarium. If one accepts the idea of an aquarium as a coastal resource, its popularity becomes more understandable. An aquarium can present scientifically accurate recreations of natural ecosystems and interpret these exhibits in a manner that gets the observer personally involved. These facilities provide opportunities for marine education, vocational training and scientific research. They can interpret local ecosystems and encourage responsible use of marine resources. They are equipped to take an active role in the welfare of wild populations, including rehabilitation, conservation and breeding programs. In effect, an aquarium serves a public interest role that is not easily provided through any other means. Best of all, they encourage everyone to get involved.

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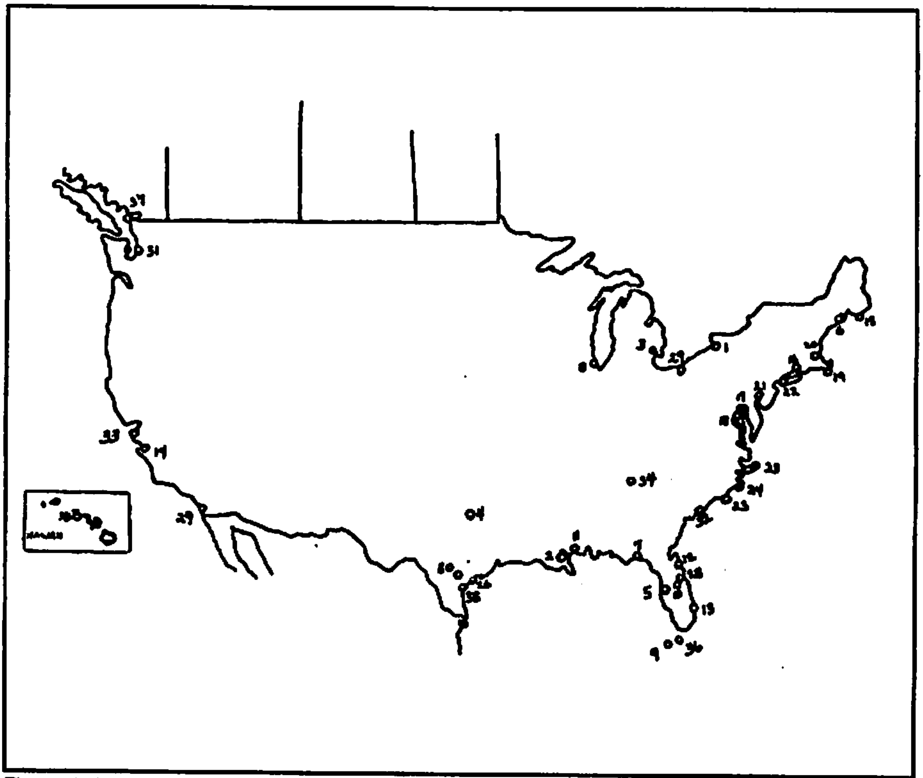

Figure 1. Locations of major U.S. aquaria. Please refer to Table 1 for locations and opening dates.

Table 1. Major U.S. aquarium locations and opening dates. Numbers refer to the map in Figure 1.

	Facility	Location Date
1	Aquarium of Niagara Falls	Niagara Falls, N.Y.1965
2	Aquarium of the Americas	New Orleans 1990
3	Belle Isle Zoo and Aquarium	Royal Oak, Mich.1904
4	Dallas Aquarium	Dallas1936
5	Florida Aquarium Inc.	Tampa, Fla.1993
6	Gulf of Maine Aquarium	Portland, Me.1993
7	Gulfarium	Fort Walton Beach, Fla.1955
8	John G. Shedd Aquarium	Chicago1930
9	Key West Aquarium	Key West, Fla.1934
10	Living Seas (Walt Disney)	Lake Buena Vista, Fla.1984
11	Marine Life Oceanarium	Gulfport, Miss.1956
12	Marineland of Florida	Marineland, Fla.1938
13	Miami Seaquarium	Miami, Fla.1955
14	Monterey Bay Aquarium	Monterey, Calif.1984
15	Mount Desert Oceanarium	Southwest Harbor, Maine1972
16	Mystic Marinelife Aquarium	Mystic, Conn.1973
17	National Aquarium in Baltimore	Baltimore1981
18	National Aquarium	Washington, D.C.1873
19	National Marine Fisheries Service Aquarium	Woods Hole, Mass.1871
20	New England Aquarium	Boston1969
21	New Jersey State Aquarium	Philadelphia1992
22	New York Aquarium	Brooklyn, N.Y.1957
23	North Carolina Aquarium, Fort Fisher	Kure Beach, N.C.1976
24	North Carolina Aquarium, Pine Knoll Shores	Atlantic Beach, N.C.1976
25	North Carolina Aquarium, Roanoke Island	Manteo, N.C.1976
26	Sea-Arama Marine World	Galveston, Texas1965
27	Sea World of California	San Diego, Calif.1964
28	Sea World of Florida	Orlando, Fla.1973
29	Sea World of Ohio	Aurora, Ohio1970
30	Sea World of Texas	San Antonio1988
31	Seattle Aquarium	Seattle1977
32	South Carolina Aquarium	Charleston1992
33	Steinhart Aquarium	San Francisco1923
34	Tennessee Aquarium	Chattanooga, Tenn.1992
35	Texas State Aquarium	Corpus Christi, Texas1990
36	Theater of the Sea	Islamorada, Fla.1946
37	Vancouver Public Aquarium	Vancouver, B.C., Canada1956
38	Waikiki Aquarium	Honolulu1904

The Oceans, the Coasts and the Earth Summit: The United Nations Conference on Environment and Development (UNCED)

THE THREAT OF ACCELERATING SEA LEVEL RISE: THE INTERNATIONAL RESPONSE

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Abstract

This paper presents an overview of the international response that has been generated as a result of the perceived consequences of climate change induced sea level rise. The paper will examine the scientific data regarding sea level rise; the potential impacts on coastal areas; the international community's efforts to focus world attention on this problem; and the recommendations that are likely to be put forth at the upcoming U.N. Conference on Environment and Development.

Introduction

During the week of March 9-13, 1992, 114 representatives of 33 nations and 10 regional and international organizations gathered in Margarita Island, Venezuela, to formulate recommendations for addressing the worldwide threat of accelerating sea level rise. This meeting, under the auspices of the Coastal Zone Management Subgroup of the Intergovernmental Panel on Climate Change (IPCC), highlighted once more the seriousness with which many countries, particularly small island states and those with low-lying deltaic areas, view this problem. It also underscored the uniformity of opinion that more needs to be done by the international community to support sound coastal zone management planning.

Climate Change and Sea Level Rise

The IPCC First Assessment Report, issued in August 1990, provided a "best estimate" of likely worldwide mean sea level rise of 6 cm per decade over the next century under a "Business as Usual" scenario, with an uncertainty range of 3 to 10 cm per decade. This could lead to as much as a 1-meter rise in sea level by 2100. If greenhouse gases are reduced or stabilized by 2030, the level of change would still be an estimated 44 cm by 2100, because of the lag between warming in the atmosphere and its effect on the oceans. (IPCC, 1990a)
The IPCC supplement to the First Assessment Report, released in February of this year, slightly decreased estimates of the rate of global warming. This was reported at the Venezuela meeting by a representative of Working Group I. But, the figures still point in the direction of increasing sea level rise, and that presents a very real concern to many nations. To understand the context in which countries view the threat of sea level rise, it is important to review briefly the current scientific understanding regarding this subject.

Predicting global sea level is a difficult problem. While tide gauge data from around the world are one of the most useful of long time series data sets available for studying climate and global change, there is still an open question as to how reliable a global sea level trend can be determined from this record. The measurements are affected by meteorological phenomena, including the astronomical tide, changes in atmospheric pressure, wind, river discharge, ocean circulation, water density, and added water volume due to melting of ice. The measurements are also affected by land movement due to glacial rebound or subsidence. All of these phenomena produce signals larger than the estimated 1- to 2-mm-per-year estimated sea level rise signal (Parker).

To date, research points to an increase in global eustatic sea level rise, although how much will occur over the next century is still difficult to gauge. Despite this fact, however, concern has been heightened through the IPCC process and by the results of recent modeling efforts, which have produced results with ranges of 20 to 100 cm. This has produced just enough uncertainty to trigger many countries into action.

Why the Concern?

The consequences of even a 30-cm rise in sea level are considerable. While the impacts would vary from region to region and depend on the type of coastal regime, the list of problems staggers the imagination (IPCC, 1990b):

More severe storm damage and flooding;

Inundation, erosion and recession of protective barrier beaches and shorelines;

Destruction or drowning of coral reefs and atolls;

Disappearance or redistribution of wetlands;

Increased salinity of rivers, bays and estuaries;

Reductions in biological diversity;

Wildlife extinctions;

Loss of beaches, lowlands and spits;

Loss of coastal structures, both natural and man-made; and

Changes in biophysical and biochemical properties of the coastal zone.

The coastal zones of the world are fragile environments that are vital to sustaining life. For many countries the consequences of any such impacts would be devastating both environmentally and economically. But, the ultimate consequence for some could be total inundation, as might well be the case for many small island states and inhabited coral atolls. In the end it is the human and social dimension that draws one to this problem and the effects are dramatic. More than 60 percent of the world's population resides along the coast; 300 million people live in highly vulnerable low-lying coral atolls, islands, or deltaic areas, with 100 million within reach of a 1-meter rise in sea level. As populations and development continue to grow in coastal areas, accelerated sea level rise will exacerbate threats to life, property, and natural resources.

The IPCC Process: Working Group III

IPCC Working Group III, the Response Strategies Working Group, was created in 1988 and quickly divided into four subgroups: Energy and Industry, Agriculture and Forestry, Resource Use Management, and Coastal Zone Management. The Coastal Zone Management Subgroup (CZMS) had the task to provide information and recommendations on coastal zone management strategies for the next 10 to 20 years and long-term policies dealing with adaptation to climate change and sea level rise.

Under the direction of the chairs, The Netherlands and New Zealand, with substantial support from Australia and the United States, two international workshops were conducted in Miami, Fla. (November 1989) and in Perth, Western Australia (February 1990). Representatives from nearly 70 countries, including 50 developing countries attended these workshops. Each workshop produced a report along with recommendations. These in turn were consolidated into a major CZMS report entitled: *Strategies for Adaptation to Sea Level Rise*, which was completed in November 1990.

The CZMS report included recommendations for coastal nations to implement by 2000 comprehensive coastal zone management plans dealing with sea level rise and the other effects of climate change; identify coastal areas at risk from a 1-meter rise in sea level; and assess the implications of response measures. In their simplest terms these include:

Retreat: abandonment of the land and structures in vulnerable areas and resettlement of inhabitants;

Accommodation: continued occupancy and use of vulnerable areas through adaptive modifications; and

Protection: defense of vulnerable areas, especially population centers, economic activities and natural resources.

Each response strategy has different implications for different coastal resources and is best implemented within a framework of integrated coastal zone management. The IPCC also recognized a need to provide coastal countries, including small island nations, in the context of their socioeconomic development, technical assistance to implement these response strategies.

The work of the CZMS was spirited and had significant grassroots and developing country participation throughout the process. This not only resulted in a strong report but, also built the foundation for the work that was to follow in assessing coastal vulnerability, developing a common methodology for gathering information, and conducting specific case studies. (Carey and Mieremet, 1991)

The International Response

Sea level rise and coastal zone management are issues being considered in at least two important international forums: the Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change and the United Nations Conference on Environment and Development (UNCED).

Without waiting for a global convention on climate change or for UNCED, several member countries of the CZMS formed an ad hoc steering committee to provide technical assistance on a bilateral basis to interested developing countries. These countries include The Netherlands, Australia, the United States, France, Japan, and the United Kingdom. With subsequent strong support from the IPCC Secretariat, the group undertook three very specific tasks:

Task 1. In August 1991, a questionnaire was distributed asking coastal nations to identify the status of their efforts to address sea level rise. The results of the survey indicated that nearly 90 percent of those who responded (37 countries) expect that all or portions of their coastlines will be vulnerable to sea level rise. But, only 30 percent had conducted an impact study of sea level rise on their coastal resources and fewer than 20 percent had studied potential response options or had some form of coastal zone management plans (IPCC, 1992).

Task 2. The Netherlands and the United States cooperated in the development of a common methodology for conducting vulnerability assessments. The methodology (Table 1) provides a step-by-step process that can be used to gather relevant data on resources at risk and assist in developing appropriate response strategies. More importantly the methodology can be replicated in different countries and provide for an ability to make cross comparisons of an equivalent basis—something that was lacking in the presentations made at the Miami and Perth workshops. The common methodology includes consideration of the present sea level, a 0.3-meter, and a 1.0-meter sea level rise by 2100. These represent the low and high estimates in the 1990 IPCC First Assessment Report.

Task 3. An organized effort was made to initiate specific case studies of sea level rise, its impact, and likely response strategies focusing primarily on developing countries. The case studies were targeted to be representative of islands including atolls, deltaic areas, and continental areas with varied coastlines. While initially only 6 to 10 studies were envisioned, the response from the international community and developing countries was overwhelming. In the end almost 30 case studies were completed, many using the common methodology. Not surprisingly, many of the world's most developed countries, such as The Netherlands, France and the United States, are also conducting similar vulnerability studies.

As this process unfolded, the core group of countries developed a strong working relationship with the United Nations Environment Programme (UNEP) Office of Coastal Areas/Program Activity Center, in Nairobi, Kenya, which manages the international Regional Seas Program. UNEP has become a major supporter of the effort and is advancing the international interest in coastal zone management generally. One of the case studies sponsored by the United States involving the Marshall Islands was administered by the South Pacific Regional Environment Programme, a coordinating body of the Regional Seas Programme in the South Pacific.

Overall, the level of international interest and support for the work of the CZMS was overwhelming and well beyond what is the usual response to international coordinating efforts. In many ways this may be attributed to the fact that the participants, while representing different countries, were experts knowledgeable about their countries' coastal conditions. Representatives also included policy-level officials that are beginning to integrate this information into decisionmaking, a process the CZMS strongly encourages.

A number of small preliminary workshops with groups of experts were held in Caracas, Venezuela (January 1992), and in Colombo, Sri Lanka (February 1992), to assess the status of coastal zone management in those regions. But, the major focus of the CZMS was on Margarita Island, Venezuela, in March 1992. Out of this meeting would come the final recommendations to the Intergovernmental Negotiating Committee (INC) on a Framework Convention for Climate Change and to UNCED, through the IPCC.

Margarita Island, Venezuela

The Margarita Island meeting was both a culmination and a celebration of more than three years of work. Many of the participants had been with this process from the outset and had seen the work of the group increase in its visibility and importance as the international community organized itself for UNCED. The meeting was hosted by the Venezuelan Ministry of Environment and Natural Resources. As evidence of the importance attached to this meeting and the subject, the week was opened by an address from WMO Secretary General G.O.P. Obasi. Also in attendance, Ambassador Robert Van Lierop, the U.N. Ambassador from Vanuatu, chair of the INC working group on legal and institutional mechanisms, and chairman of AOSIS (the Alliance of Small Island States), a powerful force in both the INC and UNCED negotiations.

Based on the 28 case studies presented at the workshop some extremely significant findings have emerged that underscore the urgency for action now. Without appropriate coastal response strategies, a rise in sea level of 1 meter would double the number of people worldwide vulnerable to coastal storm surges and threaten half the world's remaining coastal wetlands. In many cases the cost of the retreat or accommodation strategy can be as expensive or more expensive than the traditional protection response of building sea walls, dikes, etc. In many cases, for small developing countries, particularly small island nations, the cost can be large or prohibitive when compared with the gross domestic product. National coastal zone management planning is essential for the implementation of response measures to sea level rise. Response strategies affect almost every aspect of coastal activities and need to be considered in a comprehensive way.

While many comments were made concerning the use of the common methodology, by and large many felt that it was useful and allowed for some structure to the case studies and ability to compare some of the data collected. However, some developing countries found it difficult to fully apply the methodology because they lacked much of the required data. Such findings point to the need for increased data collection and international assistance. The case studies to be presented in the final workshop report cover small islands, deltas, and continents (including large islands). The following three topics served as focal points for the review groups at the workshop.

Small Islands. Seven of the case studies involved small low-lying islands whose land mass lies within 3 meters of current sea level. Island ecosystems include coral reefs, sandy beaches, mangrove forests, and hard rock cliffs. Current human activities (e.g., water extraction, pollution, sand and coral mining, and construction) are increasing the vulnerability of small islands to sea level rise. On the islands of Antigua, Kiribati, St. Kitts-Nevis, Moorea in French Polynesia, and the Marshall Islands, critical agricultural and tourist areas were shown to be at risk with little area available for retreat. In most of these islands the economic base is almost totally dependent on the narrow coastal zone.

Deltas. In the larger deltaic areas of the world, particularly in Asia, the most striking feature is the density of population. In Bangladesh alone, 110 million people live in an area of just 144,000 km^2. The case studies of Bangladesh, India and Egypt show how vulnerable these areas would be to increased sea level rise. In extremely flat deltaic areas, a 1-meter rise would cause shores to retreat several kilometers, displacing hundreds of villages and depriving millions of people of their means of subsistence. In many of these areas the retreat option may not be viable just because of the sheer number of people involved.

Continents (and Large Islands). Coastal nations with predominantly continental shoreline environments have the benefit of elevation, inland space, and more stable coastal regimes to pursue varied response strategies. However, many of the problems associated with sea level rise will be experienced on a regional or local level. The case studies, in countries as geographically diverse as Argentina, France, Mexico, Nigeria, Peru, Poland, Senegal, Venezuela, and the United States, all contain elements that point to common problems, such as loss of critical wetlands and habitats, erosion, vulnerability of coastal infrastructure, and impacts on agricultural areas. Therefore, these areas present no less of a challenge for the development of response strategies and critically need vulnerability assessments.

Conclusions

The "bottom line" coming out of the Venezuela meeting reaffirms and expands on the recommendations put forth in the IPCC First Assessment Report, namely that: all coastal countries need to start now to assess their vulnerability and develop coastal zone management plans that include measures to reduce vulnerability; international guidelines on coastal zone management should be developed to guide these efforts; increased support should be provided to international organizations that are implementing systematic observation and monitoring networks; and international financial aid and development agencies need to consider vulnerability to sea level rise and coastal zone management planning in their decisionmaking.

These recommendations are likely to find support in the language of the UNCED Agenda 21, the Framework Convention on Climate Change, and supporting documents that will be debated in Rio de Janeiro, Brazil, this coming June.

In fact, at the fourth and final UNCED PREPCOM meeting in New York last month, language in support of coastal zone management was retained in the Agenda 21 document. It calls on coastal states to, "commit themselves to integrated management and sustainable development of coastal areas and the marine environment under their national jurisdiction."

One interesting section of the current document says that, "States should cooperate, as appropriate, in the preparation of national guidelines for integrated coastal zone management and development, drawing on experience, including a first global conference to exchange experience in the field that could be held before 1994. (UNCED, 1992)

It will remain to be seen what impact the developing countries and, in particular, the small island states will have on the UNCED outcome. It is clear, however, that the IPCC CZMS sea level process has sensitized the international community to the need for sound coastal zone management and paved the way for international action.

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Table 1. The seven steps for assessing vulnerability to sea level rise.

1. Delineate case study area and specify sea level rise boundary conditions.
2. Inventory study area characteristics.
3. Identify relevant development factors.
4. Assess physical changes and natural system responses.
5. Formulate response strategies and assess their costs and effects.
6. Assess the vulnerability profile and interpret results.
7. Identify actions to develop a long-term coastal zone management plans.

The States and Coastal Management

MARINE EXTENSION CONTRIBUTIONS TO STATE PUBLIC POLICIES[1]

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Research-based education remains an appropriate model for state universities as they address societal issues through public service and extension education. Marine and coastal resource problems provide appropriate issues for university researchers and extension educators to develop projects which assist society and its state public policy decisionmakers work their way through problems and potential solutions.

One of the unique aspects of public higher education in the United States is the public service/outreach and extension education roles originally developed by Land Grant colleges authorized by the Morrill Land Grant Act of 1862. The current Land Grant university system developed its three-pronged mission of teaching, research and extension/public service activities over time through implementation of the 1862 Morrill Act, establishing the original Land Grant colleges, the 1887 Hatch Act establishing agricultural experiment stations and the 1914 Smith-Lever Act responsible for creating a national system of agricultural extension services.

Successful applications of the Land Grant model to agricultural development provided a basis for the National Sea Grant College Act which was signed into law in 1966 (Miloy, 1983). Sea Grant utilizes the three-pronged concept of research, education, and advisory services (extension) to encourage the development of university-based marine research and development programs in coastal and Great Lakes states of the United States. The National Sea Grant College Program is currently reviewing its mission, approaches, and organizational structures used to carry out its charge to further the conservation, utilization and management of marine and coastal resources.

Changing approaches to the development of public policies by the federal and state governments provide opportunities for universities that are developing marine extension programs through participation in the Sea Grant and Land Grant systems. The 1980s saw the application of the "new federalism"
" philosophy which shifted responsibility for developing public policy from the federal to the state level. The era of major new federal initiatives like the early 1970s Coastal Zone Management and Clean Water Acts was over.

The "new federalism" places more responsibility on innovative public policy development at the state level. While it is possible that this creates a fragmented approach to developing public policy, it can be an opportunity for universities to apply research-based extension/outreach education methodologies to state marine public policy development.

It is time for universities with Land Grant and Sea Grant programs to assess current and future marine resource information needs of their respective

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[1]This paper borrows heavily from Bender, N., Extension education contributions to environmental policy. *The County Agent*, in press.

state legislatures and marine resources management agencies which can be addressed by marine extension and research faculty. Once educational needs are identified, then a university can review existing knowledge bases which can be utilized to contribute research-based information to the marine public policy decisionmaking process.

This paper will review state public policy processes, policy-makers' information needs and approaches for working with state legislatures and resource management agencies as they examine marine public policy issues. Successful approaches to building marine extension and legislative relationships will be reviewed based upon experiences during a sabbatic leave with the Connecticut General Assembly's Environment Committee and a survey of Sea Grant Marine Advisory Programs' experiences with legislatures and marine resources agencies.

State Public Policy Processes

Legislatures and state executive branches address a wide range of environmental and natural resources issues that involve marine resource policy. These are often handled through standing committees; some legislatures having committees specifically addressing natural resources and environmental concerns.

Developing marine extension and research programs directed toward legislative and executive branches as primary audiences requires an understanding of their organizational cultures which differs from that found in academia. During a legislative session, decisionmaking is often quick-paced with legislators and staff moving in numerous directions within a short period. For example, legislators with the Connecticut General Assembly's Environment Committee made decisions regarding more than 400 bills during the 1991 session.

The legislative time frame is much quicker than that found in most university activities. Elected officials and staff are reacting to daily and hourly decisionmaking situations which create reliance upon existing information sources, including legislative research and fiscal analysis offices, party caucuses, lobbyists, their own gut feelings, and, when available, quick responses from university educators.

Fred Springer, University of Missouri at St. Louis (Wunnicke, 1991) indicates that publications written for legislators should "be about actual problems in the state, not a review of the literature." He further comments that issues should be of interest to state legislatures and "it must have some implications for action." Springer feels that legislative staffers may be a more receptive audience for public policy analysis than legislators.

Opportunities and challenges to developing successful academia/state agency partnerships were recently explored by Charles H.W. Foster (1991) in an issue of *Renewable Resources Journal.* Foster noted that "the problem of two distinct communities and cultures—one academic, the other governmental—had been responsible for significant perceptual and attitudinal difficulties." He also noted that a "Lack of perspective due to time scale differences was also reported to be a problem. The longer range interests of academia were not always compatible with the shorter-term needs of the agency administrator." Foster's comment about time scale differences also applies to the different perspectives of many legislators and academians.

The hectic and fragmented pace of a legislative session creates an atmosphere that doesn't appear to lend itself to active involvement of university extension educators. Yet, these same elements create opportunities for extension educators and researchers who can effectively bridge the gap between these two worlds.

The different organizational cultures (including reward systems, time scales and decisionmaking processes) present challenges to those attempting to strengthen the ties between the Sea Grant and Land Grant University systems and state legislative policy makers.

Concern for marine-related policy issues is a trend that will continue during the 1990s into the 21st Century. During the 1991 General Assembly session, Connecticut legislators addressed a wide range of issues which had direct or indirect consequences for Long Island Sound resources:

Water quality (point and non-point-source pollution);
Solid waste management;
Hazardous waste management;
Coastal pollution;
Land use management;
Global climate change;
Recycling and composting programs;
Natural habitat protection and restoration;
Integrated pest management;
Funding of public environmental and natural resources activities;
Efficiency of state Department of Environmental Protection regulatory activities; and
Balancing competing interests for water and land resource uses.

Legislators commonly address a wide range of marine environmental and natural resources issues through a variety of organizational structures and approaches. In Connecticut the following are part of the environmental policy process in the state's General Assembly:

The Environment Committee is a 34 member standing committee of the General Assembly with members from both the House of Representatives and the Senate. It has formal responsibility for all bills pertaining to environmental and agricultural manners being addressed by the General Assembly (*Connecticut Legislative Guide*, 1991).

The Office of Legislative Research conducts research on issues being addressed by the legislature. It has researchers assigned to issues addressed by the environment committee (e.g. Leff, 1991).

The Legislative Commissioners Office develops the wording of Bills for the committee leadership and provides legal review for a bill's language.

Task forces were set up to review special issues with the following operating in Connecticut during 1991. (Environmental fees, land use, and municipal solid waste).

Political caucuses range from partisan caucuses (Democratic House and Senate, and Republican House and Senate) to those that are bi-partisan like the Long Island Sound Caucus.

Connecticut Council on Environmental Quality (CEQ), while part of the executive branch, issues an annual report on the status of the state's environment including specific issues of concern that may be addressed by the legislature. Environment committee leadership frequently interacts with CEQ staff on legislative issues.

Inter-state approaches like the Bi-State Long Island Sound Marine Resources Committee comprised of legislators and environmental management officials from Connecticut and New York state (e.g. LISMRC, 1991).

Legislative interactions with regulatory agency staff; and

Legislative interactions with lobbyists and the public.

Marine Environmental Legislation Passed by the 1991 Connecticut General Assembly Session (Leff, 1991):

Non-point-source pollution;
Planning and zoning;
Combined sewer projects;
Regulation of oysters;
Pilotage study;
Immunity from oil spill response; and
Commercial fishing license suspensions.

University Knowledge Base

Land Grant institutions have worked on public policy issues through the years in agriculture, natural resources, community and economic development, public health, labor issues, consumer education, engineering, youth development and education. The magnitude and severity of society's marine issues requires a directed approach by a wide range of extension and research faculty cutting across the breadth of disciplines and academic departments.

Sea Grant College programs, modeled after the Land Grant system, created a national network of state marine resources research and development programs with a strong extension education component. The Sea Grant Program recently observed the 25th anniversary of the initial legislation passed in 1966.
Both systems have been criticized for drifting from their original mandates to foster problem-solving through collaborative research/extension relationships. There recently has been debate about the relevance of Land Grant universities to contemporary society. Concern has been raised both internally and externally regarding the trend toward basic research that has little utility within Cooperative extension education programs and little immediate relevance to societal problems.

The research base in Colleges of Agriculture and Natural Resources, Engineering, and Arts and Sciences, are already addressing a variety of environmental concerns with direct application to issues facing coastal and marine regions. Together with expertise organized in specialized centers and institutes like environmental and marine research institutes, centers for environmental health, Sea Grant programs and agricultural experiment stations extension educators can tap a research base directed toward 1990s and early 21st century issues.

Society's concerns about the marine environment and other related issues offer opportunities to renew the balance among the tripartite missions of state universities by strengthening the extension/research interface. Appropriate audiences for these efforts are legislators and public policy analysts in state legislative and executive branch policy research offices.

Building University/Legislative Ties

Successful marine extension educators who develop educational programs for legislators will develop an understanding of state-level public policy processes including:

State legislative processes including decisionmaking time frames;

State legislative organizational structures including standing and ad hoc committees, leadership positions, and support offices like legislative research and fiscal analysis;

Impacts of elected officials' personalities on the decisionmaking process;

Current marine and related key issues facing a state;

External factors affecting the legislative process; and

Educators need to understand that aspects of the legislative culture also apply to their universities' culture, structure, processes, personalities and issues. An important part of these factors are the specific relationships among teaching, research and public service/extension education at one's academic institution.

Methods that contribute to legislative utilization of research-based extension education programs include:

Placing legislators and key staff on mailing lists for newsletters, technical reports and educational activity notices;

Developing briefing papers providing summaries of information addressing issues of interest to state environmental decisionmakers. These should be short and to the point;

Developing a list of university faculty and staff with environmentally related expertise to be distributed to legislators and staff. They should be interested in interacting with legislators and staff;

Identifying a legislative liaison with responsibility to build legislative/extension educational relationships;

Providing copies of reports and other publications to legislators, staff, the legislative library and research offices;

Providing briefings on current university research and extension education activities related to legislative issues at committee meetings and special meetings convenient to legislators and staff; and

Involving legislators and staff in educational programs like advisory committees, conferences, radio and television programs and tours addressing environmental issues.

Successful Approaches to Marine Extension/Legislative Ties

State Sea Grant Marine Advisory Service Programs (MAS) have used a variety of approaches when extending research-based knowledge to public policy decisionmakers. A survey of MAS program leaders during 1991 (Bender et al., 1992; Bender, 1992) provided responses to the following questions:

Provide examples of educational/applied research ties with the state legislature and/or state natural resource/marine resource agencies?

Describe the activities' outcomes. Were they positive or negative? Why?

Provide recommendations on methods to ensure positive working relationships with legislative/natural resources agencies.

Responses illustrated MAS interaction with legislative policy makers spanning a range from no direct interaction allowed to a variety of interactions including:

State Legislative Day on Lake Erie issues;

Legislators involvement in MAS field events and research cruises;

Sabbatic leave assignment with legislative Environment Committee;

Faculty assignment as temporary advisor to Environment Affairs Committee;

Testimony at legislative meetings and hearings;

Briefing materials on marine issues provided to legislative committees, research and fiscal analysis offices, governor's office, legislative library, and relevant staff; and

Legislative outreach agenda developed utilizing:

Survey of legislators and staff regarding their information needs;

Fact sheets on Great Lakes issues;

Folders provided to legislative committees and research offices;

Follow-up survey concerning information's usefulness; and

Service on legislative task forces and studies.

Several MAS programs have conducted extension education field activities for legislators and staff. Ohio State University Sea Grant initiated an annual Legislative Day on Lake Erie for state legislative and congressional officials. Organizers of the events include Sea Grant staff and members of Sea Grant's Regional Advisory Committees. These events provide opportunities for elected officials to take a first hand look at Lake Erie issues.

State legislators also participate in University of Maryland Marine Advisory Service field events like aquaculture facility tours and Sea Grant research cruises. The Connecticut Sea Grant Marine Advisory Program (SGMAP) organized a "Marine Environmental Issues for Legislators and Staff Workshop", which involved an on-land seminar and on-the-water boat trip aboard an educational vessel. One outcome was a request from the State Legislative Environment Committee co-chair for a SGMAP organized briefing on "Zebra Mussels: Potential Impacts in Connecticut" at the committee's initial meeting of the 1992 General Assembly session.

Faculty assignments working with legislative committees and task forces include: taking a six-month sabbatic leave serving as an intern with Environment Committee co-chairs, conducting research on fishing gear conflicts for a legislatively authorized study, serving as an advisor for a committee providing scientific advice, and providing testimony on bills at committee meetings and public hearings on issues such as fisheries management, Long Island Sound public education, and the need for a regional vocational-aquaculture high school center.

MAS program leaders responding to the survey indicated the following were part of successful approaches to extension contributions to developing marine public policies:

Being aware of current and emerging environmental public policy issues through ties with legislators and legislative staff, and on-going field contacts with marine industry, public officials, organizations and individuals;

Providing objective, non-biased information which addresses current and emerging legislative issues;

Utilizing university research bases;

Identifying issues where university faculty and legislative staff share common goals and interests ("a commonality of purpose");

"Willingness to share the limelight as well as the workload;"

Being available when needed to share information and perspectives; and

Keeping legislators and staff informed of available extension and research information relating to current/emerging public policy issues ("constant communication and an effort at doing high quality work that arrives on time").

Summary

Society's shift in the development of major environmental policies from the U.S. Congress to state legislatures provides opportunities for Land Grant and Sea Grant academic institutions. Universities with Land Grant and Sea Grant faculty have the unique capacity to provide research-based technical information to legislators and legislative staff which is not available from other institutions.

Marine extension faculty can play a key role in this process by serving as a link between the research community and the legislature in making available objective, factual information regarding marine-related environmental issues facing society. Marine extension can also combine several roles by utilizing research-based information together with perspectives developed when working with marine industries, local public officials, environmental groups and other groups and individuals involved with marine and coastal resources issues.

The continuing need to address marine environmental issues through the development of state public policies provides opportunities for the Land Grant and Sea Grant systems to continue to utilize the academic research/extension model that has been evolving since the passage of the 1862 Morrill Land Grant Act.

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THE U.S COASTAL ZONE MANAGEMENT ACT AND THE U.S CLEAN WATER ACT: A NATIONAL EXPERIMENT IN JOINT IMPLEMENTATION WITH THE COASTAL STATES

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In 1990, the U.S. Congress amended and reauthorized the Coastal Zone Management Act (CZMA). Recognizing the importance of protecting the marine waters of the United States in a coordinated fashion, Congress linked the national management objectives of the CZMA with a companion program for regulating coastal waters under the federal Clean Water Act (CWA).

The CZMA's new Coastal Nonpoint Pollution Control Program requires each coastal state to develop a plan, to be implemented through Section 6217 of the CZMA and Section 319 of the CWA, to protect coastal waters from nonpoint sources of pollution from adjacent land uses. Oversight is shared between the National Oceanic and Atmospheric Administration (NOAA), administrator of the CZMA, and the U.S. Environmental Protection Agency (EPA), administrator of the CWA.

In 1987, Congress directed EPA to establish the National Estuary Program under Section 320 of the CWA. Due to additional recognition of mutual goals and objectives between this section of the CWA and the CZMA, EPA and NOAA took further steps through a coordination paper and joint guidance document to formalize a national administrative partnership designed to implement the two statutes.

Massachusetts has successfully made the link between the National Estuary Program and the CZMA. It is now preparing to further use its Coastal Zone Management Program by linking implementation of the CZMA with the CWA's Nonpoint Source Management Program.

This paper will show how two independent federal agencies, at times at odds with each other over national environmental protection goals and strategies, are attempting to work with each other, through their various divisions and the coastal states, to implement the priority objectives of two national statutes. In this paper, the Massachusetts Coastal Zone Management Program will serve as the model for coordination using a state and federal networking approach.

Coastal Zone Management Act

In 1972, the U.S. Congress passed by overwhelming votes the U.S. Coastal Zone Management Act (CZMA). It has continued to garner similar strong congressional support through each of its reauthorizations, the most recent in 1990.

The act is administered by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA)/Office of Ocean and Coastal Resource Management.

The purpose of the CZMA was to further congressional findings that asserted "a national interest in the effective management, beneficial use protection and development" of the nation's 95,429 miles of shoreline.
Congress declared it national policy to, first: "preserve, protect, develop and wherever possible to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations."

This was to be accomplished through a second national policy goal of voluntary federal-state coordination and cooperation. State and local leadership in this area was to take the form of management plans.

Congress envisioned state management plans that provided increased natural resource protection; improved regulation of coastal development; better public access to the shore; and public participation in the preparation of management plans at all levels of government.

As a third national policy goal, Congress called upon states to prepare special area management plans to protect nationally significant natural areas; to promote water-dependent economic growth; and to improve the management of high hazard areas.

The fourth national CZM policy goal was full public participation in the preparation and implementation of management plans.

There were two strong incentives for state participation in Coastal Zone Management. The first was money. Its purpose was for planning and implementation, found in the act at Sections 305 and 306, respectively. Plans were to be submitted to NOAA for approval, and, once they were approved, a second major participation incentive was triggered. This second carrot is a true form of federalism or states' rights review. It is a state review over all federal coastal activities and is known as federal consistency.

The federal consistency provisions of the CZMA, found at Section 307, provide for federal programs, activities and authorizations to be consistent with NOAA approved state management plans.

Today, 29 out of out of 36 eligible coastal states and territories have coastal programs covering 95 percent of the U.S. shoreline.

CZMA and Federal Consistency

In 1972, federal consistency was a controversial and major component of the national act. It remains so in the 1990s. When the statute was amended in 1990, Section 307(c)(1) was modified in order to clarify the provisions of federal consistency. Until 1990, the statute read:

> Each federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner that is, to the maximum extent practicable, consistent with approved state management programs.

In addressing the limited scope of states' consistency review over the U.S. Department of the Interior Outer Continental Shelf (OCS) oil and gas lease sale exploration, development and production activities, Congress overturned the principles set down by the U.S. Supreme Court in *Secretary of the Interior v. California* (464 U.S. 312 (1984)).

Section 307(c)(1)(A) presently reads:

> Each *federal agency activity* within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone shall be carried out in

a manner which is consistent to the maximum extent practicable with the enforceable policies of approved state management programs.

Section 307(3)(A) reads:

> ... any *applicant for a required federal license or permit* to conduct an activity, in or outside of the coastal zone, affecting any land or water use or natural resource of the coastal zone of that state shall provide in the application to the licensing or permitting agency a certification that the proposed activity complies with the enforceable policies of the state's approved program and that such activity will be conducted in a manner consistent with the program.

The new consistency requirements now allow states to review federal activities and authorizations for activities that may be *outside* of the designated coastal zone but *affect* the coastal zone. The amendment also provides coastal states with the ability to review federal actions whose secondary, indirect or cumulative impacts affect the coastal zone.

The amendment further stresses that federal activities must be consistent with an approved program's "enforceable policies." This clarification was the result of long-standing disputes between coastal states and Commerce.

NOAA's rulemaking, at 15 CFR (Code of Federal Regulations) 930, presently provides federal consistency review over federal activities, federal licenses and permits, and federal financial assistance.

Although the CZMA provided further consistency review over OCS activities, present NOAA rulemaking (15 CFR 928 and 932), will not address the issue at this time (*Federal Register*/Vol. 56, No. 202/Friday, October 18, 1991/Proposed Rules).

CZMA and Special Area Management Plans

State acceptance of well-thought-out, site-specific policies and plans is encouraged by Congress in its "Declaration of Policy," Section 303(3), of the CZMA. It reads:

> ... it is the national policy ... to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in government decision making.

The adoption of state local coastal programs as special area management plans is an appropriate action under the CZMA and should be more widely implemented by coastal states and used for consistency purposes.

National Estuary Programs

Section 320 of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act, was added by Congress on Feb. 4, 1987 (PL 100-4). EPA's Office of Wetlands, Oceans and Watersheds (OWOW) administers the program.

The purpose of the National Estuary Program (NEP) is to identify nationally significant estuaries, protect and improve their water quality and enhance their living resources. EPA describes the program as a method for identifying estuaries significant on a national level that are threatened by "... pollution, development, or overuse ..." The NEP serves to promote the development of Comprehensive Conservation and Management Plans (CCMP) in order to preserve the "ecological integrity" of designated estuaries. It also "... seeks to protect and improve water and sediment quality, and to enhance living resources."

To achieve these NEP "goals," EPA and its OWOW work to:

Establish working partnerships among federal, state and local governments;

Transfer scientific and management experience and expertise to NEP participants;

Increase public awareness of pollution problems and ensure public participation in consensus-building;

Promote basin-wide planning to control pollution and manage living resources; and

Oversee development and implementation of pollution abatement and control programs.

The NEP allows the governor of any state to nominate to the administrator of EPA an area to be designated as an Estuary of National Significance and to request the establishment of a five-year management conference. Presently, there are 17 national estuaries. Massachusetts CZM administers two NEP's. A Tier I NEP in the southeastern part of the state at Buzzards Bay and Cape Cod, and a Tier III Estuary at Massachusetts and Cape Cod Bays. Massachusetts is also represented on the Narragansett Bay Management Committee, as it shares the waters and watershed of that estuary with its southern neighbor Rhode Island.

The purpose of the management conference is to address seven national priority issues. These include:

The assessment of trends in water quality;

The collection, characterization and assessment of data;

A determination of the relationship between point and nonpoint sources of pollution;

The development of a comprehensive conservation and management plan (CCMP);

The development of plans that will ensure an intergovernmental approach for CCMP implementation;

The monitoring of CCMP action plan effectiveness; and

The review of federal financial assistance programs and development projects for consistency with the CCMP.

The main requirements of the last purpose, as found in the Clean Water Act at Section 320(b)(7), are to:

Conduct the NEP federal consistency review;

Perform the review in accordance with Executive Order 12372;

Determine whether or not the federal financial assistance project is consistent or furthers the objectives of the CCMP; and

Enlarge the review to include activities and projects found in Appendix I of the *Catalog of Federal Domestic Assistance.*

The *Catalog* can serve as a good source in developing a federal activities list. The *Catalog's* list is developed in order to ensure compliance with Executive Order 12372.

As with state coastal zone management programs, in order to perform NEP federal consistency review over the effects the spending of federal money may have on a National Estuary, estuary programs are directed to develop an inventory list of federal activities. The Management Conference should then develop criteria for reviewing federal activities and funding programs and set review guidelines that highlight the objectives of the CCMP.

EPA Guidelines provide for four CCMP federal consistency review options.

The first is Executive Order 12372. Established 1983 to replace the A-95 review process, Executive Order 12372 provides a process for the "Intergovernmental Review of Federal Programs." The executive order defines the federal government's method of consultation with state and local governments on its decisions involving grants, other forms of financial assistance and direct activities they may wish to review. Each state participating in this federal review process designates a state regional clearinghouse to coordinate the state's review. With regard to the National Estuary Program's consistency review, the state clearinghouse submits projects to the NEP Management Conference for the NEP review.

A major flaw exists in the Executive Order 12372 review process. Unlike the federal consistency review provisions of the CZMA, federal agencies are not under any obligation to abide by the policies of a state CCMP, as they are with state coastal zone management plans. Executive Order 12372 simply requires federal agencies to "accommodate or explain" why their actions and spending programs are or are not consistent with a CCMP. This weakness in the CCMP Executive Order 12372 review process is a significant reason why states should incorporate CCMPs into their coastal management programs. In this way, federal agencies are compelled to comply with the relevant enforceable policies of the state coastal program as adopted from the CCMP. All other CCMP policies, directives and guidelines can serve as "advisory policies" that must be taken into consideration by federal agencies when considering the affects of their actions on designated state coastal zones.

In addition, Executive Order 12372 provides for no state review over the issuance of federal licenses, permits and other authorizations. The CZMA does.

Where states have not established clearinghouses, a second option for CCMP federal consistency review is to have the Management Conference perform the review. A weakness with this option is that, according to Section 401 of the Intergovernmental Cooperation Act, the minimal "accommodate and explain" provision does not even apply.

A third review option is through incorporation of CCMPs into the state coastal management program, as discussed above. Reviews can also take place through the nonpoint source program under Section 319 of the Clean Water Act.

The fourth option is to tie into weak review authorities such as the National Environmental Protection Act. This and other statutes that encourage intergovernmental cooperation simply call for a discussion of possible conflicts.

Additional review considerations include direct resolution with the federal agency through the Management Conference or, if the federal agency itself is represented on the Management Conference, resolution at the conference level.

EPA guidance concludes that: "Like many facets of the CCMP, the strength in the consistency authority given to the Management Conference is achieved through cooperation, rather than through the law itself." Outside of direct incorporation of the CCMP into a state coastal management program, the three other CCMP federal consistency review options remain inadequate in that no federal agency is obligated to accommodate the comments or concerns of a state NEP. It is, therefore, to the states' advantage to use "the law itself," through the CZMA, and *ensure* federal compliance with the CCMP, rather than to rely on the good will of the federal government to cooperate, as in the case of *Watt v. California*.

Chances are that if a federal development or spending activity is going to affect an estuary, it is also going to affect the state's coastal zone. Joint consistency reviews by the Management Conference and state coastal program allow for streamlined reviews. Again, the CZMA also allows for the review of federal permits, licenses and authorizations for consistency where the Clean Water Act's National Estuary and Nonpoint Source Programs do not.

The guidance criteria for reviewing federal funding activities and development projects that might affect an estuary include:

Establishing a method of receiving notice of federal projects that might affect the estuary;

Criteria for reviewing projects for consistency with the CCMP;

Agreement with federal agencies that they would refrain from reviewing their projects sponsored by their own agencies;

A Management Conference person responsible for coordinating reviews;

A conflict resolution strategy;

A method of resolving conflicts between the state clearinghouse and Management Conference; and

A timetable for review.

CZMA and NEPs

Comprehensive Conservation and Management Plans, developed under Section 320 of the Clean Water Act, will be viewed by NOAA and the coastal states as Special Area Management Plans, under Section 303(3) of the Coastal Zone Management Act.

A coordination paper for the Coastal Zone Management and National Estuary Programs was signed by NOAA Administrator William E. Evans on Sept. 12, 1988, and Lee M. Thomas, administrator for EPA on Aug. 18, 1988.
The mutual goal of the programs, as stated in the paper, is: "... to maintain and enhance or protect the health of the nation's coastal resources."

Mutual points of interest include:

The coordination of federal, state and local government in developing and implementing environmental protection plans;

Emphasis on public education, outreach and information;

The development of plans with emphasis on action agendas; and

The need for a comprehensive examination of methods of protecting water quality and living coastal resources.

As such, NOAA *requires* the submission of CCMPs for incorporation into NOAA-approved state coastal management plans, following CCMP approval by the governor and EPA administrator.

Under Section 312 of the CZMA, NOAA performs a biennial evaluation or program audit of the states' approved coastal programs for compliance with federal-state grant agreements. Through the coordination paper, this review should now include a review of how effectively state CZM programs are supporting the goals and objectives of any state CCMP. An EPA representative also is to join the federal review team on its visit to the state.

Under the CZMA Section 309, NOAA has the authority to allocate funding for interstate projects. Through the NOAA-EPA agreement, NOAA will direct Section 309 grants to interstate estuaries.

Finally, NOAA agreed to provide EPA with any technical assistance necessary for the development of national guidance on the development of pollution control programs.

EPA has also directed states "... voluntarily, as a matter of policy ..." to submit their CCMPs to the states' coastal management programs for federal consistency review.

Further, the EPA Administrator committed to a future regulatory provision that "... CCMPs *should* be incorporated into approved CZMPs ..."

EPA also agreed that new Estuaries of National Significance would be selected based on whether or not a state had an approved coastal zone management plan.

Finally, "In order to facilitate the development of CCMPs such that they are consistent to the maximum extent practicable with the state CZMPs ...," NEP Management Conferences will include state Coastal Zone Management Program participation.

Through the NOAA-EPA agreement, both agencies recognized that the CZMA provides the "broad umbrella" for management of all of a state's coastal resources and that the NEP is a :demonstration program" that is site-specific in its focus.

Future NOAA and EPA guidance and rulemaking will recognize that cooperation, and not unilateral direction, is the objective of the agreement.
In summary:

States are "required" by NOAA to submit CCMPs for incorporation into state Coastal Zone Management Plans;

CCMPs "should be incorporated into approved Coastal Zone Management Plans;" and

CCMPs will "voluntarily, as a matter of EPA policy" be submitted to state Coastal Zone Management Programs for federal consistency review.

NOAA and EPA "Guidance" on the NEP and the CZMA program is in need of further clarification and explanation by the federal authorities responsible for mutual implementation of the statutes. The language is not clear and the administrative policies need to be coordinated and stated in stronger terms. A restatement of the concepts enunciated in the coordination paper is especially important as state coastal program adoption of NEPs appears to be the only method for long-term, certain implementation of the National Estuary Program on the state level.

Questions include: Is CCMP submission a requirement, as NOAA states, or is it a voluntary submission, as EPA states? And, once a CCMP is submitted, regardless of the method, coastal states do not have to do anything with CCMPs because of the choice of the word "should" over "shall."

Again, NEP regulations require that federal financial assistance programs that will affect an Estuary of National Significance be reviewed for consistency with CCMPs. One could argue that the spending of the CZMA Section 306 state Coastal Zone Management Program implementation funds must be submitted to NEP Management Conferences for consistency with CCMPs. It is not now done.

Clean Water Act Section 320 funding to states is for the five-year development of CCMPs. There is no money, at this time, for CCMP implementation. Congress should rectify this. If a CCMP has been adopted by a state coastal zone management agency as part of its NOAA-approved program, in the absence of an EPA-funded Management Conference under Section 320, CCMP consistency could then be performed by the state coastal zone management authority. This, obviously, would make it difficult, if not impossible, for a state coastal zone management agency to review its own CZMA Section 306 program implementation funding for consistency with the CCMP, which has been incorporated into the state's coastal zone management plan.

In Massachusetts, the state CZM program has prepared two special area management plans under Section 320 of the Clean Water Act. Incorporation of the completed Buzzards Bay National Estuary Project CCMP and plans for the eventual incorporation of the Massachusetts Bays National Estuary Project CCMP are now being developed. Massachusetts and NOAA will together define a process for amending the state's coastal program in order to accomplish this goal. The overall purpose of this task is to advance the spirit and intent of the national program, as embodied in the state's coastal plan, and provide for the effective, integrated and comprehensive management of the coastal zone through all levels of government.

Massachusetts' Buzzards Bay National Estuary Program submitted a final draft CCMP to NOAA's Office of Ocean and Coastal Resource Management for review and comment. The submission was not a regulatory requirement but done as a courtesy. OCRM responded that: "It might be advantageous to integrate the CCMP and the Section 6217 program under the umbrella of a Special Area Management Plan and then incorporate that management plan with its enforceable policies into the Coastal program." The Bay State is certainly headed in that direction. However, it will also include the Buzzards Bay Project's non-enforceable policies and guidelines in its coastal program in order to give guidance and direction to those activities that may affect the Buzzards Bay planning area. The additional inclusion of Section 320 non-point source management planning will also occur.

CZMA Section 6217

Section 6217, the "outside section" to the reauthorized Coastal Zone Management Act is titled "Protecting Coastal Waters." It requires all NOAA-approved state coastal zone management programs to draft, within 30 days of final program guidance from NOAA, a Coastal Nonpoint Pollution Control Program. Program plans must be submitted for approval to NOAA's Office of Coastal Resources Management/Coastal Programs Division and EPA's Office of Water/Office of Wetlands, Oceans and Watersheds/Assessment and Watershed Protection Division/Nonpoint Source Control Branch. Failure to do so can result in the withdrawal of NOAA funds under the CZMA and Section 319 funds under the Clean Water Act. Implementation is through state coastal zone management programs, under Section 306 of the CZMA and through updates or expansions to state water pollution control programs, under Section 319 of the Clean Water Act. A combination of the two is also an option. All states and territories have completed or partially completed EPA-approved nonpoint source management programs for which they receive federal funding.

The purpose of the CZMA water pollution control plans is to: "... develop and implement management measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities." Congress' intention was to "strengthen the links" between various levels of government charged with protecting marine water quality.

State plans are to be coordinated with state and local water quality programs and state coastal zone management plans. The CZMA-authorized pollution control plans are to be developed in conjunction with and as an "update and expansion" of Clean Water Act pollution control plans developed under Section 319 and as amendments to state coastal plans administered through the CZMA Section 306. Coordination should also take place with plans developed under the Clean Water Act's National Estuary Program (S. 320). Congress formally linked the CZMA state coastal plans and National Estuary Plans with the CZMA nonpoint source plans developed under Section 6217 of the CZMA and Section 319 of the Clean Water Act.

Section 6217 describes seven elements of a plan. They are:

First, plans should identify land uses that contribute or may contribute, "individually or cumulatively," to water degradation.

Second, "critical coastal areas" that are "adjacent to coastal waters" must be identified. New or substantially expanded uses on these lands must then be subject to management measures.

Third, plans should include updated management measures necessary to achieve federal water quality standards.

Fourth, there must be a provision providing local governments and the public with technical assistance.

Fifth, the public must have ample opportunity to participate in "... all aspects of the program ..."

Sixth, state agencies are to "improve coordination" among themselves and with local governments in the administration of permitting programs, habitat protection and public health and safety.

Seventh, where "necessary," state coastal programs are to propose modifications to their designated coastal zone boundaries in order to implement water quality plan recommendations over the new "6217 management area."

Further on in Section 6217, NOAA and EPA are directed by Congress to independently review each coastal state's inland coastal zone boundary in order to evaluate whether the boundary "extends inland to the extent necessary to control the land and water uses that have *significant* impact on coastal waters ..." If NOAA and EPA find that the coastal zone boundary should be moved further inland in order to "... more effectively manage land and water uses to protect coastal waters ...," then the recommendation is made in writing by Washington to the state.

Under the Clean Water Act's National Estuary Program, participating coastal states are directed to draft CCMPs in order to address water quality problems associated with EPA-designated Estuaries of National Significance. As part of the CCMP, the estuary's watershed or drainage basin is mapped. If there is a NOAA-approved state coastal zone management program in place, an opportunity exists for expanding the state's designated coastal zone boundary to encompass the estuary watershed through state coastal program adoption of the CCMP. There is no requirement under Section 320 of the Clean Water Act that this type of boundary reconsideration occur, as there is under Section 6217 of the CZMA. However, state coastal zone management program adoption of CCMPs, including the estuary watershed, provides a propitious occasion for coastal states to not only implement the CZMA's Special Area Management Plan (Section 303(3)) but also the CZMA's Nonpoint Source Management Program (Section 6217). It may prove to be a good beginning in state comprehensive water quality management planning.

The Massachusetts coastal program is considering adopting its two CCMPs in their entirety and developing a "coastal zone watershed contiguous zone" adjacent to its designated coastal zone. This area would include the state's coastal watersheds. In this manner, federal agencies would be given clearer indication of the area in which their activities might be reviewed for the affects they would have on the coastal zone and its associated watershed. This approach may work best for "networked: CZM programs where influence can be asserted over water quality agency decisions.

Modifications to NOAA-designated state coastal zone boundaries are a complicated matter. Under the CZMA S.306(e), the secretary of commerce has the sole authority to approve or disapprove changes to a state coastal plan. Such modifications require an amendment to the state coastal program, as described in the CZMA's Section 306(g) regulations at 15 CFR 923.80(c). A coastal zone boundary change is considered a "substantial" change in or to enforceable policies and authorities of the state coastal program and requires NOAA approval.

Upon the submission of a proposed boundary change to NOAA, the federal authority must make a determination as to whether or not the state program will continue to include, among other coastal features: "Areas the management of which is necessary to control uses with direct and significant impacts on coastal waters." (15 CFR 932.82(A). There is no mention of indirect, secondary and cumulative impacts that may result from uses, both inside and outside of the coastal zone, that degrade coastal resources. NOAA must therefore provide new and updated rulemaking regarding Congress's intentions on this aspect of federal consistency.

NOAA has indicated that it has no intentions of creating new federal consistency rulemaking for the new CZMA "affecting" section, at 307(c)(1). There is no doubt that federal consistency is a controversial topic. However, the avoidance of addressing the subject in the past has lead to federal interagency disputes, battles with the coastal states and eventually an adverse ruling to the coastal states in the U.S. Supreme Court decision of *Watt v. California*. Congress was thus forced to clarify its federal consistency intentions in the 1990 reauthorization that deleted the word "directly" from the "affecting" clause of the statute. Present CZMA regulations remain inadequate and do not provide proper, complete and relevant guidance to the coastal states in this regard.

Amendments to NOAA-approved state coastal programs involving the change in boundaries require compliance with the National Environmental Protection Act. NOAA reviews the proposed changes submitted under NEPA in the form of an Environmental Assessment in order to determine whether or not the action constitutes a major federal action having a significant effect on the environment. If there is a Finding of No Significant Impact, no Environmental Impact Statement need be prepared. If a significant impact to the environment is determined to be likely, a Draft Environmental Impact Statement is drafted consistent with Council on Environmental Quality and NOAA guidelines.

Historically, NOAA has accepted state-proposed Special Area Management Plans with boundary modifications without the filing of a full Environmental Impact Statement.

Any 307(c)(1) consistency review over federal activities that might affect a new "coastal zone" must be consistent with that state plan's "enforceable policies." Thus, if a new state coastal zone boundary moves inland, there must be concomitant enforceable coastal policies for that inland area in order for the state program to have any statutory review authority over federal activities there.

Even without a new set of clean "enforceable policies" over the new coastal zone, state and local agency adherence to new state coastal program CCMP policies, plans, guidance and directives would help in improving management over those most common land uses that degrade coastal water quality. And, even though there may be a lack of strong federal consistency review opportunities over a new coastal zone, expansion and development of "advisory policies" can be beneficial to the water quality goals set by Congress in the Coastal Zone Management Act and the Water Quality Act.

In a Feb. 18, 1986, NOAA memorandum, OCRM informed Coastal Program managers that federal agencies and applicants must give "adequate consideration" to "advisory policies" for the purposes of consistency review. NOAA's concern with state adoption of Special Area Management Plans is that those plans be consistent with the intentions of the CZMA and that the state coastal programs distinguish between enforceable and nonenforceable policies in their plans.

Again, Massachusetts Coastal Zone Management will adopt its two CCMPs as coastal policy. It will include those CCMP policies and guidelines not relevant for adoption as CZM enforceable policies as "advisory policies" giving further direction to federal agencies the actions of which might affect the Massachusetts coastal zone. This goes beyond EPA recommendations that only the "relevant" portions of the CCMP be incorporated into a CCMP (Sept. 12, 1991, draft of 320 consistency review, p. 22.)

The incorporation of a CCMP into a NOAA-approved state coastal zone management plan, however, may result in the drafting of new enforceable policies. CZMA Section 6217 certainly encourages this approach in order for states to more effectively control land uses that degrade near coastal waters. Section 320 does not. When completed, the Coastal Zone Management Act Section 6217 state Coastal Nonpoint Pollution Control plans are to be submitted to NOAA and EPA for approval. Implementation is through the CZMA S. 6217 and the Clean Water Act Section 319. Failure to submit an "approvable program" will result in serious reduction of federal funds to the states under both statutes.

The CZMA's Section 306 was also amended to require any new state coastal zone management program to include enforceable policies and measures to implement Section 6217.

Funding for the development of the state plans derives from the CZMA coastal program implementation funds at Section 306(c).

Jack H. Archer, in "Evolution of Major 1990 CZMA Amendments: Restoring Federal Consistency and Protecting Coastal Water Quality" (*Territorial Sea Journal*, Vol. I:2, 1991, pp. 191-222), states that the reason for including a nonpoint source coastal water quality program in the CZMA was to "... reconcile potential conflicts between the CZMA and Clean Water Act with respect to addressing nonpoint source pollution, the federal and state agencies implementing the two programs, and the oversight committees in Congress."

The original intent of Congress, its staff, the coastal states and environmentalists, according to Archer, was to bring together: "(1) state and local government authority over land uses under the aegis of the CZMA and (2) federal authority to determine water quality standards in order to protect and restore coastal water quality under the Clean Water Act ..."

The statute carefully balances the roles of NOAA and EPA with no one agency in a position to implement its program independent of the other. Coastal states must participate if they are not to risk losing substantial funding from both agencies. Archer believes that "The program cannot succeed without a high degree of cooperation between EPA and NOAA and their counterparts within state agencies."

Along with the federal consistency provisions of the reauthorized the CZMA, Archer concludes that the water quality program is a "major achievement" by Congress. "The workability of these statutory arrangements," however, "is yet to be determined." At least, he says, "the administrative framework" for an effective nonpoint source pollution program is in place.

Joint national implementation has begun through the issuance of three draft public comment documents by EPA and NOAA. They are:

"Economically achievable" management measures, guidance for controlling nonpoint sources of pollution, released under Section 6217(g) in the *Federal Register*, Vol. 56, No. 115, Fri., June 14, 1991, pp. 27617-27620;

State Program and Development Guidance, published in the *Federal Register*, Vol. 56, No. 200, Wed., Oct. 16, 1991, pp. 51882-51884; and

A complete guidance document titled "Joint Proposed EPA and NOAA Guidance for State Coastal Nonpoint Pollution Control Programs," released in October 1991 and obtained through request to the agencies.

Final management measures guidance on the Coastal Nonpoint Pollution Control Program will be promulgated in May 1992. And on the same date, final program development and approval guidance for Section 6217 will be jointly issued, as Congress mandated, by NOAA and EPA.

The guidance for state use in the development of specific management measures for nonpoint pollution in coastal waters, comes from EPA with input from

NOAA, the U.S. Fish and Wildlife Service and other agencies. Under CZMA section 6217(b), the states must prepare their pollution control plans and "provide for the implementation, at a minimum, of management measures in conformity with the guidance published under subsection (g) to protect coastal waters generally..."

According to EPA and NOAA, the purpose of management measures is to provide state and local governments with the best technological basis for major components of state coastal nonpoint programs. The management measures are for "categories of sources" that the federal agencies have determined are major contributors to nonpoint source pollution. Sources include road runoff, agricultural practices, coastal erosion, marinas, silvaculture, hydromodifications, dams and levees. There are also management measures for wetlands, riparian areas and vegetated filter strips.

If this first-tier NOAA/EPA approach is neither adequate in protecting coastal waters, through the achievement of certain standards of the Clean Water Act found at Section 303, nor adequate in protecting designated uses, then a second-tier approach, specific to water quality problems, is called for in the guidance.

The second-tier approach would require two additional measures. The first would manage land uses that individually or cumulatively degrade coastal waters. The second would designate critical areas within which new or additional land uses would be managed to improve the condition of coastal waters and protect them against future threats.

On Dec. 13, 1991, Congressman Studds, as "... one of the principal Congressional authors of section 6217 ..." wrote to NOAA, "... that state or local law is to be the source of the control requirements, rather than national effluent guidelines under Title III of the CWA."

The role of local governments is emphasized by Rep. Studds throughout his comment letter to EPA. "The importance of local governments is not properly reflected in the guidance document." It is "barely mentioned" and when it is, it is "perfunctorily identified."

The Coastal States Organization (CSO), an alliance of coastal states, commonwealths and territories, also provided EPA and NOAA with comments on the program. Essentially, the CSO objected to the small amount of funding provided the states for implementation. The $2 million appropriated is to be divided among 29 state coastal programs, amounting to less than $69,000 per state.

On Nov. 7-8, 1991, a workshop titled "Coast & Estuary Management: A Need for Collaboration" was held in Seattle, Wash. Among the "specific strategies" concluded by Marc J. Hershman, workshop coordinator at the University of Washington, was a recommendation similar to that of Rep. Studds: that nonpoint source programs can only be most effectively implemented on the local level in conjunction with local governments.

Section 319 of the Clean Water Act

Briefly and as background, the Nonpoint Source Management Program, at Section 319 of the 1987 Water Quality Act, is administered by EPA's Office of Water/Assessment and Watershed Protection Division. Its purpose is to provide funding to states in order that they can adequately prepare assessments of their inland and coastal nonpoint pollution problems and develop a management program to control the pollution sources.

Section 319 also calls for federal consistency review of federal projects and plans with Nonpoint Source Programs using the Executive Order 12372 process. Again, however, states should incorporate their Nonpoint Source Programs into their coastal management programs for a more thorough, far-reaching and effective review. Contrary to EPA guidance documents, coordination and cooperation are most often effectively achieved "through the law itself."

Conclusion

State coastal management programs have broad authority for setting and implementing policy over federal activities, both inside and outside of the coastal zone, that might affect coastal resources. State-prepared National Estuary Plans, developed through the Clean Water Act, should be adopted by state management programs as special area management plans. State-developed nonpoint source pollution plans, also developed through the Clean Water Act, should also be incorporated into state management plans. Both state actions should include program amendments that incorporate enforceable and advisory policies. In this way, long-term and effective management of land and water uses that affect coastal water quality is ensured.

THE PAST AND PRESENT OF COASTAL MANAGEMENT IN TEXAS: AN ANALYSIS OF CHANGE

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Abstract

The Texas General Land Office is leading the state's effort to develop a comprehensive coastal management program for federal approval under the Coastal Zone Management Act of 1972. Development of the Texas Coastal Management Program is a cooperative effort among federal, state and local agencies, affected user groups, and coastal citizens. Key issues to be addressed by the program are wetlands and habitat protection, water quality, natural hazards management, beach access, shoreline protection, energy resources management, special management areas and marine debris.

In imparting understanding of Texas' coastal management initiatives, this paper will examine coastal management in Texas from a historical perspective. It will analyze why the state's first attempt to develop a federally approvable coastal program failed and why this latest endeavor may be successful. This will be followed by an explanation of what Texas envisions for the program, what the foreseeable problems are, and how Texas proposes to deal with them.

Introduction

The Texas coast is 367 miles long, with an inner bay shoreline of more than 1,000 miles. The state's coastal region encompasses many different habitats and valued natural resources. Its oil and gas reserves are of national significance. Its wetlands serve as nurseries for many economically important fish species and provide habitat for wildlife and migratory waterbirds. Many places along Texas bays and barrier islands are nesting areas for colonial waterbirds and wintering grounds for such endangered species as the Whooping Crane and Piping Plover. Coastal fisheries provide livelihoods for some coastal residents and recreation for others. The state's Gulf beaches are important recreational areas for Texans and attract thousands of out-of-state tourists to the Texas coast each year.

A steadily growing population has increased threats to the well-being of the natural environment of the Texas coast and intensified competition among coastal resource users. To protect its natural resources, to solve widespread problems affecting coastal communities, and to ensure fair, well-founded decisions about the use of coastal resources, the state of Texas is developing a comprehensive coastal management program.

In January 1992, the Texas General Land Office (Texas G.L.O., 1992) submitted a Coastal Zone Management Program Development grant application to the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, for approval. Thus far, Texas' coastal management efforts have received widespread support from coastal communities, government agencies, industry and business groups, and environmental groups.

Historical Background

Texas has long been concerned with coastal management issues, such as storm protection, waterway development, recreational development, fisheries management and beach protection. It was one of the first states in the nation to pass an open beaches law. The Texas Open Beaches Act of 1959 guarantees public access to all state beaches accessible by ferry or motor vehicle (*Texas Nat. Res. Code Ann.* 61.001 *et seq.*).

In 1974, Texas received program development monies under the federal Coastal Zone Management Act for development of a comprehensive state coastal management program. However, after seven years of planning and negotiating, this effort was terminated by the governor. Many took this as an indication that Texas would abandon the effort to enter the federal Coastal Zone Management Program.

Several reasons have been given for the failure of the state's first attempt to gain admittance to the federal program (Curley, 1990). First, the effort did not have the support of coastal businesses and industries; nor did it have strong backing from the governor. Second, the oil-and-gas industry was prospering. Because state finances were in good shape, federal money held little appeal, particularly for interests that balked at the possibility of increased federal interference in state affairs. Third, although there was strong support from coastal citizens—particularly conservation interests—the program was seen by many as a federal-to-state-to-local one, imposed from the top down, rather than a program called for and shaped by the people who would be most affected by it. In addition, the federal Coastal Zone Management Office did not fully support Texas' proposed program.

In 1989, a grassroots movement for the development of a comprehensive state coastal management plan arose along the upper coast. It was initiated by city and county officials and local citizens who sought help in contending with the problems of shoreline erosion and the demands of a growing population around Galveston Bay. They soon built support for the cause throughout the Texas coast, because other communities recognized that they, too, faced problems that exceeded their management capabilities, their local budgets, and even their jurisdictions.

The grassroots initiative led to the passage of Senate Bill 1571, which designated the Texas General Land Office as the lead agency to coordinate the development of a long-term plan for the management of Texas coastal public lands. The passage of this bill showed acknowledgement within the state that some coastal problems cannot be solved at the local level but must be addressed comprehensively by the state.

During the year that followed, the Texas General Land Office held a series of public hearings along the coast to identify the resource management issues of greatest concern to coastal residents. Shoreline erosion, dune protection, beach access and wetland loss emerged as the most critical coastal issues.

The General Land Office then conducted a series of consensus-building workshops for representatives of a wide range of coastal interest groups. The Alternative Futures Assessment Process, a computer-assisted workshop procedure, was used to clarify the concerns of the various interests with respect to each of the identified critical coastal issues. Participants in the workshops represented the oil-and-gas industry, real estate developers, commercial and recreational fishermen, conservationists, scientists, all levels of government, and coastal citizens. Through the workshops, these diverse interests were able to reach a consensus on strategies to address the target issues and on recommendations to present to the state legislature.

Their recommendations for management solutions to the problems of wetland loss, coastal erosion, and beach access were incorporated into the 1990-91 *Texas Coastal Management Plan* (Texas G.L.O., 1991). Other concerns considered by the plan were oil spills, marine debris, freshwater inflow, non-point-source pollution, and hazardous waste generation and disposal.

The Texas Coastal Management Plan became the basis for Senate Bills 1053 and 1054, which were passed by the Texas legislature in the spring of 1991. These bills, along with previously passed legislation, provided Texas with the authority and jurisdictional basis necessary to develop a coastal management program that would meet the requirements of the federal Coastal Zone Management Act.

Senate Bill 1053, the Coastal Management Plan for Beach Access, Preservation and Enhancement, Dune Protection, and Coastal Erosion, focused on shoreline management. Specifically, it made the Texas General Land Office the lead agency for coordinating erosion planning and remediation, directed the General Land Office to quantify erosion rates and identify critical erosion areas, required state and local governments to plan for beach access and use, made the state's Dune Protection Act mandatory for all coastal counties, and established the Coastal Coordination Council (*Texas Nat. Res. Code Ann.* 33.601 *et seq.*).

The Coastal Coordination Council was created to provide a forum for reviewing state, federal and local actions for consistency with the Texas Coastal Management Program. The council is composed of the commissioner of the Texas General Land Office, who serves as chair, the chair of the Texas Parks and Wildlife Commission, a member of the Texas Railroad Commission, the chair of the Texas Water Commission, the attorney general, and two members appointed by the governor: a coastal elected official and a coastal citizen.

Senate Bill 1054, the Coastal Management Plan for State-Owned Coastal Wetlands, directs the Texas Parks and Wildlife Department and the Texas General Land Office to develop a state wetlands conservation plan for state-owned wetlands. The conservation plan will require studies of freshwater inflows and water quality issues tied to activities involving state lands; establish long-range plans for navigational dredging and disposal; require studies of sea level rise, the impacts of boat traffic on wetlands, and sediment bypassing at inland dams; and include provisions to reduce non-point-source pollution in coastal wetlands, bays, and estuaries (*Parks and Wildlife Code Ann.* 14.001 *et seq.*).

With the passage of these bills, Texas Gov. Ann Richards sent a letter to the U.S. secretary of Commerce informing him of the state's intent to apply for a program development grant under Section 305 of the Coastal Zone Management Act and designating the Texas General Land Office as the lead agency to coordinate the state's effort to develop a federally approvable coastal management program.

Analysis

Though the state's first attempt to join the federal Coastal Zone Management Program failed, it was by no means fruitless. It produced new state legislation promoting dune and wetland protection, greater public awareness of coastal concerns, increased coordination among the state's resource management agencies, extensive inventories and analyses of Texas' coastal resources, and numerous reports and public information documents that have been of continuing use (Davenport and McKenna, 1992).

Since 1980, the economic and political climate in Texas has changed significantly. First, Texas coastal businesses and industries have become more environmentally conscious. In response to this, as well as to the Texas coastal management initiative, the Texas General Land Office has reorganized its own energy resources division and is giving more emphasis to the environmental aspects of energy development.

Second, Texas state finances have been adversely affected by the recession and the downturn of the oil-and-gas industry, making the availability of federal funding for coastal management initiatives a much more compelling reason for seeking admission to the program. In order to adequately protect the state's coastal resources, Texas must receive federal assistance.

Third, coastal issues are receiving widespread attention in Texas. Coastal communities have come to realize that many of their problems cannot be solved at the local level but require a broad cooperative approach at the federal, state and local levels. Evidence of this is the formation of several regional foundations (the Galveston Bay Foundation, the Lower Laguna Madre Foundation and the Coastal Bend Bays Foundation) to address coastal concerns related to regional bays and estuaries. The primary impetus for these foundations has been the public, with the objectives being to increase public awareness of coastal issues and to gain admittance to the EPA National Estuary Program for the bays. With Texas coastal communities taking a greater interest, Texas' coastal management initiatives have received strong support from Richards, as well as from many other political figures. When Richards was elected governor, she brought with her the "New Texas" philosophy of giving the government back to the people. This is what Texas' current coastal management initiatives are about: asking the public to identify the problems in need of attention and encouraging state interests to reach a consensus on ways to address the problems.

Finally, the various state agencies with authority over the coastal region are cooperating on a much broader scale than ever before. The Galveston Bay National Estuary Program, for example, has brought many state agencies together to address coastal issues as they relate to Galveston Bay. This cooperative management method is proving successful. The Coastal Coordination Council will promote such cooperative management coastwide. The council brings together the major agencies with permit and review authority over Texas coastal lands to assess major projects that may affect the Texas coastal region and to act as an appeals board when proposed activities are in dispute. Section 33.205 of the Texas Natural Resources Code requires all state agencies and subdivisions whose actions may adversely affect coastal natural resources to comply with the goals and policies of the coastal management plan as adopted by the Coastal Coordination Council.

Planning for Coastal

The purpose of the Texas Coastal Management Program is threefold:

To establish long-term comprehensive planning for and management of the state's coastal natural resources;

To establish long-term planning for and management of all land and water uses that significantly impact the state's coastal resources; and

To establish more effective and consistent governmental decisionmaking for the coastal region.

In the course of program development, state and federal agencies, local governments, and the public must determine the status of Texas' coastal resources, determine what activities are significantly affecting those resources, and evaluate how those resources and activities are used and managed under existing policies and programs. Where resources are found to be threatened or mismanaged, it will be determined what existing policies or programs need to be changed. Where existing legal authority to manage these resources and their uses is lacking, new authority will be sought and enacted and appropriate new policies and programs established.

The program framework will be established through seven interrelated activities (Figure 1). First, a resource inventory will be made to permit assessment of the status and trends of key coastal resources. Second, a matrix will be developed that records the status of each resource and identifies land and water uses that have a "direct and significant effect on coastal waters." Third, a comprehensive listing of relevant federal, state and local legal authorities will be compiled. Fourth, an inland coastal management boundary will be delineated that encompasses all the uses identified in the matrix. Fifth, enforceable policies and appropriate management techniques will be developed for each use. Management techniques permitted by the Coastal Zone Management Act are the establishment of state criteria and standards for local implementation; direct state land and water use planning and regulation; and case-by-case review of actions subject to the management program. Sixth, an organizational structure for implementation will be established by institutionalizing consultation, coordination and communication among all levels of government, special interest groups and coastal citizens. Agreements may be developed that will govern how relevant agencies, governments, and organizations will work with the Coastal Coordination Council and within the coastal management program, and how consistency review will be conducted. Seventh, the public will be educated about the importance of the Texas coast and the coastal management program through photographic displays, slide shows, factsheets, brochures and quarterly newsletters, and will have an opportunity to participate in the planning process through public hearings, meetings, and workshops.

In addition, eight program elements represent environmental issues previously identified as being of greatest concern to coastal residents. These elements and their broad policy statements, explained in Table 1, will evolve with the program and as new information is obtained.

Conclusion

Several major issues remain to be resolved in the development of the Texas Coastal Management Program. Two of them are how best to manage all wetlands to be included in the program, both public and private, and how to control nonpoint-source pollution in the coastal area.

Another major endeavor is to expand the constituency for the program among coastal business and industrial interests. The Texas General Land Office is working to garner their support by soliciting their recommendations early in program development.

Coordination and consistent implementation of rules and policies are key components in managing uses in the coastal region. The Texas General Land Office will coordinate with other state, federal and local agencies and with the private sector to ensure better protection of Texas' coastal natural resources. Public education through training workshops and publications will increase citizens' awareness of coastal problems and strengthen their commitment to sound coastal management. Grassroots and consensus-building efforts that include all coastal interests will be the heart of developing the Texas Coastal Management Program to ensure the protection of Texas' coastal environment and the health of its economy.

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Texas Natural Resources Code Annotated 61.011 *et seq.*; Texas Open Beaches Act.

Texas Parks and Wildlife Code Annotated 14.001 *et seq.*; The Coastal Management Plan for State-Owned Coastal Wetlands.

Table 1. Program elements.

Issue Area	Policy Statement
Wetlands Protection	A statewide coastal wetland conservation plan will be developed to protect all coastal wetlands.
Erosion Response and Dune Protection Planning	The loss of coastal property to erosion will be minimized, and dune systems will be protected by developing erosion response and dune protection rules and guidelines.
Public Access to the Shoreline	Public access will be provided to beaches, bay shorelines and other public areas in an environmentally sound manner by reviewing local beach plans and developing access plans for other coastal areas.
Special Management Areas	Specific management plans will be developed for areas with special values (e.g., recreational, aesthetic, biological, cultural) that are designated as special management areas.
Energy Resources Management	Environmentally sound energy production, transportation, storage, and facility siting will be promoted by reviewing and revising rules and guidelines and developing a comprehensive facility siting plan.
Marine Debris	Beach cleanup activities and work on the Gulf of Mexico Program's Marine Debris Action Plan and the MARPOL treaty will be continued. Source reduction of pollution will be promoted.
Water Resources Management	Management measures for required levels of freshwater inflows and a coastal non-point-source pollution control program will be developed, and current hazardous waste permitting process will be reviewed and revised as necessary, in coordination with the state's lead water agency.
Dredging	A comprehensive dredging plan will be developed to minimize the adverse affects of dredging on coastal resources.

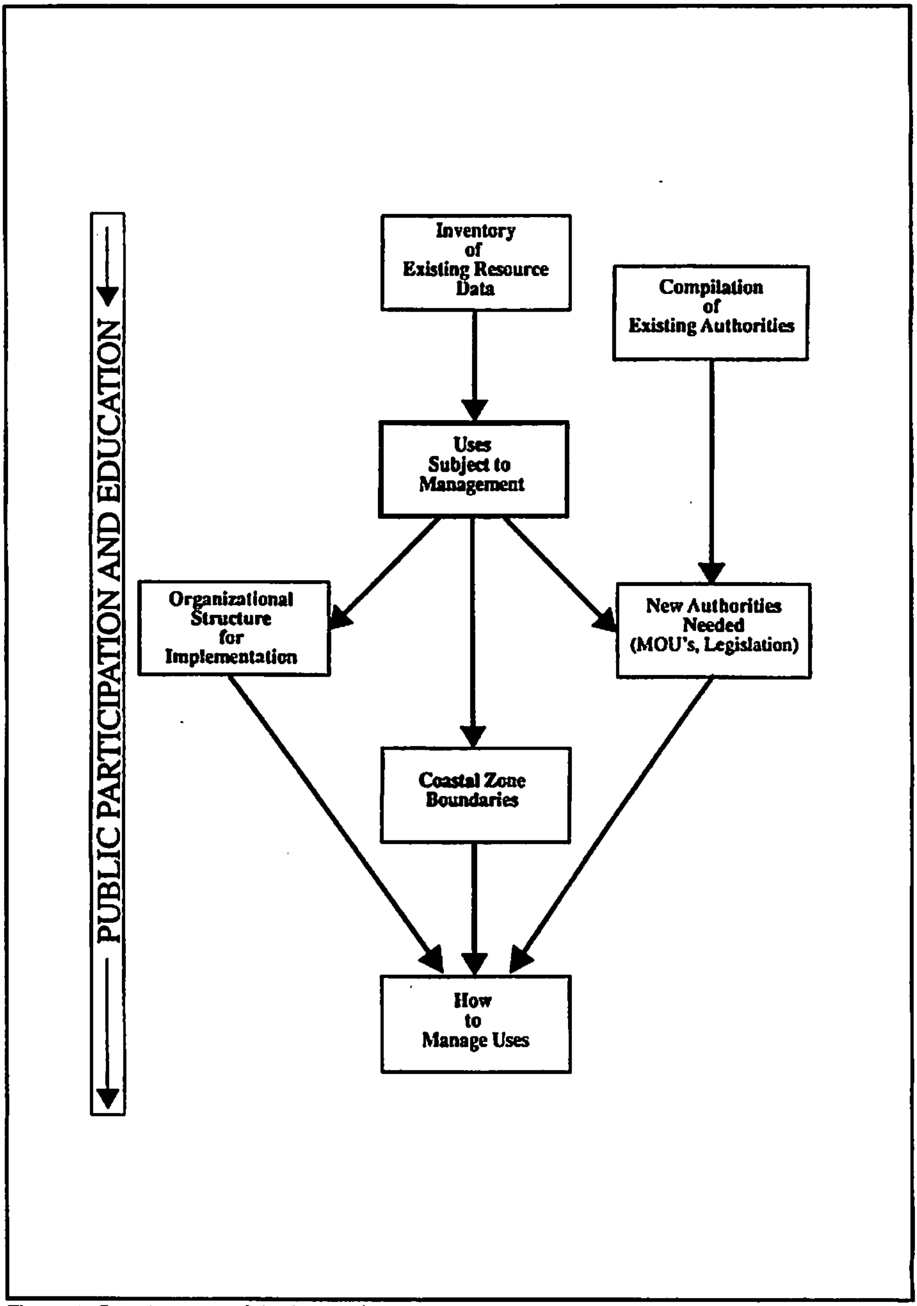

Figure 1. Development of the Texas Coastal Management Program.

THE EVOLUTION OF THE FEDERAL CONSISTENCY PROVISIONS: IMPACTS OF THE 1990 REAUTHORIZATION OF THE COASTAL ZONE MANAGEMENT ACT

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Introduction

The 1970s marked a new era in U.S. environmental protection efforts. One of the main pieces of legislation passed by Congress to protect the nation's coastal zone was the 1972 Coastal Zone Management Act (CZMA) (16 *U.S.C.A.* 1451-1464). (Sections 208, 303, 201 of the Federal Water Pollution Control Act Amendments also had provisions for planning in coastal areas.) The purpose of the CZMA has been to improve the management and protection of the nation's coastal resources. The emphasis of individual state efforts has been on issues such as the loss of marine resources and wildlife, decreased public space, multiple-use conflicts, and shoreline erosion (NOAA, 1988).

The CZMA is a voluntary grants-in-aid program administered by the National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce. In order to encourage state participation in the Coastal Zone Management (CZM) program, incentives were provided. Individual states were eligible for funding to plan and develop coastal resource management programs. Once approved, state management programs were eligible for implementation funding. But perhaps the most important incentive for participation in the program has been the federal consistency provisions.

The federal consistency provisions are found in three sections, 307(c)(1), 307(c)(2) and 307(c)(3), which deal with federal agency activities, federal development projects, and federally permitted activities, respectively. The federal consistency provisions have been important implementation tools because they ensure that federal agencies and federally permitted activities comply with approved state coastal management plans (NOAA, 1988).

This paper traces the evolution of the federal consistency provisions in the CZMA. It begins with a brief examination of the CZMA and then focuses on the development and interpretation of the federal consistency provisions. These provisions, when introduced, were thought to be powerful incentives for state participation in the CZM program. In the early 1980s, the power of these provisions diminished due to the Supreme Court ruling in the *Secretary of the Interior v. California* (464 *U.S.* 312 (1984)). However, the 1990 reauthorization of the CZMA (P.L. 101-508) reversed the court's decision and has given these provisions new life and importance. This paper will then examine some of the implications of the 1990 legislation, as well as some of the potential new uses of the federal consistency authority in other programs.

The Coastal Zone Management Act

In 1972, Congress declared four national coastal management policies with the CZMA. These policies are to preserve, protect, develop and, where possible, restore or enhance the resources of the U.S. coastal zone and to encourage state and local participation in the management of the coastal zone (16 *U.S.C.A.* 1452). In addition to these policies, Congress set nine performance standards to be met in the design of state coastal management programs. These included the protection of natural resources, consideration of water-dependent uses, consultation and coordination with federal agencies, as well as participation by the public and local governments in management and decisionmaking (16 *U.S.C.A.* 1452).

Although the CZMA relies primarily on states for the management of the resources, it declares that there is a national interest in the effective management, beneficial use, protection and development of the coastal zone (16 *U.S.C.A.* 1451). Two specific national interests in state coastal zone management programs have been energy and defense. Because the secretary of Commerce reviews or approves state programs, he or she has the responsibility of ensuring that state programs adequately address these national interests. Accordingly, the secretary has the power to deny approval of state programs if they fail to adequately recognize these national interests (Archer and Knecht, 1987).

Despite the many requirements with which state programs must comply to receive program approval, NOAA has granted a great deal of flexibility in the structure of these programs (Matuszeski, 1985). The CZMA only contains broad standards, which allow states to develop management programs that address issues of state and local concern (Lowry, 1985). Issues typically addressed by state programs include minimizing coastal hazards; public access; preserving coastal dependent uses; redeveloping urban waterfronts and ports; locating industrial and commercial facilities in the coastal zone; and clustering new coastal development (Archer, 1988).

Once their programs are approved, states are given a great deal of flexibility in implementing their programs. This has been unquestionably valuable because it allows each state to implement programs based upon the specific local conditions. Accordingly, states have relied upon a wide range of techniques to protect and manage their shorelines. Some typical examples of these techniques are special area management planning and direct permitting.

Perhaps the most important means of implementing the provisions of these programs has been the promise that once a state program is approved, federal agencies and permittees, whose activities affect the coastal zone and its resources, will remain consistent with state policies. This concept extends far beyond the advisory reviews of federal actions established under the National Environmental Policy Act (NEPA) (Dean, 1979). These federal consistency provisions allow states to reject certain federal actions that are not consistent with their approved CZM programs. This includes federal agency activities, as well as federally permitted activities and federally assisted projects and activities (Center for Urban and Regional Studies, 1991).

Federal Consistency Provisions Prior to 1990

Before the 1990 reauthorization of the CZMA, the federal consistency provisions required that federal activities that directly affect the coastal zone be consistent with approved state CZM programs. Section 307(c)(1) of the CZMA required that activities conducted or supported that directly affect the coastal zone, remain consistent, to the maximum extent practicable, with the state CZM programs.

Development projects undertaken by the federal government inside the coastal zone also had to remain consistent, to the maximum extent practicable, with the state program (Section 307(c)(2) of the CZMA). In addition, federally licensed and permitted activities affecting land or water uses in the coastal zone also had to remain consistent with the state CZM programs (Section 307(c)(3)(A)). The phrases, "directly affecting" and "to the maximum extent practicable," are common throughout Section 307 and have been contested because they are ambiguous.

Section 307(c)(1) stated that if a federal activity directly affects the coastal zone, federal consistency provisions apply. One issue that was not adequately addressed was whether outer continental shelf (OCS) oil and gas lease sales directly affect the coastal zone and therefore require a consistency determination. This uncertainty led to the *Secretary of Interior v. California* (464 *U.S.* 312 (1984)). To arrive at its decision, the Supreme Court reviewed the legislative history of the CZMA. It revealed that while some members of Congress wanted to expand consistency to cover federal activities regardless of exact location, an early version of Section 307(c)(1) required that only federal activities in the coastal zone be consistent (Eichenberg and Archer, 1987). In a compromise between the House of Representatives and the Senate, Section 307(c)(1) was expanded to "directly affecting" the coastal zone. Based on this legislative history, the Supreme Court ruled that the sale of OCS oil and gas leases was not an activity that directly affects the coastal zone.

The CZMA further required that federal activities directly affecting the coastal zone be consistent to the maximum extent practicable with approved CZM programs. This definition is crucial because it established a standard for federal agency compliance with approved state coastal management plans (Center for Urban and Regional Studies, 1991). In other words, Congress wanted federal agencies conducting or permitting activities directly affecting the coastal zone, to make a concerted effort to remain consistent with a state CZM program.

Federal Consistency Certifications and Determinations. Once the secretary of Commerce approves a state CZM program, any application for a federal permit or license for activities directly affecting the coastal zone must include a certification that the proposed activity complies and remains consistent with the enforceable policies in the CZM program (15 *C.F.R.* 930.57). If the state or designated agency fails to furnish, within six months, the required notification of its consistency review decision, concurrence is assumed (15 *C.F.R.* 930.63). No permit or license shall be granted unless the state or its designated agency concurs with the applicant's consistency certification or the secretary, on his or her initiative or on appeal by the applicant, deems the activity to be consistent with the state CZM program (15 *C.F.R.* 930.64; and 16 *U.S.C.A.* 1456(c)(3)(A)).

Federal agency activities directly affecting the coastal zone must make their own consistency determination to be reviewed by the state (15 *C.F.R.* 930.37). After 45 days, if the designated review agency fails to object, the federal activity may proceed (15 *C.F.R.* 930.41). If the state objects to the consistency determination, the federal activity may not proceed (15 *C.F.R.* Ch. IX, 930.42).

Federal Consistency Dispute Resolution. The CZMA has two administrative mechanisms for resolving disputes, mediation and administrative appeals. Mediation by the secretary of Commerce occurs in cases of serious disagreement between the coastal state and the federal agencies. Secretarial mediations may involve disagreements between state and federal agencies concerning consistency of federal activities, federal licenses and permits, and federal grants and assistance (16 *U.S.C.A.* 1456(h)). As of 1987, secretarial mediation had proven to be unsuccessful. (Only one dispute was mediated, and that settlement was later challenged in the Supreme Court case of the *Secretary of Interior v. California.* 464 *U.S.* 312 (1984)).

The CZMA also provides for appeals to the secretary to resolve state objections to federally permitted activities. The secretary may override a state objection if he or she finds that the activity is necessary in the interest of national security or if he or she finds the activity to remain consistent with a state program and the objectives of the CZMA (16 *U.S.C.A.* 1456(c)(3)). To override on national security grounds, the secretary must find that the project directly supports national defense or security (15 *C.F.R.* 930.122). In order to override a state's objection and determine that the activity is consistent with the CZMA, the secretary must find that it met a national objective listed in Sections 302 and 303 of the CZMA; that the national interest outweighs the adverse individual and environmental impacts; that the project is not in violation of the Clean Water Act or the Clean Air Act; and that there are no other reasonable alternatives for the disputed activity (15 *C.F.R.* 930.121).

As of 1987, 22 appeals had been filed with the secretary of Commerce (Eichenberg and Archer, 1987). In addition, from 1972 through 1990, 15 consistency decisions were issued; seven upheld the state's objections (Saurenman and Pease, 1991). The secretary has yet to override a state's objection on the grounds of national security (Saurenman and Pease, 1991). The appeal to the secretary of Commerce between South Carolina and Georgia in 1989 illustrates the complexity of the issues raised in the appeals process.

This controversy involved several federal agencies, the states of South Carolina and Georgia, and a private developer. South Carolina and NOAA asserted that the federal consistency provisions allow a state to review a project even though the project may not be located in the state's jurisdiction. On the other hand, the developer, Georgia officials, and the U.S. Army Corps of Engineers argued that the 1984 Supreme Court ruling in *Secretary of the Interior v. California* set a precedent for denying South Carolina the right to review this project (Archer and Eichenberg, 1989).

In 1988, L.J. Hooker Development applied for a dredge-and-fill permit from the Corps of Engineers to develop an area on Hutchinson Island in Georgia just across the Savannah River from South Carolina. On May 24, 1988, the South Carolina Coastal Council (SCCC) received notice from the Savannah District of the Corps of Engineers that it was undertaking review of Hooker's application. The SCCC told the Corps that the project would have direct and significant impacts on South Carolina's coastal waters. On Oct. 18, 1988, the SCCC found the project to be inconsistent with the South Carolina Coastal Management Program (SCCMP) (Cournoyer, 1986).

The Corps rejected the SCCC's objections, holding that the effects of the project would have only negligible impacts on South Carolina; Hooker appealed South Carolina's inconsistency ruling to the secretary of Commerce. However, a few months later, Hooker withdrew the consistency appeal because the project was addressing some of the impacts with which South Carolina was concerned. South Carolina in turn dropped most of its objections (Archer and Eichenberg, 1989).

This case presents two major legal issues. The first is whether a state with an approved coastal management program can review federally permitted activities outside of its coastal zone. The second is whether one state's federal consistency authority is limited when the federally permitted activity occurs within the boundaries of an adjacent state but impacts its own coastal zone (Archer and Eichenberg, 1989).

The plain language of Section 307 (c)(3)(a) clearly states that the activity need only affect the land or water of the coastal zone. In *Granite Rock Company v. California Coastal Commission* (590 F. Supp. 1361, 1365 (N.D. Cal. 1984)), the District Court held that "an activity outside but affecting the coastal zone ... would be subject to consistency review by the state." In addition, NOAA has interpreted Section 307(c)(3)(A) to allow a state to object to a proposed project "regardless of location" and to seek mediation or appeal to the secretary of Commerce (Archer and Eichenberg, 1989).

Although this dispute was resolved without a formal ruling, it raised serious questions about the extent to which a state may employ consistency reviews. This controversy lead to increased doubts concerning the strength of the consistency doctrine.

Federal Consistency Rulings

When administrative mechanisms fail to settle federal consistency conflicts, the disputing parties must turn to the courts for resolution. The three cases described below exemplify the variety of legal disputes that the courts have been asked to mediate. Each emphasizes the importance of federal consistency authority in the implementation of state CZM programs.

The Secretary of the Interior v. California. This 5-4 1984 Supreme Court decision drastically altered a state's power to use its federal consistency review authority. This case arose out of the secretary of the Interior's sale of oil and gas lease tracts on the OCS off California. The court ruled that oil and gas lease sales on the OCS are not subject to consistency review (464 *U.S.* 312 (1984)).

The phrases, "directly affecting" and "the maximum extent practicable," were of vital importance in the *Secretary of the Interior v. California*. The Department of the Interior claimed that no consistency review was necessary because lease sales do not directly affect the coastal zone. The state of California on the other hand insisted that a consistency review was necessary because the lease sale set in motion a chain of events culminating in activities directly affecting the coastal zone.

Justice O'Connor, writing for the majority, held that legislative history documented the intent of Congress to exclude lease sales from state consistency review. Congress had rejected a proposed provision that could have required that the secretary of Commerce "apply the coastal zone program to waters immediately adjacent to the coastal waters of a State, which that State has designated for specific preservation purposes" (118 *Cong. Rec.* 35549-35550 (1972)). Furthermore, Justice O'Connor cited the Outer Continental Shelf Lands Act Amendments of 1978, which defined four distinct stages in oil and gas development. The first two stages, preparation of a leasing program and lease sales, were not subject to review, because these activities do not directly affect the coastal zone (464 *U.S.* 312 (1984)).

The controversy surrounding this decision centered around the effect that it might have on consistency review policies. Justice Stevens said that the opinion will have the affect of "discourag[ing] rather than promot[ing] intergovernmental planning and cooperation ... and ... is squarely at odds with the CZMA's purposes" (Esler, 1986). This ruling weakened state consistency authority by restricting the range of activities that a state could object to, which thereby limits review to activities occurring within the coastal zone and restricts state consistency review authority (Eichenberg and Archer, 1987).

Chemical Waste Management Inc. v. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. *Secretary of the Interior v. California* created questions regarding a state's ability to review other federal ocean activities. The federal ocean waste disposal program is one area in which the state's powers remained undetermined. *Chemical Waste Management Inc. v. U.S. Department of Commerce, National Oceanic and Atmospheric Administration* involved this uncertainty (Cournoyer, 1986).

This dispute began when Chemical Waste Management Inc. (Chem Waste) applied to the Environmental Protection Agency (EPA) for a permit to conduct, for research purposes, a burn of hazardous wastes off New Jersey (Cournoyer, 1986). The proposal involved the transportation of 700,000 gallons of PCB-contaminated waste fuel oils from the Port of Philadelphia to a point 140 nautical miles east of the mouth of Delaware Bay. The *Vulcanus II* was to then conduct 19 days of test burns. Because of the vessel's route, New Jersey requested a consistency review.

New Jersey notified Chem Waste of the conditions that it had to meet before the state would approve the permit. Chem Waste objected to these conditions and sued EPA and the Department of Commerce. Chem Waste requested the court to declare that EPA, when making its permit decision, not consider New Jersey's permit conditions. The argument made by Chem Waste was that a state cannot impose requirements on an activity that federal law regulates. In other words, at issue was whether federal ocean waste disposal laws precluded New Jersey from attaching conditions to the federal discharge permit. Although Chem Waste did not argue regarding New Jersey's right to conduct a consistency review, it suggested that the federal ocean waste disposal laws preempted the consistency process (Cournoyer, 1986).

The district court agreed that it would not be proper to hear the case until EPA made its final permit decision. On June 1, 1986, EPA denied the permit, stating that the ocean incineration research should be postponed until final regulations on ocean incineration were issued. The parties did drop this case, but the legal issues surrounding the preemption of federal ocean waste disposal laws over consistency authority were left unsolved (Cournoyer, 1986).

Cape May Greene Inc. v. Warren (698 F.2d. 179). In this case, after reviewing factors such as flood hazards, air and water quality, traffic, and the effect of a proposed development on environmentally sensitive areas, New Jersey granted permission for construction of dwelling units in a floodplain area in Cape May. In part, this decision was based on the existence of development in the surrounding area.

In October 1978, at the same time this development was proposed, EPA said that it would fund the construction of a new sewage treatment plant to service this region. In June 1979, EPA conditioned the grant with a ban on all sewer hookups to lots in floodplains or environmentally sensitive areas. Many of these lots included those that New Jersey had granted permission to develop. EPA asserted that the hookup restriction was reasonable because a federal standard that is more protective than a state's standard may be enforced.

In *Cape May Green Inc. v. Warren*, the federal circuit court of appeals concluded that EPA acted arbitrarily by imposing sewer hookup restrictions for a new development in the floodplain (698 *F.2d.* 179). EPA's actions were found to be arbitrary because they did not give credence to the state's coastal management plan. Because consistency requires that federal agencies respect state policies, EPA's blatant inconsistencies were deemed arbitrary. In other words, EPA had overextended its authority by attempting to limit development in an area that the state coastal authority had determined appropriate. This ruling had the effect of strengthening the federal consistency authority of states with approved CZM programs.

1990 Amendments to the Federal Consistency Provisions

On Nov. 5, 1990, President Bush signed the Omnibus Budget Reconciliation Act (P.L. 101-508) reauthorizing the federal Coastal Zone Management program for five years and amending the provisions of the CZMA. A major accomplishment of these amendments is that they overturned the Supreme Court's 1984 decision in *Secretary of the Interior v. California* by subjecting outer continental shelf oil and gas lease sales to the federal consistency provisions (Section 307(c)(1)(A) of P.L. 101-508).

The new legislation clarifies that all federal agency activities, whether in or outside of the coastal zone, are subject to the consistency requirements of Section 307(c)(1) if they affect any land or water use or natural resource of the coastal zone. In other words, the requirement for consistency review is based on the effect of the activity on coastal zone uses and resources and not on location. Therefore the term "affecting" should be construed to include direct and indirect effects that the activity may cause.

Because of the limits and uncertainty that had been placed upon the power and use of the federal consistency provisions due primarily to the Supreme Court's ruling in *Secretary of the Interior v. California*, Congress felt a great deal of pressure from the coastal states to rewrite the federal consistency provisions of the CZMA thereby overturning the court's decision. The 1990 reauthorization was also an opportunity to repair and preserve the 20-year-old incentive for participation in the Coastal Zone Management program.

The amendment found in the new Section 307(c)(1)(A) reads as follows: "Each Federal agency activity within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone shall be carried out in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved state management programs."

Federal agency activities are subject to this section unless they are federal development projects in the coastal zone or involve the issuance of federal licenses or permits. Any development projects in the coastal zone shall be consistent to the maximum extent practicable with the enforceable policies of an approved state management program (Section 307(c)(2)). Federal license or permit activities, whether in or outside of the coastal zone and which affect any land or water use or natural resources of the coastal zone, shall provide a certification that the proposed activity complies with the enforceable policies of the state management program (Section 307(c)(3)(A)). Furthermore, any plan for the exploration or development of any area that has been leased under the Outer Continental Shelf Lands Act (43 *U.S.C.* 1331 *et seq.*) and regulations under the act shall attach a certification that all proposed activities comply with the enforceable policies of the state's approved management program, and that the activities will be carried out in a manner consistent with such a program. This language clearly overturns the *Secretary of the Interior v. California* decision. It extends the federal consistency review authority inland beyond the jurisdictional limits of a state's CZM program. It also extends consistency review authority to activities taking place seaward beyond the jurisdictional limits of a state's territorial sea. Essentially, any federal agency activity that affects any land, water or natural resources of the coastal zone is subject to a state's consistency review authority.

A new provision, Section 307(c)(1)(B), has been added entitling the president to exempt a specific federal project if it is in the paramount interest of the United States. This exemption can only occur after a federal court has determined the activity to be inconsistent with a state CZM program. But, the presidential exemption prevents states from having a complete veto power over federal activities. This legislation does prevent blanket exemptions and requires the president to use this authority case by case.

The 1990 reauthorization also refined the definition of enforceable policies as "state policies which are legally binding through constitutional provisions, laws, regulations, land use plans, ordinances, or judicial or administrative decisions by which a state exerts control over private and public land uses or natural resources in the coastal zone" (Section 304 (6a) as amended). This definition was included to apply the same consistency standard to federal activities that is applied to state and private activities. Thus, as the scope of a state's federal consistency authority is expanded, limits are placed upon the elements of an approved CZM program that would be subject to the expanded federal consistency authority.

Summary and Conclusions

The federal consistency provisions emerged in an era of tremendous environmental consciousness, almost collapsed in the 1980s, and is now more powerful than ever. The ability to require federal agency action and financial assistance to remain consistent with a state program is a powerful implementation tool and an essential element of many state coastal management programs.

Congress has recognized the importance of the concept of federal consistency and has incorporated similar consistency provisions and requirements into many other coastal environmental programs to allow states to more effectively implement their programs and to give states an added incentive to participate. For example, Section 320 of the 1987 Water Quality Act (WQA) (P.L. 100-4) includes a requirement to conduct a "Purpose 7" consistency review. Section 320(b)(7) is designed to identify federal financial assistance programs and development projects that are inconsistent with the provisions of the comprehensive conservation and management plans (CCMP) that are to be produced by estuaries in the National

Estuary Program (NEP). The main objective of the Purpose 7 review is to provide a means of negotiation and cooperation between the private and the local, state and federal public sectors (EPA, 1991). It is also intended to have the CCMP identify an ongoing process by which the state ensures that federal activities remain consistent with the CCMP's provisions. For the most part, this is to be accomplished through the coordination of existing consistency review powers such as those provided under the Executive Order (E.O.) 12372 process and under Section 307 of the CZMA. This coordination of review authority ensures that federal agency activities are consistent with the provisions of a CCMP that is produced (EPA, 1991). In addition, relevant portions of the CCMPs are supposed to ultimately become incorporated into NOAA's state coastal programs (1988 Memorandum of Understanding between EPA and NOAA). This will allow Section 307 federal consistency authority to be applied to those enforceable policies that become incorporated into CZM programs.

The Purpose 7 consistency authority is not as powerful as the authority of federal consistency under the CZMA because it cannot preempt federal activities. Under this mechanism, the management conference, a decisionmaking system composed of numerous committees, identifies federal financial assistance programs and development projects, applications and proposals that it would like to review (EPA, 1991). If the programs and projects listed for review are also subject to E.O. 12372, then the management conference's review can be incorporated into the "state process recommendation," which comprises the official comments by the state to the federal agency (EPA, 1991). The federal agency then has three options; to accept the recommendation; to negotiate acceptable solutions; or to explain in writing why the recommendation cannot be accepted (EPA, 1991). Under this E.O. 12372 process the federal agency is obliged only to "accommodate and explain." Thus, estuary programs have an incentive to develop enforceable policies that can be incorporated into state coastal programs such that Section 307 federal consistency authority applies. This could, in many cases, expand the scope of policies subject to Section 307 reviews.

Another consistency provision that undoubtedly will increase in importance is contained in EPA's Section 319 Nonpoint Source Management Program created by the 1987 WQA (P.L. 100-4). This consistency review process is similar to the Section 320 consistency process except Section 319 has a broader authority. Section 319 requires federal financial assistance programs and development projects listed under E.O. 12372 and those listed in the *Catalog of Federal Domestic Assistance* to "accommodate and explain." This enables programs under Section 319 guidance to comment on a greater variety of federal agency activities.

As states with approved CZM programs develop their Section 6217 coastal non-point-source pollution programs, it is reasonable to expect that an increased use of consistency review authority and a coordination in existing review processes will occur.

Whereas the first two decades saw the federal consistency provisions weakened, the next two decades will inevitably see the expansion of the concept. This expansion is essential in order to allow states to develop effective coastal environmental management programs. Expansion will also help to coordinate governmental activities and reduce inefficiencies that arise through intergovernmental conflict. But, as the use of federal consistency authority continues to evolve, several new questions are expected to arise.

One question being asked is, what level of state control is necessary to have a policy considered to be enforceable? As states begin to develop their Section 6217 coastal non-point-source pollution plans and individual estuary programs continue to develop their CCMPs, this is certainly going to be a subject of increased attention.

As states begin to expand their federal consistency authority to federal activities not only offshore but to federal activities that are inland beyond the jurisdictional boundaries of both approved state CZM programs, the phrase "affects any land or water use or natural resource of the coastal zone" is likely to be challenged legally. In addition, it is also likely that many more interstate disputes will emerge as federal consistency authority is applied to federal activities taking place in other states' jurisdiction. Thus, there may be expanded use of existing dispute resolution processes.

Perhaps the most interesting question involves the expanded use of similar consistency provisions to other environmental programs. Section 307 federal consistency authority remains unquestionably the strongest provision of its type. However, Congress has continued to create coastal environmental programs with overlapping boundaries, such as between EPA's National Estuary Program and NOAA's Coastal Zone Management programs, and between NOAA's Section 6217 Coastal Nonpoint Source Plans and EPA's Section 319 Nonpoint Source Management Plans. The problem is the difference in federal mandates. EPA seeks to protect and improve the environment, while NOAA's coastal programs seek to balance the needs of conservation with those of development. In the future it is reasonable to expect conflict between these two programs as each develops along a different mandate and seeks to make the other consistent with its approach.

Other federal agencies are beginning to understand the usefulness of federal consistency as an implementation tool and are now attempting to integrate this concept into their programs. The true power and usefulness of federal consistency remains to be seen.

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Pollution

CLEANING UP HAZARDOUS WASTE DISPOSAL SITES IN THE COASTAL ZONE: A REVIEW OF FEDERAL AND STATE LEGAL REQUIREMENTS FOR REMEDIATION AT ALLEN HARBOR, NARRAGANSETT BAY, R.I.

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Abstract

In many coastal areas hazardous waste disposal practices have created current pollution problems. Cleanup and restoration of these sites poses significant technical, social, political and legal questions. The wide diversity of coastal areas and the complexity of various federal, state and local laws and regulations makes it necessary to focus this review on the specific requirements pertaining to a hazardous waste site investigation being conducted by the U.S. Navy at the Naval Construction Battalion Center Davisville, located adjacent to Allen Harbor in Narragansett Bay, R.I. The cleanup requirements specified by the Comprehensive Response Compensation and Liability Act (CERCLA) and the National Contingency Plan (NCP) are reviewed in the context of other federal and state laws and regulations including the Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Coastal Zone Management Act (CZMA), Resource Conservation and Recovery Act (RCRA), natural resource protection (fisheries, endangered species, migratory birds, etc.), federal facility agreements (FFA) and Rhode Island statutes that define applicable or relevant and appropriate requirements (ARARs) for remediation. The cleanup requirements common to all coastal disposal sites, the relationship between cleanup and other coastal zone management issues, and the need for development of an effective policy strategy for coastal cleanup projects are presented and discussed.

Introduction

Coastal areas are coming under increasing pressure from development, land use, runoff and pollution discharge. An area of major concern is the cleanup of toxic and hazardous materials that have been disposed in coastal areas. Disposal practices which were deemed acceptable only 20 to 30 years ago have left a legacy of pollution and the threat of environmental harm. Coastal and estuarine areas are important economic and ecological resources, and the ultimate question of impact depends on the ability of the environment to assimilate the wastes. Impacts could have a direct impact on human health through contaminated seafood and closures of recreational areas because of unsafe contamination levels. Cleanup and restoration

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pose significant technical, social and political questions. Can the potential impact of the disposal sites be accurately assessed, and is there technology available to effectively remediate the impact? Will the threat to the environment be reduced, or will cleanup efforts only make the problem worse? This is especially critical in coastal wetland areas where mixing by tides and currents and biological interactions tend to spread and/or concentrate contaminants in complex patterns. Other questions that must be addressed are: Who pays for the cleanup; what are legal requirements for cleanup and how are priorities for cleanup established; and, how clean is clean?

Some of the answers are contained within the legal framework that defines the requirements and identifies the responsibilities for cleaning up hazardous waste disposal sites. The Navy's investigation at NCBC Davisville will serve as a site-specific example of how cleanup requirements interact with other coastal requirements and management issues (see Table 1 for acronyms used in the paper). The specific requirements of other coastal disposal sites will differ, but the basic aspects will be similar and will provide a useful evaluation of the legal requirements pertaining to coastal zone cleanups.

Disposal Site Description

Allen Harbor has been closed for shellfishing by RIDEM due to suspected hazardous waste contamination from a landfill and disposal area adjacent to the harbor (Figure 1). The landfill, about 15 acres in size, received a wide variety of wastes, including sewage sludge, solvents, paints, chromic acid, polychlorinated biphenyl-contaminated waste oils, preservatives, blasting grit, demolition debris, burned material and other municipal and industrial wastes generated at NCBC Davisville and Naval Air Station Quonset Point between 1946 to 1972. For most of the landfill operation, wastes were simply deposited in a low-lying marshy area adjacent to the harbor. During the latter period of disposal (after 1970) wastes were burned and buried. When disposal activities ceased (about 1972) a two- to six-foot cover of soil was placed over the landfill (Naval Energy and Environmental Support Activity, 1984), which has since revegetated into dense brush. Adjacent to the landfill is a wetland area that has been designated a Coastal Wetland (CRMC, 1983). Allen Harbor is also used for recreational boating, especially in the summer (URI, 1990).

There are 14 other disposal sites, located on the base, which could potentially impact aquatic resources. These include a chemical disposal site located on Calf Pasture Point, battery acid disposal area, underground storage tanks, solvent disposal areas, a transformer oil disposal area, and a film processing disposal area. Previous analyses of sediment and bivalve tissues from Allen Harbor have shown increased levels of heavy metals and organics (TRC Environmental Consultants Inc., 1986). The site investigations at NCBC Davisville are being funded by the Department of Defense Environmental Restoration Program and administered through the Navy's Installation Restoration Program by the Northern Division of Naval Facilities Engineering Command, Philadelphia. In 1989 NCBC Davisville was added to the NPL by EPA (54 *Fed. Reg.* 48184, 1989). On April 15, 1991 NCBC Davisville was among the installations recommended for closure and realignment by DOD, in accordance with the National Defense Authorization Act of 1991 (56 *Fed. Reg.* 15184, 1991).

CERCLA Requirements

The requirements for cleaning up past hazardous waste disposal sites are defined by CERCLA as amended by SARA. Under CERCLA a facility is defined as "any site or area where a hazardous substance had been deposited, stored, disposed of or placed or otherwise come to be located" (42 *U.S.C.* 9601 Section 101). For NCBC Davisville, a federally owned and operated facility, the whole Navy base is considered a "facility" with multiple disposal sites. These sites must be investigated to determine whether a "remedy" or "remedial action" ("those actions consistent with permanent remedy taken instead of or in addition to removal actions") must be developed. Under CERCLA, parties responsible for a "release" are responsible for the cleanup and liable for the recovery of damages for injury or loss of natural resources resulting from the release (42 *U.S.C.* Section 9601; 40 *C.F.R.* Section 300.72).

The amendments added by SARA included provisions to specifically apply CERCLA to federally owned facilities: "in the same manner and to the same extent, both procedurally and substantively as any non-government entity, including liability" (42 *U.S.C.* Section 9601(120)). In addition, SARA increased public involvement by directing responsible parties to prepare community relations plans. Community relations planning involves establishing an administrative record, soliciting inputs from the community located near the facility and forming a TRC to oversee the remedial activities at the facility.

An RI/FS is currently underway at NCBC Davisville to determine the appropriate response and remedy for the disposal sites. Investigation activities at the facility are overseen by a TRC, which is made up of representatives from the Navy, including the base commander and executive officer, the remedial program manager from Northern Division of Naval Facilities Engineering Command, Philadelphia, and Navy contractors. Members of the TRC also include representatives from EPA Region I, RIDEM, and the town of North Kingston. In addition, technical representatives from the EPA Environmental Research Laboratory, Narragansett; Naval Command Control and Ocean Surveillance Center, San Diego; U.S. Public Health Service; National Oceanic and Atmospheric Administration (NOAA); U.S. Fish and Wildlife Service (USFWS); University of Rhode Island Graduate School of Oceanography; Narragansett Bay Project; and Save the Bay also regularly attend and participate in the TRC meetings. The purpose of the TRC is to provide a technical forum to review, comment and provide guidance on the site investigations and remedial options being developed for the site. At this writing 21 TRC meetings have been held at NCBC Davisville (U.S. Dept. of Navy, 1992). The investigations at NCBC Davisville are attempting to characterize the level of contamination at the disposal sites, determine impacts on groundwater and hydrology (TRC Environmental Consultants Inc., 1992), and determine impacts on the marine environment (Munns et al., 1991). All workplans, data, information, progress, interim and final reports presented at TRC meetings are included in the administrative record and placed in a repository located at the North Kingston Public Library.

National Contingency Plan (NCP)

A main provision of CERCLA is the implementation of the NCP to provide a unifying framework to coordinate and "effectuate the response powers and responsibilities created by CERCLA and the authorities established by Section 311 of the Clean Water Act" (40 *C.F.R.* Section 300.1). The NCP provides guidance on the responsibilities and response actions to be initiated in the event of "discharges or substantial threat of discharges ... to ... navigable waters of the United States and adjoining shorelines, and the high seas, or which may affect natural resources" (40 *C.F.R.* Section 300.31). The NCP outlines the requirements for responding to uncontrolled hazardous waste disposal sites and establishes the NPL to identify the sites with the highest priority for cleanup and eligibility for cost recovery from Superfund. In order to identify the highest priority sites a Hazard Ranking System was developed to evaluate the potential public health and environmental threat posed by disposal sites. If a facility's score is greater than 28.5 the facility is eligible for listing on the NPL. Currently 1,183 sites are listed on the NPL and 116 are federal facilities (57 *Fed. Reg.* 4824, 1992). The NCP also identifies the response activities required to clean up hazardous waste disposal sites (Table 2). The response actions may be considered to consist of three phases: determine whether a site should be listed on NPL, assess site conditions and evaluate alternatives, and cleanup. The RI/FS, currently in progress at NCBC Davisville, includes development and execution of sampling, quality control and quality assurance plans, which are developed with advice from EPA, RIDEM, and members of the TRC. A community relations plan has been developed and implemented to keep the public informed of the Navy's progress during the investigation (Table 2).

During the RI/FS the ARARs will also be developed by EPA, RIDEM, natural resource trustees, and the Navy. Applicable requirements are promulgated federal and state regulations that define specific requirements for hazardous substances found at CERCLA sites. Although relevant and appropriate requirements are also standards promulgated under federal or state law, they do not specifically define numerical standards, but rather "address [other] problems or situations sufficiently similar to those encountered at the CERCLA site" (55 *Fed. Reg.* 8814, 1990). The selected remedy must be able to meet or exceed the ARARs identified for chemical-specific, location-specific, and action-specific conditions at the site. State standards can also identify ARARs, if they are more stringent than federal standards and if they are identified in a timely manner.

The ARARs can be used to establish objectives for cleanup and provide guidance for selecting treatment options. Examples of ARARs that can be identified for Allen Harbor are SDWA maximum contaminant levels, or soil contamination levels set by regulations promulgated under RCRA. CERCLA requires that all ARARs are attained irregardless of whether a less stringent requirement would provide adequate protection of human health and the environment, because remedies must "be protective of human health and the environmental *and* attain ARARs" (55 *Fed. Reg.* 8741, 1990). However, in some instances, "variances" or "exemptions" may be invoked to satisfy specific ARARs (55 *Fed. Reg.* 8741, 1990).

At the completion of the feasibility studies treatment technologies should be narrowed to only those which are feasible, implementable and cost-effective. The selection of a remedy will require close cooperation with the state and community. At the end of the public review and comment period a Record of Decision (ROD) is signed and remediation may begin.

Natural Resource Trustees

Under NCP guidelines, responsible parties are required to notify and coordinate site cleanup with Natural Resource Trustees. Trustees are federal officials who act on behalf of the public as trustees for natural resources (Table 3). Trustees are "authorized to act when there is injury to, destruction of, loss of, or threat to natural resources as a result of a release of a hazardous substance" (40 *C.F.R.* Section 300.600). Interior is tasked with developing regulations for determining natural resource damage and has promulgated regulations for procedures for simplified assessments in coastal marine environments (52 *Fed. Reg.* 9042, 1987) and site-specific detailed assessments for specific cases (51 *Fed. Reg.* 27674, 1986). Interior has proposed revisions to damage assessment procedures to comply with a court ruling. The court held that restoration or replacement costs should be used to determine natural resource damage under CERCLA rather than costs determined from lost value or use of the resource (54 *Fed. Reg.* 39016, 1989; 56 *Fed. Reg.* 19752, 1991).

The Navy, which has a dual role in the cleanup program—Responsible Party and Natural Resource Trustee, must coordinate the remediation effort with the other federal trustees (NOAA and USFWS) and state trustee (RIDEM). The interaction between trustees is key to obtaining adequate natural resource protection because it is unlikely that one trustee would bring action against another as a means of compensation for resource injury. The preferred approach is to work closely with the federal facility through the remedial investigation process to develop an environmentally protective remedy (Finkelstein, 1991).

Federal Facility Agreement (FFA)

The coordination between the Navy, EPA and the state of Rhode Island has been enhanced by the March 23, 1992, signing of a FAA for NCBC Davisville (U.S. EPA et al., 1992). The FFA will help ensure that all actions necessary "to protect public health, welfare and environment" are taken within the procedural framework required by CERCLA. Provisions covered by the FFA include procedures and schedules for conducting the site investigation, selecting remedies, resolving disputes, expediting cleanup, and enforcement. Language is also included pertaining to base closure issues, implementing and maintaining cleanup technologies, and integrating the CERCLA response with other federal (Table 4) and state statutes (Table 5) to determine site-specific ARARs. The deadlines specified in the FFA require the Navy to complete the RI/FS by Sept. 15, 1994 and develop RODs for each of the disposal sites by May 15, 1995. However, deadlines may be extended if there are justifiable circumstances, such as discovering significantly different conditions at the sites during the RI/FS (U.S. EPA et al., 1992). The agreement should expedite the cleanup process because it clearly defines the responsibilities of each party and identifies the procedures for selecting appropriate remedies. Moreover, the agreement does not release the Navy from claims resulting from "damage to natural resources..., failure to meet a requirement of the agreement, [or] liability for the disposal of any hazardous substances taken from the site" (U.S. EPA et al., 1992).

Cleanup Requirements

Remedies selected for Allen Harbor must protect human health and the environment, and comply with ARARs and allowed waivers. The remedy should be cost-effective, encompass long-term solutions, and reduce toxicity, mobility or volume of hazardous material. Finally, the remedy must meet state and community acceptance. The RIDEM seeks to ensure consistent application of state statutes and regulations as they apply to the remediation process, and keeps other state agencies and townships informed, such as the Coastal Resource Management Council.

The Coastal Resource Management Plan was developed as part of Rhode Island's coastal zone management program and is designed to regulate activities in the coastal zone by establishing management categories for coastal activities. Allen Harbor is designated (Type 3) for high-intensity recreational boating (Figure 1). In fact, the council has earmarked Allen Harbor for marina development to meet the growing demand for recreational boating facilities (CRMC, 1983; URI, 1990). The classification of areas adjacent to Allen Harbor are industrial waterfronts and commercial navigation channels (Type 6), multipurpose areas (Type 4), and conservation areas (Type 1) (Figure 1). The coastal wetland designation and the Type 3 water classification means harbor uses should be consistent with "marinas, boatyards, and associated businesses [which] take priority over other uses, and dredging and shoreline alterations are to be expected" (CRMC, 1983). However, since these wetland areas have been designated for preservation, dredging and filling are prohibited and alterations are limited (CRMC, 1983). The situation is further complicated by the fact that Allen Harbor waters are classified as "SA" (highest attainable quality) (R.I. Statewide Planning Program and R.I. Dept. of Health, 1977) and would be eligible for shellfishing, if not for the special closure within the harbor. Quahog clams are abundant in the harbor and were commercially harvested in the past (Pesch; Ganz and Sisson, 1977).

Conclusion

At this time the RI/FS at Allen Harbor has not progressed far enough to determine whether the potential impact has been accurately assessed and whether technologies are available to remediate any impact. The apparent conflicting uses regulated for Allen Harbor could require significantly different cleanup standards depending on whether the harbor is used as a shellfish resource or as a high-intensity recreational boating and marina facility. Provisions of the FFA and CERCLA require the Navy to maintain financial and managerial responsibility for cleanup even after the Navy base is closed and property ownership is transferred. Therefore, the remedies selected must provide long-term solutions and account for changing coastal uses which will ultimately determine how clean is clean.

The conflicting use designations and the enormous job of meeting the legal requirements for site cleanup (see Tables 4 and 5) are common to almost all coastal hazardous waste sites. The estimated cost of compliance for the two Navy-owned superfund sites in Narragansett Bay (NCBC Davisville and Naval Education and Training Center Newport) is in excess of $65 Million (Fleming, 1992). The accumulative effect of such sites, multiplied around the nation's coastal areas, makes it imperative that policies are implemented that will assure better management and protection of coastal resources. The all-encompassing aspects of CERCLA and the significant level of public funds required for the program[2] may provide the unifying framework necessary to cut across jurisdictional boundaries, tackle heretofore technically infeasible alternatives, and develop environmental protection strategies consistent with environmental quality.

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40 *C.F.R.* Section 300.31.

40 *C.F.R.* Section 300.600.

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[2]The U.S. EPA Office of Program Management estimates that it will take more than $37 billion to remediate all of the sites listed on the NPL. See 57 *Fed. Reg.* 4829 (1992). DOD has budgeted $1,062M, $1,562M, and $1,513M for fiscal years 1991, 1992, and 1993, respectively, to pay for the military's cleanup program (pers. comm., Deborah Rayworth, Office of the Assistant Commander for Environment Safety and Health, Naval Facilities Engineering Command, Alexandria, Va.).

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Table 1. Acronyms used in paper.

ARARs	Applicable or Relevant and Appropriate Requirements
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulation
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DOA	U.S. Department of Agriculture
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NCBC	Naval Construction Battalion Center
RCRA	Resource Conservation & Recovery Act
RIDEM	Rhode Island Department of Environmental Management
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendment and Reauthorization Act
SDWA	Safe Drinking Water Act
TRC	Technical Review Committee
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service

Table 2. The process required by the NCP to clean up hazardous waste disposal sites.

PHASE I

Remedial Preliminary Assessment (PA)
Evaluate release and review available information
Removal action? Further investigation necessary?

Remedial Site Investigation (SI)
Collect and develop additional data

Hazard ranking:	Removal action?
	Further investigation necessary?
Include on NPL?	Hazard score > 28.5?
	Highest priority for state?
Or (all of the following):	
	1. ATSDR issues health advisory
	2. EPA determines significant threat
	3. EPA determines more cost effective

PHASE II

Remedial Investigation/Feasibility Study (RI/FS)
Assess site conditions and evaluate alternatives
Workplans: Sampling, analysis, quality assurance
Natural resource assessment
Community relations planning

Remedial Investigation (RI)
Data collection: Wastes, exposure, and effects
Assess risks to human health and environment

Feasibility study (FS)
Evaluate alternatives and establish objectives
Identify ARARs and evaluate remedies

Selection of Remedy
State and community acceptance
Public review and comment

PHASE III: RECORD OF DECISION (ROD)

Remedial Design
Develop remediation plan

Remedial Action
Implement remediation

Operation and Maintenance
State assumes responsibility for 10-year treatment

Table 3. Natural Resource Trustees, 40 *C.F.R.* 300.

Department of Commerce (NOAA)
Waters navigable by deep-draft vessels
Tidally influenced waters
Waters of the contiguous zone
Exclusive Economic Zone/Outer Continental Shelf
(Marine and anadromous fishes, marine mammals)

Department of the Interior (USFWS)
Areas managed by DOI
Federally owned minerals and water resources
(Migratory birds, certain endangered species)

Department of Transportation (Coast Guard)
Navigable waters

Land Managing Agency
Natural resources located on, over, or under land administered by federal government (DOI, DOA, DOD, DOE, Indian tribes)

State Trustees
Natural resources within the state

Table 4. Federal laws that can define ARARs.

STATUTE/COMMENT	REGULATION
Clean Water Act (33 *U.S.C.* 1300 *et seq.*)	
Effluent guidelines for discharge	40 *C.F.R.* 122
Water quality criteria	40 *C.F.R.* 125
Toxic pollutant standards	40 *C.F.R.* 129
Water quality planning requirements	40 *C.F.R.* 130
Water quality standards	40 *C.F.R.* 131
Safe Drinking Water Act (33 *U.S.C.* 1251 *et seq.*)	
Drinking Water Regulations	40 *C.F.R.* 141
Maximum Contaminant Level Goals	40 *C.F.R.* 142
Maximum Contaminant Level Standards	40 *C.F.R.* 143
Toxic Substances Control (15 *U.S.C.* 2601 *et seq*)	
Toxicity Testing Guidelines	40 *C.F.R.* 797
Solid Waste Disposal Act (42 *U.S.C.* 3251 *et seq.*)	
Defines Hazardous Substances	40 *C.F.R.* 116
Determines Reportable Quantities	40 *C.F.R.* 117
RCRA (42 *U.S.C.* 6901 *et seq.*)	
Waste Storage, Use and Disposal	40 *C.F.R.* 243
Disposal Facilities	40 *C.F.R.* 265
Hazardous Waste Management	40 *C.F.R.* 266
Clean Air Act (42 *U.S.C.* 7401 *et seq.*)	
Ambient Air Quality Standards	40 *C.F.R.* 50
Emission Standards	40 *C.F.R.* 61
Coastal Zone Management (16 *U.S.C.* 1451 *et seq.*)	
Land-use planning	15 *C.F.R.* 923
NEPA (42 *U.S.C.* 4321 *et seq.*)	
Environmental Impact Statements	40 *C.F.R.* 1502
Rivers and Harbors Act (33 *U.S.C.* 2200 *et seq.*)	
Oil and Hazardous Substance Removal	33 *C.F.R.* 153
Marine Protection, Research and Sanctuaries Act (16 *U.S.C.* 1431 *et seq.*)	
Ocean Dumping and Resources	33 *C.F.R.* 1401
Endangered Species (16 *U.S.C.* 1531 *et seq.*)	
Conservation and Protection	50 *C.F.R.* 17
Fisheries Management Act (16 *U.S.C.* 1801 *et seq.*)	
Conservation and Management	50 *C.F.R.* 620
Migratory Bird Act (16 *U.S.C.* 715 *et seq.*)	
Conservation and Protection	50 *C.F.R.* 20
Sikes Act (16 *U.S.C.* 670a *et seq.*)	
Conservation on Military Reservations	

Table 5. Rhode Island laws that can define ARARs.

General Law	Title	Comment
2-1-20	Fresh Water Wetlands Act	Wetland management and conservation
20-3	Marine Fisheries Council	Regulates quahog dredging
20-7	Lobster and Other Crustaceans	Lobster and crab harvests
20-8.1	Shellfish Grounds	Regulates growing and taking of shellfish
23-18.9	Refuse Disposal Act	Regulates disposal of hazardous materials
23-19.1	Hazardous Waste Management	Storage, transport, and disposal
23-23	Rhode Island Clean Air Act	Air quality standards
46-12	Water Pollution	Defines water pollution; permits for discharge
46-12-25	Solid Waste Disposal Areas	Sets monitoring requirements
46-12-28	Protection of Groundwater	Establishes groundwater protection goals
46-13.1	Rhode Island Groundwater Protection Act	Clean drinking water standards
46-15	Water Resources Board	Manage water resources
46-23-1	Coastal Resources Management Act	Coastal planning
46-25	Narragansett Bay Water Quality Management	Water quality management

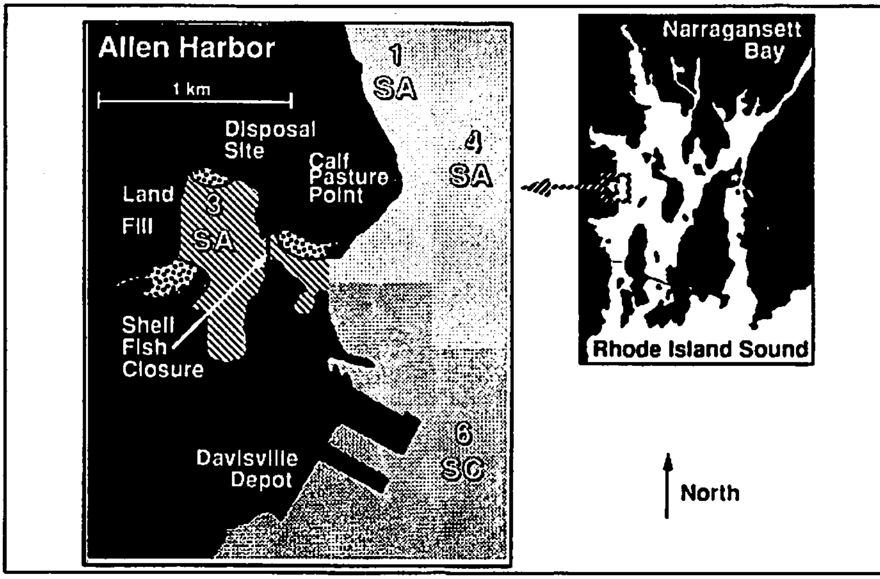

Figure 1. Location of Allen Harbor and adjacent disposal sites. Also shown are management areas for wetlands (stipple) conservation, multipurpose, commercial and high-intensity boating (diagonal) uses.

ECOLOGICAL EFFECTS OF CCA-TREATED LUMBER IN COASTAL AREAS

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Summary

Copper, chromium and arsenic leach from wooden structures treated with chromated copper arsenate (CCA) that are placed in the estuarine environment. These contaminants can accumulate in the "fouling" or epibiotic community that grows on the wood surface. Elevated levels of the contaminants were found in two species of green algae growing on treated wood, and in oysters attached to CCA bulkheads. When the algae were fed to grazing snails, the snails retracted into their shells, and many died within a month. In contrast, snails fed control algae remained active. The three metals were also found to accumulate in nearby benthic organisms (fiddler crabs), which probably pick up the contaminants from the sediments in which they live. When boards made of treated wood and control wood were placed into the estuary, the community that formed on the CCA wood had lower species richness, lower biomass and lower diversity than the community on the control wood.

Introduction

To prevent rot, wooden structures placed into the marine environment are often preserved with chemicals. A common wood preservative for bulkheads and docks is chromated copper arsenate, or CCA, which is pressurized into the wood, making it green. The process of preserving wood with these elements is called "Wolmanizing" and generally uses oxides (CrO_3, CuO and As_2O_5). While wood designed to be placed on land generally receives 0.4 lb/ft^3 of the mixture, wood designed for marine use receives between 1.5 lbs/ft^3 and 2.5 lbs/ft^3. While each of the three elements is known to be toxic to aquatic biota, there has been little work on effects of treated wood in the estuaries into which it is so often placed.

Treated wood structures may be located in backwater areas with little circulation, which may allow chemicals to accumulate. Therefore it is important to determine to what degree chemicals may leach out from treated wood, and whether toxic effects to biota may ensue. Warner and Solomon (1990) showed that in fresh water leaching of all three metals occurs, with leaching being greater at lower pH. Sanders (pers. comm.) has measured leaching rates of 14.8 µg/cm^2 Cu, 0.65 µg/cm^2 Cr, and 28.4 µg/cm^2 As from wood treated with 0.4 lbs/ft^3 placed in 12‰ salinity for one week.

Our earlier work also demonstrated that in the laboratory, metals do leach out from the wood in seawater and that the rates generally decrease over time. This study also demonstrated toxicity to a variety of estuarine biota. One particularly sensitive organism was the mud snail *Nassarius obsoletus*, which, in response to the leachates, retracted into its shell and lay on the bottom of the aquarium, and finally died. Retracted snails were distinguished from dead ones by their response to a probe. Toxicity was reduced in experiments in which the wood had previously leached out some of its contents.

Experiments in which snails were exposed to individual metals and combinations ascertained that the response is primarily to copper, which is also the one leached to the greatest extent from the wood. The response is not dependent on accumulation of the copper, however, since snails placed in leachates from CCA wood often exhibited the response within one hour, which is not enough time for uptake of significant levels of the metal. Such animals quickly recovered when placed in clean seawater. Other experiments demonstrated that limb regeneration and molting in fiddler crabs (*Uca pugilator*) were retarded by leachates from CCA wood. Subsequent studies showed toxicity of CCA-treated wood in a sea urchin fertilization bioassay (Weis et al., 1992). These experiments were done in confined containers in which chemicals could build up to lethal levels, unlike an estuary in which water movements can dilute the leachates.

Chemicals leaching from treated wood can enter aquatic food webs via different routes. They can dissolve in water and be taken up directly by biota, and they can be initially adsorbed onto sediments and be taken up by benthic organisms. Uptake from the aquatic phase would be expected to be greatest by encrusting organisms that live directly on the wood surface. Some of these might accumulate elevated levels of chemicals that could then be transferred trophically to motile organisms that feed on these members of the fouling community. The actual environmental impact of CCA wood structures in a particular estuary will depend on a number of factors, including the amount leached (determined by the area of leaching and the leaching rate); the rate of current flow to dilute and disperse leachates; the rate of uptake by the fouling community (determined by the species present and their density); the adsorptive capacity of the sediments (determined largely by particle size distribution); and uptake from the sediments by benthos.

In the present study we investigated whether the macroalgae that grow on treated wood develop elevated levels of the chemicals, and whether they can then be passed on to grazing animals (mud snails). We also studied metal levels in oysters attached to CCA wood and in fiddler crabs, which live in burrows in the intertidal zone and would be expected to accumulate metals primarily via the sediments. We also studied differences in the epibiotic community that develops on CCA wood compared to that forming on untreated wood.

Materials and Methods

Ulva lactuca and *Enteromorpha intestinalis* were picked off CCA-treated wood bulkheads and floating docks in Fort Pond Bay, Southampton, N.Y. in July, to be used as experimental material. The structures were about three years old. Subsamples of algae were frozen for metal analysis. Additional samples of both species of macroalgae were collected from rocks in Fort Pond Bay to be used as control material. *Nassarius obsoletus* were collected from Bull Head Bay, Southampton, far from any treated wood structures. Four groups of 10 snails each were set up: snails with experimental *Ulva*, with control *Ulva*, with experimental *Enteromorpha*, and with control *Enteromorpha*. Each group of snails was placed in a shallow polystyrene container with 0.5 L seawater (29‰ S, 24-26 C) and 8 g of either *Enteromorpha* or *Ulva*. Snails were observed regularly for inactivity or mortality, and algae were added when all had been consumed. Water was changed and fecal material removed after two weeks. After four weeks, any remaining snails were frozen for subsequent metal analysis.

Metal analysis was done by first drying at 150 C, wet-ashing a subsample (2-3 g) in 3:1 HNO_3:$HClO_4$ (Baker reagents labeled "for trace metal analysis" if available), and determining Cu and Cr by flame-aspiration in a Perkin-Elmer 403 atomic absorption spectrophotometer. Arsenic was determined in the same instrument following hydride generation and with deuterium lamp background correction. Quality control was ensured by including NIST Standard Reference Materials oyster powder and orchard leaves (SRM 1566 and SRM 1571, National Institute of Standards and Technology). Student's *t*-test was used for statistical analysis.

Oysters, *Crassostrea virginica*, were collected in January from three sites in Pensacola Beach, Fla.: a CCA dock in an open-water environment, a bulkhead in a residential canal lined with CCA wood, and rocks in open water. Tissues were digested in nitric acid, and metals were analyzed by inductively coupled plasma emission spectroscopy (ICP) in a Jarrell-Ash series 800 instrument. Data were analyzed by *t*-tests with Bonferroni's adjustment.

Fiddler crabs, *Uca panacea*, were collected in November from Pensacola Beach; from the residential canal immediately adjacent to a CCA bulkhead, immediately adjacent to a CCA piling, and from an area distant from CCA wood structures. Crabs were analyzed for levels of Cu, Cr and As by the atomic absorption methods described above for algae. Additional fiddler crabs, *U. pugilator*, were collected from the immediate vicinity of, and distant from, a bulkheaded area in Shelter Island, N.Y., and also analyzed for levels of Cu, Cr and As. Levels were compared statistically by means of Student's *t*-test.

To study the epibiotic community forming on treated vs. untreated wood, one-foot lengths of 2" x 6" dimensional lumber (4 x 14 x 30.5 cm) of treated yellow pine and control pine were strung from a rope to be suspended in the water. The treated wood was 1.5 lb/ft^3 material. Boards were attached by means of screw eyes and were weighted down on the other end, so that they hung vertically in the water, an orientation like that of wood in bulkheads. Three panels of each material remained in the water, and three of each were removed at monthly intervals and replaced with new panels. At the beginning of May, panels were placed into Fort Pond Bay in Southampton; an estuary with a considerable amount of bulkheading and boating. Panels were examined by removing them from the rope, placing them in a pan of seawater and counting and identifying all resident organisms. At the end of each month, the community that had developed on each of the one-month boards was scraped off into individual jars and analyzed for biomass (dry weight) and metal levels. These boards were then replaced by fresh boards. Diversity was calculated by means of the Shannon-Wiener diversity index. This measure is non-parametric. Other data were analyzed by *t*-test and analysis of variance, using the 5-percent level of significance.

Results

Metal levels in *Enteromorpha* (two replicate samples) from the CCA dock were: 55.2 ± 17.5 µg/g Cu, 6.25 ± 1.9 µg/g Cr and 4.68 ± 0.39 µg/g As. Control *Ent-*

eromorpha had 13.95 ± 2.6 µg/g Cu, 2.55 ± 0.35 Cr, and 1.06 ± 0.24 µg/g As, all of which are significantly lower. Metals in the *Ulva* (two replicate samples) from the CCA dock were 53.6 ± 7.2 µg/g Cu, 13.3 ± 0.4 µg/g Cr and 7.9 ± 5.0 µg/g As. The control *Ulva* had 15.6 ± 3.0 µg/g Cu, 4.0 ± 1.7 µg/g Cr, and 0.9 ± 1.0 µg/g As, which are also significantly different.

All groups of snails consumed the algae but the group with the CCA-exposed *Enteromorpha* ate at the greatest rate. New food had to be supplied to them after 1.5 weeks, while the other groups did not need new algae until two weeks or more. Effects were observed initially in the snails feeding on the CCA-exposed *Ulva*. Within one week, three were retracted and lying on the bottom. With time, more of these snails became retracted or died. The snails eating the CCA-exposed *Enteromorpha* demonstrated this response more slowly. By four weeks, all snails eating CCA algae were either retracted (R) or dead (D) (*Ulva*, 6R, 4D; *Enteromorpha*, 8R, 2D), while all controls were alive and active.

Concentrations of chromium in all oysters (wet weight) were below detection limits of the instrument. Arsenic levels were: reference site, 6.62 ± 1.57 (SD) µg/g; dock, 7.16 ± 2.48 (n.s.); and canal, 10.05 ± 1.50 (t = 5.109). Copper levels were: reference site, 12.59 ± 3.23 µg/g; dock, 27.05 ± 8.09 (t = 5.246); and canal, 154.30 ± 15.6 (t = 29.47). These canal oysters were greenish. Thus, while Cu was significantly elevated in both groups of exposed oysters, As was elevated only in the canal (worst-case scenario), and Cr did not reach detectable levels.

Cu, Cr and As levels found in the field-collected fiddler crabs from Shelter Island are shown in Figure 1. While the *U. panacea* from Florida had elevated Cu but not Cr or As, the *U. pugilator* from New York had significantly elevated levels of all three. Sediments from this site also had elevated levels in the fine-grained fraction (<63 um): 344 µg/g Cu, 85.4 µg/g Cr, and 77.5 µg/g As. These concentrations in fine-grained sediments decreased with distance from the bulkhead, while the percentage of fine-grained sediments increased.

On the one-month wooden boards placed in the estuary, as well as on the permanent boards, species richness (Figure 2), biomass (Figure 3) and Shannon-Wiener diversity index (Figure 4) increased over the course of the summer. Boards of each type at each location were generally quite similar to one another. Dominant organisms in the community were the barnacle, *Balanus eburneus*, the bryozoan *Membranipora* sp., and the bryozoan *Bugula turrita*. Additional species frequently noted were the tunicate *Molgula manhattensis*, amphipods (mostly *Gammarus mucronatus*, *Microdeutopus gryllotalpa*, and *Ampithoe valida*), and the polychaete *Polydora ligni*. Common macroalgae included *Cladophora* sp., *Ectocarpus* sp., *Polysiphonia* sp., *Ulva lactuca*, *Enteromorpha intestinalis*, *Ceramium* sp., and *Cystoclonium* sp. Motile grazers included young blue crabs, *Callinectes americanus*, grass shrimp, *Palaemonetes pugio*, gobies, *Gobiosoma bosci*, and mud crabs, *Rhithropanopeus harrisii*. Striking differences were seen between the biota that settled on treated wood and those that settled on control wood. Fewer species were found on the treated wood. Biomass was considerably less at each measurement, as was the diversity index. On the continuing boards, differences in diversity index were less striking than on the one month boards. However, *Bugula* settled most readily on the treated wood in its first month of submersion. High accumulation of all three metals occurred in the epibiotic community on the CCA boards.

Discussion

Data on the chemical analysis of algae and oysters demonstrate that toxicants leached from CCA-treated wood can accumulate in organisms that grow on the wood. In a dock in open water, oysters developed moderately elevated levels (2X) of Cu, while in a residential canal lined with CCA wood and with relatively little flushing, oyster Cu levels were 12X background.

The snail/algae experiment demonstrates that toxicants accumulated in macroalgae can be lethal to grazers. Deleterious effects were seen initially in the snails eating the *Ulva*, but by the end of four weeks, all snails in both experimental groups were either dead or retracted, while all snails eating control algae remained alive and active. *Ulva* was found to accumulate metals and to be a good indicator of Mn, Fe, Zn and Pb, as well as Cu contamination (Ho, 1990). Macroalgae, in general, can be used as monitors of metals in coastal waters (Bryan and Hummerstone, 1973), as they respond to metals present in solution in ambient waters. Bivalve mollusks can also be used as monitors of contaminants, as in the "Mussel Watch" program (Farrington et al., 1983).

The sites from which the experimental algae were collected have, in addition to CCA-containing bulkheads and docks, a fair amount of boating activity. Antifouling paints leached from boats could be an additional source of copper contamination. However, the control *Enteromorpha* and *Ulva* were collected from rocks from the same general areas, and these algae, unlike those growing directly on the CCA wood, did not cause adverse responses in the snails and contained significantly less Cu, Cr and As.

Biological effects of CCA wood were also apparent in the settling study. Fewer species, fewer individuals, and lower biomass were found on these panels compared to control wood. The scarcity of organisms on all surfaces of the treated wood implies that chemicals leach from all sides of the boards, not just the recently cut ends, as might have been the case. The only organism that did not appear to be at all inhibited from settling and from growing on the treated wood was the bryozoan *Bugula turrita*. It may be relevant that this is a species with a very small area of attachment to the substrate. A possible reason for the enhanced settlement on treated wood may be that there is less competition from algae and other epifauna for space on the treated wood.

Previous work on hard substrate communities demonstrated that initial community development is rather unpredictable, based on larvae available for settling at particular times and in particular places. Subsequent changes in species composition depended largely on the ability of larvae to invade existing assemblages (Sutherland and Karlson, 1977; Menge, 1991). Osman (1977) determined that five factors were primarily responsible for the development and distribution of the epifaunal community: selection by larvae of attachment sites, seasonal changes in larval abundances, biological interactions among species (primarily competition for space, and predation), the size of the substrate, and physical disturbance of the substrate (due to waves). Osman (1978) noted that smaller rocks are disturbed more often than larger ones. Hurricane Bob struck Long Island a week before the late August counts but did not appear to have any effect on the biota on the panels.

Barnacles (whose presence and growth was reduced on the CCA boards) have also been found to be useful monitors for heavy metals, including Cu, Zn and

Pb (Phillips and Rainbow, 1988). They sequester Cu and Zn in parenchyma cells below the gut epithelium.

The presence of motile grazers on the panels (gobies, shrimp and crabs) indicates a potential for metals accumulated in the epibiota to be passed into the general estuarine food web.

The sediments are another route of transfer of contaminants from the CCA wood into the estuarine ecosystem. The elevated metals found in the fiddler crabs living near CCA structures were probably taken up from the sediments which these animals inhabit and process for food. The *U. panacea* living in proximity to CCA wood had elevated Cu, but not Cr or As. The crabs collected by the piling had moderately elevated levels of copper that were statistically significant. The mean Cu level in the crabs collected by the bulkhead was much higher (bulkheads having a far greater surface area than pilings), but the variation was so great that statistical significance was not achieved. Some of these animals had extremely high levels of Cu exceeding 2,000 µg/g. The *U. pugilator* from Shelter Island had elevated Cr and As as well as Cu, as did the sediments in which they lived. These differences may reflect differences in the levels of the three chemicals leached from the wood, environmental differences in bioavailability of the metals at the two sites, or species differences in uptake of Cr and As. The Shelter Island bulkhead was only one year old, while the one in Florida had been in place a longer time. Wood for marine use in Florida is pressure-treated with 2.5, rather than 1.5 lbs/ft^3 however.

Conclusion and Recommendations

We have found that the CCA wood structures, which are in extensive use in coastal areas, can release contaminants that can accumulate in both epibiota and nearby benthic organisms, with deleterious effects. It can be a significant source of contamination in areas that are otherwise relatively clean.

We have previously found that toxicity of pieces of CCA wood decreased over time, so that after a piece had soaked for a few months, it had much less of an effect in laboratory studies. Therefore, wood preservers could let the wood soak for a few months on site before marketing it. That way, most of the leaching would have occurred and the wood would be much less of an environmental problem. Another approach would be to replace the treated wood with another material altogether. One alternative construction material that we have examined is a product made of recycled plastic, which can be used for making bulkheads and had much less toxicity than the wood. In addition, this would provide a market for recycled plastic. Thus, using this material would solve two problems at once—removing it from the waste stream and replacing a more toxic construction material.

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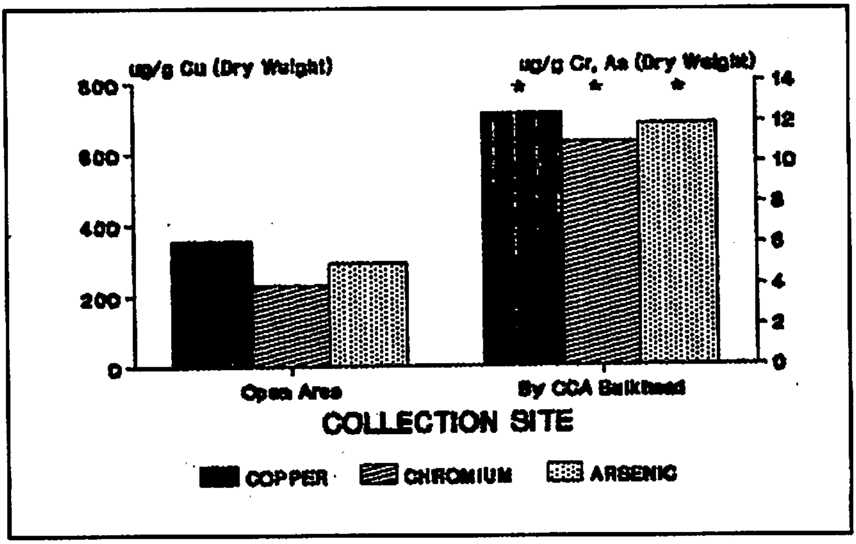

Figure 1. Contaminant levels in *Uca pugilator* collected in August 1991 from an open area and near a CCA-treated bulkhead, Shelter Island, N.Y.

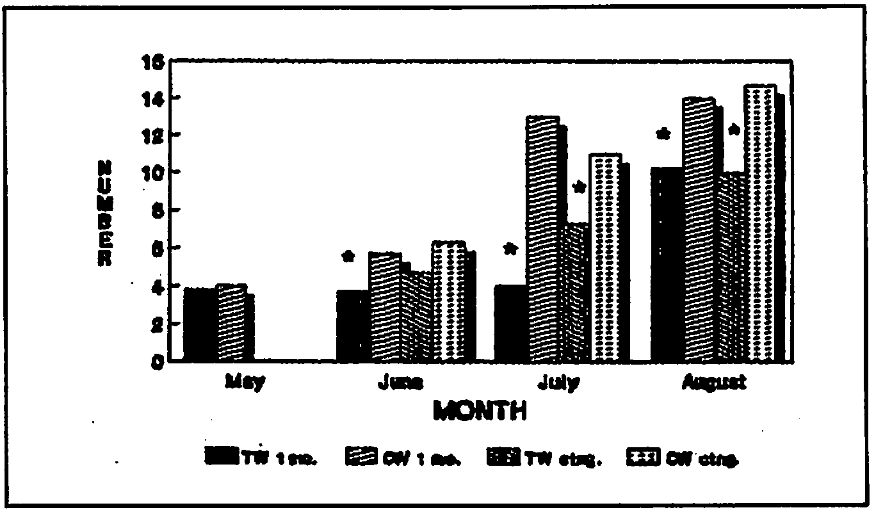

Figure 2. Species richness on one-month (1 mo) and continuing (ctng) boards of CCA treated wood (TW) and control wood (CW) placed in the estuary.

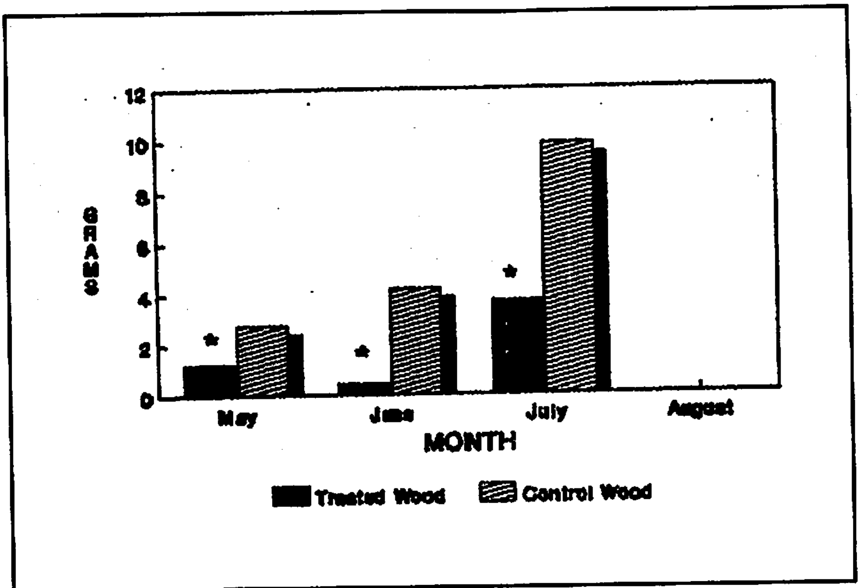

Figure 3. Biomass accumulated on the one-month boards of treated and control wood.

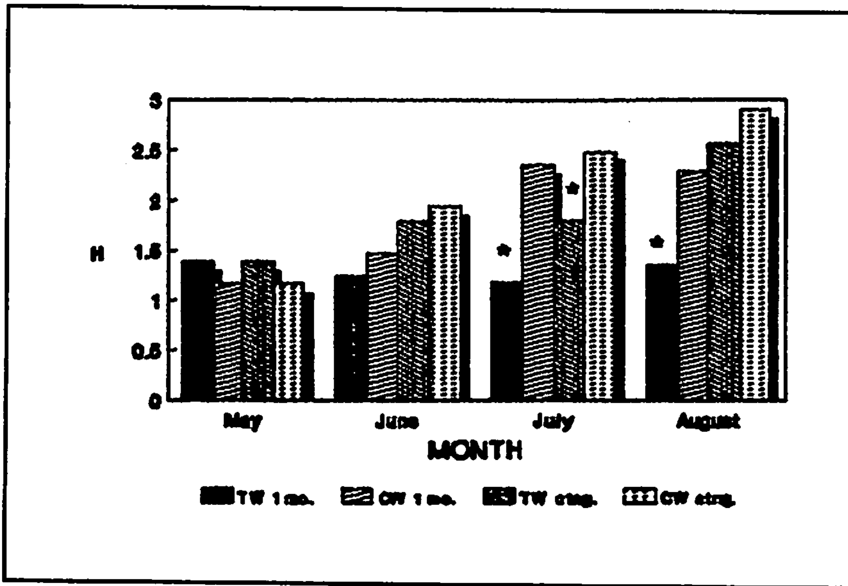

Figure 4. Diversity index on one-month and continuing boards of treated wood and control wood.

MANAGEMENT OF OFFLOADED SHIPBOARD WASTE IN GULF OF MEXICO COASTAL COMMUNITIES

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Introduction

Annex V of the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL 73/78) entered into force on Dec. 31, 1988. Simply stated, it calls for a change in the way shipboard wastes are disposed of and managed. The Marine Plastics Pollution Research and Control Act (MPPRCA) of 1987 implemented MARPOL Annex V in the United States. The legislation prohibits the discharge of any plastics into the waters of the United States and requires that every port, terminal and marina maintain adequate waste reception facilities. Appendix A outlines MARPOL Annex V garbage disposal restrictions.

While Annex V and MPPRCA set requirements and restrictions, neither specified how compliance was to be attained. The approaches and techniques for handling waste aboard ship are left entirely up to the vessel owners and operators. The ports, terminals and marinas were simply mandated to have "adequate" waste reception facilities.

Exactly how the implementation of such a far-reaching program will affect port and harbor operations in the Gulf of Mexico and the rest of the United States remains uncertain. Little guidance is given for shoreside handling, and even less attention is given to the landside impacts that might result from the additional volume and nature of the materials.

These concerns prompted the Texas General Land Office and Texas and Louisiana Sea Grant College programs to collaborate in a survey of selected public ports, terminals and marinas located throughout the U.S. Gulf of Mexico region. The primary objectives of the study were to determine the garbage and other waste-handling practices at the shoreside installations; the nature, costs and adequacy of the existing facilities; the extent of use of the facilities and implications of the impending special area designation for the Gulf of Mexico.

More than 70 telephone, written and personal contacts were made in August and September 1991. A total of 61 surveys was completed. Respondents included 46 U.S. public ports, private terminals, recreational boating and commercial fishing marinas and offshore staging bases, as well as 15 public or private organizations that are involved in waste-handling and disposal activities.

Findings and Conclusions

The 61 survey respondents included 22 international/coastwise trade public ports; 7 private marine terminals; 7 commercial fishing ports; 6 recreational boating marinas; 4 offshore staging bases; 11 waste management operations; 2 steamship agents/stevedores; and 2 USDA Animal and Plant Health Inspection Service (APHIS) offices.

Most international/coastwise shipping ports reported that only 5 to 10 percent of the vessels calling at their installations each year have used APHIS-approved reception facilities since the program went into effect in 1989. The private terminals estimated the same figure to be closer to 10 percent.

All 22 international/coastwise shipping ports and seven private terminals provide reception facilities for disposal of restricted waste. Forty of the 46 facilities provide dumpsters for general waste disposal. All six ports and terminals restricting direct access to port dumpsters allow third-party contractors to provide dumpsters requested by the vessel's agent on behalf of the vessel. Since commercial fishing ports, recreational boating facilities and offshore staging areas seldom, if ever, receive APHIS waste, such facilities are not necessary, and arrangements can be made in the event the need for such services would arise. All of these facilities do, however, provide dumpsters of various sizes for general waste disposal. All general waste goes directly to local landfills.

APHIS-approved incinerators are available through private contractors or port operations at 20 ports and all seven private terminals. Two ports do not make incinerators available but utilize an APHIS-approved commercial steaming or autoclave system. Three of the ports that use incinerators provide refrigerated facilities to collect APHIS waste until a third-party contractor can make a weekly pickup. This represents an extra step in the process, but due to the location of the port it may be necessary to refrigerate the waste in order to avoid extra contractor pickups and thus higher costs. The infrequent requests for this service have made temporary refrigeration the only practical approach, even though it may be more expensive.

A few ports and private terminals surveyed have a choice between the incinerator and a commercial autoclave system. The autoclave system is preferred in some areas due to lower costs and the convenience in not having to sort the trash. Most of the ports prefer incineration, however, due to the convenience of using the plastic-lined, cubic-yard, cardboard boxes for APHIS waste disposal, rather than the four-cubic-yard or larger container furnished by the autoclave system. Autoclave-treated wastes are taken to local landfills.

Ports and private terminals indicated that their existing facilities were adequate for handling and disposing of garbage, and only two indicated that they plan to expand their waste reception facilities in the future. Both of these port operations only provide dumpsters for general waste disposal, and both indicated that they only needed larger dumpsters. None plans to expand its APHIS-approved disposal facilities, but one private terminal that now uses a 14-gallon plastic drum has begun to explore alternatives due to the higher cost of the drum over the conventional plastic-lined boxes. Another private contractor is building an autoclave system to handle restricted waste from ships.

Eighteen of the 22 ports and five of the seven terminals contract with third parties to offload and dispose of ship-generated waste. The four remaining ports use a combination of port and third-party handling and disposal.

Commercial fishing ports and recreational boating facilities manage their own garbage-handling and disposal programs, even though they may hire a third-party for disposal. Often, the third party is the city or county sanitation department, but more often it is a private waste-management firm. Offshore operations normally provide dumpsters at their own expense, but the port in about one-half the cases manages the waste-handling processes at these bases.

Most ports and terminals prefer that the contractor take care of handling and disposal of garbage, as well as billing, etc. Only three ports charge the vessel for disposal of restricted waste and three charge for disposal of unrestricted waste. Some ports and terminals may have both free disposal for limited amounts of waste and charge a fee for larger amounts of garbage disposal. Only fishing ports and recreational boating facilities provide free disposal, but they recover some of this cost in a dockage charge. Ports and private terminals may also provide limited free disposal as part of their dockage and other landside charges.

The charges for handling restricted or APHIS waste vary widely. Coastwise, they average $1 per pound, which many operators feel is excessive and sometimes prohibitive. Plastic-lined boxes with 38-pound capacity can be offloaded for $25 to $75 per box. A 14-gallon plastic drum (100 pounds capacity) is incinerated in Freeport for $75. The autoclave systems charge from $100 per cubic yard if the waste is picked up in the immediate vicinity to $500 per cubic yard if the waste is hauled more than 50 miles. Charges for handling unrestricted waste vary to an even greater extent than the restricted type, but the average is approximately $10 per ton. There is no consensus among those interviewed as to whether a reduction in costs will result in more use of the reception facilities.

Thirteen ports responded that they had received user-complaints regarding APHIS facilities and Annex V. The most common complaint is cost of services, followed by inadequacy or unavailability of facilities. The cost of shoreside disposal services, plus a desire to be in compliance with MARPOL Annex V, has prompted some vessel operators to add incinerators and other disposal methods aboard their vessels. Companies that provide waste-disposal services complained that there was lack of enforcement of the regulations and that the U.S. Coast Guard should become more active to ensure compliance.

Twenty-nine of the 40 ports and terminals are of the opinion that special area designation for the Gulf of Mexico will increase use of the reception facilities and the other 11 felt that there would be no change. In addition, 71 percent of those responding to this question said that they expected more competition among waste-management firms as vessels began to offload more of their waste at their facilities.

There are indications, albeit anecdotal, from the survey responses that the volume of general waste that is being brought ashore for land disposal is steadily increasing, especially for recreational, commercial fishing and offshore operations. Most respondents attribute this to growing awareness of the marine debris problem plus a concern for law violations and fines.

EPA'S APPROACH TO PRIORITY PROBLEMS IN COASTAL WATERS

Marian Mlay
U.S. Environmental Protection Agency

To most Americans who have lived, worked or vacationed on any of our nation's coastal areas, the signs of environmental problems have been clearly visible. Many of us have been disappointed to find beaches littered with plastic debris; shellfish beds closed to harvest; waters fouled by fish kills or pollutants and closed to swimming or fishing; or reduced populations of certain saltwater fish and coastal wildlife species that we enjoy. Continuing population growth and urban development in coastal areas are intensifying the pressures on and increasing the difficulty of protecting our most valued ecosystems and resources.

As this environmental protection challenge mounts, we also must deal with very real limitations on the budgetary and human resources available to address our problems. We will have to be more creative in our approaches and more strategic in our allocation of resources. At EPA, we have looked for opportunities to increase the effectiveness of environmental protection programs by focusing our resources on high-priority issues and geographic areas that present the best opportunities for restoring environmental quality and preventing further environmental degradation. We also are making a concerted effort to increase our effectiveness through better coordination with other government agencies as well as with various non-governmental interests. We are committed to helping develop and promote new ideas, technologies and approaches for more effective resource management and protection. Finally, EPA continues to play an important role in fostering exchanges of information that allow one community to benefit from the experience of another.

This paper provides some perspectives on EPA's approach to priority problems in coastal waters. The first section discusses the Watershed Protection Approach, a concept crucial to improving the basic environmental protection framework for aquatic ecosystems. The next section presents our views on the importance and value of institutional coordination and cooperative decisionmaking, highlighting several recent projects. Some of the more innovative or non-traditional approaches to coastal protection are discussed in a third section. The paper closes with an overview of our technology transfer efforts.

The Watershed Protection Approach

Environmental problems in coastal areas tend to be complex, reflecting the wide range of human activities that occur within a drainage basin. Certainly, this is true for pollution, since coastal areas tend to serve as the ultimate sink for contaminants from sources throughout a basin or watershed. Over the past two decades, we have been relatively successful in controlling the discharge of many contaminants from industrial and municipal point sources. It has become increasingly evident, however, that other types of sources account for a substantial portion of the total pollutant loadings that enter coastal waters. Of particular concern are non-point sources, such as agricultural and urban runoff, contaminated sediment, atmospheric deposition, and seepage from contaminated ground water. We have found, for example, that as much as 67 percent of the nutrient load to the Chesapeake Bay comes from non-point sources.

In addition to the multimedia nature of pollution, we have recognized that the fate and effects of contaminants are determined by ecological dynamics or the complex of physical, chemical and biological interactions within a natural system. For example, we know that wetlands can serve as a filtering system for certain types of contaminants and, thus, that the extent and condition of wetland communities within a watershed can influence overall water quality and the "health" of aquatic ecosystems. Accordingly, EPA, along with other government agencies, is broadening our outlook on water quality protection to account for the full range of factors that sustain natural resources and their beneficial uses.

EPA's emerging resource protection approach draws from a wide range of recent programs and activities that relate to watershed protection. A number of states have emerged as leaders in developing and promoting various watershed protection concepts. EPA programs, particularly the National Estuary Program (NEP) and its predecessors the Chesapeake Bay and Great Lakes Programs, also serve as a foundation for our new direction in environmental protection.

The NEP, initiated in 1987 with six designated estuaries for which NEP management conferences have been convened, has grown to include 17 management conferences along the East, West and Gulf coasts. Comprehensive Conservation and Management Plans (CCMPs) for these NEP estuaries are being developed, with some near completion. From the beginning, the NEP focused on selected estuarine watersheds and the living resources associated with those estuaries where a collective concentration of the best public and private efforts could be targeted toward solving the estuary's problems. The NEP's geographic approach has permitted comprehensive identification, assessment and action on a variety of environmental problems within a single watershed.

This approach was a step up from the traditional approach to resource management, which was to control specific sources of contamination, with little consideration of the effectiveness of such actions on maintaining or improving the condition of the ecosystem as a whole. Such "end-of-pipe" solutions failed to recognize comprehensive protection of the resource as their goal. This in turn led to priority issues being defined more by the availability of programs focusing on a specific problem than by the health of the whole watershed.

We have now moved into the next generation of resource management protection—to what we at EPA are describing as the Watershed Protection Approach. The Watershed Protection Approach is predicated upon three main principles. First, the target watersheds should be those where pollution poses the greatest risk to human health, ecological resources, desirable uses of the water, or a combination of these. Second, all parties with a stake in the specific local situation should participate in the analysis of problems and the creation of solutions. Third, the actions undertaken should draw on the full range of methods and tools available, integrating them into a coordinated, multi-organizational attack on the problems confronting our coastal resources.

The Watershed Protection Approach has proven through the NEP and other coastal resource protection programs to be an effective way of addressing water quality and the protection of aquatic resources. As our experience grows and techniques evolve, this holistic, locally tailored approach gradually will become—indeed *must* become—the standard operating procedure not only for our coastal water protection programs, but also for *all* water programs within the Agency.

Cooperation for Coastal Protection

Cooperation and talent sharing from federal/state institutions, business and public interest groups, the scientific community and local citizenry are critical for coastal protection. Cooperative efforts generally are difficult and require a substantial initial investment of time and resources to build consensus on priority problems, to develop an action plan for resolving them, and to obtain commitments from participants to accomplish specific tasks on a schedule. Although government institutions are bound by their statutory missions and all participants in a multi-party process are driven by their own interests or those of their constituents, communities can transcend narrower interests to develop and implement an environmental management strategy that represents a net improvement in terms of environmental quality.

At EPA, we certainly have witnessed a number of success stories—notably the Chesapeake Bay Program and more recent projects within several NEP communities. The Chesapeake Bay Program continues to be an important model for cooperative action. After struggling during its early years to define its mission and mechanisms of action, the program helped build a framework for municipal governments, states, federal agencies and interest groups to work with local citizens to improve environmental conditions within the Bay. For example, participants reached a historic agreement to work collectively toward reducing nutrient loadings in the Bay by 40 percent by the year 2000. Participating federal and state agencies developed specific commitments and schedules for meeting the joint goal. Chesapeake Bay Program participants, who have been meeting their commitments, recently completed an evaluation of their nutrient reduction strategy to determine the need for mid-point course corrections.

Similarly, the NEP is based on concepts of cooperative action to identify and resolve priority environmental problems in estuaries with particular national significance. The strength of the NEP is its commitment to consensus building and strong focus on involving responsible government agencies and the public. For example, the CCMP for Puget Sound has succeeded in galvanizing the various interests within the Basin in a coherent strategy for implementing common environmental management and protection goals. Approved by EPA Administrator William Reilly in May 1991, Puget Sound's CCMP focuses on the restoration and protection of biological health and diversity of the sound, identifying the following specific areas needing action: fish and wildlife habitat protection, spill prevention and response, shellfish protection, abatement of municipal and industrial discharges, and remediation of contaminated sediments. The approval of Puget Sound's CCMP represented culmination of two years of work by the state of Washington, plus an additional four years under the federal, state and local partnership fostered by the NEP. Another critical component of the Puget Sound CCMP is continued active participation by the public.

In the federal arena, EPA has been working closely with other agencies to create greater net benefits in terms of environmental protection. Our experiences in the Chesapeake Bay Program and the NEP provided tangible evidence of the benefits of interagency cooperation. For example, EPA and the National Oceanic and Atmospheric Administration (NOAA) often undertake joint surveys that allow single cruises to collect data of interest to both agencies. Similarly, EPA and the U.S.

Department of Agriculture (USDA) are working to more efficiently share responsibility in the non-point-source control area. The Soil Conservation Service (SCS) is able to draw on its expertise and field office structure to effectively reach agricultural and residential interests, while EPA can contribute technical information and outreach materials on certain aspects of water quality protection. The Coastal America Initiative, which formally brings together four federal agencies with responsibilities related to coastal environmental protection, has supported a number of cooperative projects focusing mainly on habitat loss. The initiative provides an opportunity for us to focus on key problems in various coastal regions and to orchestrate federal activities more effectively to help solve them.

In specific cases where federal missions overlap, EPA has been working to clarify roles and responsibilities, and to identify new opportunities for collaboration and coordination. A prime example is the 1988 agreement between EPA and NOAA that delineated our concepts for coordinating the National Estuary and Coastal Zone Management Programs. In this agreement, EPA and NOAA recognized their mutual missions in coastal areas, and pledged to make use of the various tools available under the NEP and CZM program to benefit coastal protection. The agreement focused on the value of NEP CCMPs as comprehensive planning mechanisms, as well as the value of State Coastal Zone Management Plans for implementation of management actions.

Pursuant to this agreement, we have made positive steps to carry out specific commitments: we have clarified several key policy questions regarding the legal interrelationships between the programs (e.g., consistency determinations), and we are involving NOAA in developing a methodology for evaluating progress made under the NEP. We are holding periodic joint Headquarters/Regional staff meetings to discuss integration of aspects of the CZM Program, NEP, and the Near Coastal Waters (NCW) Program. We have recently developed a joint EPA-NOAA Implementation Plan to assure that our 1988 agreement for coordinating the CZM Program and the NEP is carried out in spirit and in fact.

Similarly, the Assessment and Watershed Protection Division of OWOW is working with NOAA's Office of Ocean and Coastal Resource Management on guidance for the development of state coastal non-point-source management programs, as authorized under the 1990 amendments to the Coastal Zone Management Act. The passage of such programs by Congress clearly acknowledges the link between water quality and coastal zone management concerns, and provides a tremendous opportunity for coordination through our existing coastal resource protection efforts.

There are other areas of interagency cooperation within coastal resource protection and management programs:

The Ocean and Coastal Protection Division (OCPD) of OWOW works closely with the U.S. Army Corps of Engineers in the designation of ocean dump sites for dredged materials and in permitting the use of those sites;

OCPD works jointly with the U.S. Coast Guard to regulate the permitting of vessels that transport municipal and other nonhazardous municipal waste under the Shore Protection Act;

OCPD, the Coast Guard, and NOAA have jointly developed a plan for monitoring and surveillance of the 106-mile sewage sludge dump site, and work together to implement this plan; and

OCPD works closely with NOAA and the Coast Guard to assess and control marine debris.

Innovation: Another Key to Improving Environmental Protection

Innovation in environmental protection is a broad concept, extending beyond technical invention and encompassing the full range of non-traditional options for accomplishing our goals. So, for example, the trend toward cooperative decision-making and consensus-based environmental management represents a significant departure from traditional environmental management approaches. In addition to this general reorientation in our approach, we have seen some innovative or non-traditional solutions to specific problems that are also of particular interest.

Targeting non-point sources of pollution in the Chesapeake Bay basin. More than a decade of investment in the complex Chesapeake Bay model has led to some important revelations about the contributions of upstream sources to total pollutant loadings with coastal areas as well as the contribution of certain sources that had been difficult to gauge. For example, recent modeling results point to atmospheric deposition and contaminated ground water as more important sources of pollution than previously believed.

The Chesapeake Bay states have made important strides in identifying specific sources of pollution within the basin and prioritizing them for control. Virginia, for example, has developed a geographic information system (GIS) that is useful in identifying specific agricultural fields that represent likely significant sources of nutrient loadings. Based on this system, Virginia has guided its financial and technical assistance programs to increase the benefit in terms of pollutant load reduction.

Adopting a whole-basin approach to water quality management in North Carolina. In 1990, the North Carolina Division of Environmental Management (NCDEM) Water Quality Section initiated plans for a whole basin approach to water quality management. Activities within the North Carolina Water Quality Program will be coordinated and integrated for each of the 17 major river basins in the state. North Carolina's whole basin planning and management will improve efficiency by focusing monitoring, modeling and permitting efforts in certain geographic areas; increase effectiveness through a multimedia approach targeting linkages between aquatic and terrestrial systems, multiple inputs to aquatic systems, and potential interactive effects; and promote consistency and equitability by providing a focus for management decisions.

NCDEM plans to implement its approach in phases. Permitting activities and associated routine support activities have already been rescheduled by basin. All National Pollutant Discharge Elimination System (NPDES) permit renewals within a basin will occur simultaneously and be repeated at five-year intervals. The NPDES permit renewal schedule will drive the timetable for developing and updating the whole basin management plans. The management plan for a given basin must be available prior to the scheduled date for permit renewals. Although the earliest basin plans may not achieve all of the long-term objectives for whole basin management, subsequent updates of the plans will incorporate additional data and new assessment tools and management strategies as they become available.

As part of these efforts being undertaken in North Carolina, several new and innovative management approaches for encouraging water quality protection have been proposed. For example, whole-basin management strategies are to include procedures for the following:

"Agency banking" of assimilative capacity by the NCDEM to provide for potential future growth and development in the basin;

Pollution trading among permitted dischargers, or between point and non-point sources, adding flexibility to the permitting system and also using the free market system as an aid to identify the most cost-effective solution to water quality protection;

Industrial recruitment mapping, providing specific recommendations on the types of industry and land development best suited to the basin's long-term water quality goals and also an individual basin's ability to assimilate a particular type or quantity of discharge or non-point-source pollutants; and

Consolidation of wastewater discharges, which may result from economic considerations and be easier to coordinate with permits in similar geographic areas being issued at similar times.

Controlling land-based marine debris. Plastic debris in the marine and other aquatic environments is a significant environmental problem worldwide. U.S. efforts to control aquatic debris have been motivated in large part by the sheer ubiquity and the documented impacts of debris on marine wildlife and waterfowl. Debris is categorized as having either ocean sources (such as commercial fishing vessels, recreational boating and offshore oil rigs) or as having land-based sources (including combined sewer overflows [CSOs], plastic manufacturing activities, and sewage treatment plants). EPA's long-term solution to this problem is to control non-degradable debris before it becomes aquatic debris—in other words, to prevent it from entering receiving waters.

In addition to other efforts to curb marine debris from land-based sources as part of an interim solution, EPA has recently funded several field investigations that have linked the presence of certain plastic items to CSOs where storm water and street runoff combine with sewage during heavy rainfalls and are discharged directly into receiving water. The apparent correlation between certain debris and the presence of CSOs has provided the basis for several other EPA studies addressing the potential for release of debris from treatment facilities to the environment during CSO events and the ability for various technologies to remove debris from incoming wastewater.

The Agency has also implemented the National CSO Control Strategy under the Water Quality Act of 1987, which treats CSO discharge points as individual point sources subject to NPDES permit requirements. The strategy requires that all CSOs be identified and categorized according to their status of compliance with regulations. Pursuant to the strategy, most states have begun developing statewide strategies with measures to ensure that the most serious CSO discharges are eliminated first. CSO discharges to marine and estuarine waters are given highest priority. By controlling the effluent from CSOs and storm drains, EPA hopes to significantly curtail the discharge of sewage, sewage-related plastics and street litter into the marine environment at times of heavy rain.

Retrofitting wastewater treatment plants in Long Island Sound for nitrogen removal. The Long Island Sound Study, which will culminate with the issuance of an NEP CCMP for Long Island Sound, identified five problem areas that merit special attention: low dissolved oxygen (hypoxia), toxic contaminants, pathogens, floatable debris and the health of the community of living marine resources as they relate to water quality. Primary among these problems is hypoxia, which impacts substantial areas in the western sound in the late summer. The study has further identified nitrogen as the nutrient most directly linked to the causes of hypoxia in the sound. Discharges from sewage treatment plants and nonpoint runoff are the primary sources of the increased nitrogen load.

To begin to address this problem, states bordering the sound have adopted a "no net increase" policy to prevent increases in current nitrogen loadings from point source discharges. Effective immediately, any new facilities to be constructed that will discharge directly to Long Island Sound or in close proximity to the sound will be required to implement best treatment technology for nitrogen removal. This requirement will be reflected in state permits issued to the facilities. In addition, the states will initiate nitrogen load reductions by encouraging existing facilities to retrofit using current nitrogen removal technologies. Eventually, state efforts to control or reduce nitrogen levels will extend to other portions of the tributary drainage area to Long Island Sound.

Emerging Issues

Coastal environmental protection has always been somewhat frustrated by profound scientific uncertainty about key issues. A National Academy of Sciences (NAS) committee is exploring innovative approaches to wastewater management in urban coastal areas and is expected to produce recommendations for changes to current technology-based programs under the Clean Water Act. In a related study, EPA is assessing the benefits of secondary treatment and examining the relationship between the secondary treatment program and Clean Water Act Section 301(h). (Section 301(h) allows waivers from secondary treatment requirements for publicly owned treatment works that discharge into ocean waters, provided that certain conditions are met.) More specifically, EPA's study will include the history of technology-based standards and the secondary treatment program, report on national progress in maintaining a minimum level of treatment, demonstrate the environmental benefits of secondary treatment, and assess the influence of the Clean Water Act Section 301(h) program on the secondary treatment program.

Our ability to assess the risks associated with pollution or certain types of resource uses or activities within coastal environments provides the foundation for our environmental management decisions. In the absence of scientific certainty about the risks we incur, determining the "right" level of environmental protection remains a question of technical and political debate. So, for example, there has been some interest in the Congress in extending the scope of regulation both under Sections 301(h) and 403 (which prohibit issuance of NPDES permits for point source discharges into ocean waters unless in compliance with statutory guidelines). The benefits of additional regulation, the associated costs, and the risk reduction to be gained compared to other uses of our resources for environmental protection are not well understood.

There are many areas where we have made significant progress in resolving the technical and policy issues that underpin environmental management decisions. For example, EPA, with the Corps of Engineers, has recently published a revised testing manual (the "Green Book") for evaluating the environmental acceptability of a dredged material proposal for ocean disposal. In addition, EPA is developing sediment quality criteria and compiling and analyzing data on sediment contamination problems in key coastal areas. Taken together, these efforts are essential to multi-media management of dredged material disposal and selection of disposal options that protect the marine environment.

EPA and the Corps are also jointly supporting the use of clean dredged material to restore and protect our depleted coastal wetlands and other habitat. For instance, EPA and the Corps are developing guidance for evaluating the relative effects and merits of a wide range of disposal options, including beneficial uses. By jointly creating a decisionmaking framework for selecting disposal alternatives, EPA hopes that beneficial uses of dredged material will receive greater attention in the decisionmaking process.

Finally, EPA's Environmental Monitoring and Assessment Program (EMAP) is initiating efforts to monitor the health of the nation's coastal waters. Primarily through the NEP and NCW program, the OCPD is sharing expertise and experience, as well as data that will be helpful to both programs. We are exploring ways to link EMAP's large-scale national look at monitoring with geographically-targeted monitoring of the NEP to give a more comprehensive picture of coastal water quality. In addition, technical spin-offs from EMAP in the areas of monitoring design, methods development, quality assurance, indicator selection and assessment framework will prove beneficial to coastal program managers at the regional, state and local levels. For example, EMAP representatives will participate in a series of OCPD Monitoring Workshops for the NEPs, the first of which is scheduled this year for the Galveston Bay Estuary Program.

Technology Transfer

The success of all of our efforts to protect coastal resources can be amplified through effective technology transfer. EPA actively fosters an exchange of information among federal, state and local agencies, as well as non-governmental interests, by disseminating technical information through documents, workshops, meetings and other communication vehicles.

Our goal is to improve environmental protection in the field through the identification and communication of useful technical and programmatic information. Technology transfer can be difficult to achieve and its benefits can be difficult to measure. For example, how can a new NEP estuary be encouraged to apply the approaches developed in another NEP community? How do you decide what to transfer? How do you convince the local experts that for a specific set of issues for a certain set of circumstances, a particular solution works? How do you teach effectively from past experience that certain practices can achieve a positive result in the majority of instances?

To date, there are several activities already underway in the area of technology transfer. For instance, OCPD will shortly publish a guide manual for local government, as well as offer workshops designed to demonstrate the role that local government plays in the protection of coastal resources and mechanisms available to them. In addition, we will be setting up focus groups of coastal protection experts to assist us in identifying successful methods and approaches, and help us identify ways to bring them into current practices. With our research and development office, we will also develop a coastal research strategy to identify technical information and research needs and support development of scientific and technological tools within EPA laboratories.

Finally, because monitoring and data analysis are required to support virtually all programs administered by OCPD (including the NEP, the ocean disposal program, CWA 301(h) and 403(c)), OCPD has developed monitoring guidance. To ensure that these guidance documents effectively meet the needs of a diverse community or users, OCPD must provide technical assistance and training sessions on designing monitoring plans and implementing monitoring programs. Specifically, we are developing workshops for the EPA regions and states to provide assistance with the design and implementation of comprehensive estuary monitoring programs and characterization studies, as well as ocean discharge and marine monitoring programs.

RECENT LEGISLATION TO COMBINE THE STRENGTHS OF WATER QUALITY AND COASTAL MANAGEMENT TO IMPROVE AND PROTECT WATER QUALITY

Walter Rittal
Soil Conservation Service, U.S.D.A.

I'm not here today to talk to you about legislative efforts but rather efforts within the U.S. Department of Agriculture (USDA) to address coastal water quality issues through the upland treatment of agricultural lands and through shoreline protection. I have a master's degree in marine resource management and worked at the Environmental Protection Agency's (EPA) National Marine Pollution Research Program; therefore, it is pleasing to me to have been part of USDA's slow but unrelenting move to integrate water quality into the priorities of its programs. At present, water quality is the No. 2 priority within the department. This change was voluntary but has been legitimized and broadened by provisions of the 1985 and 1990 farm bills and the 1980 legislation that created the experimental Rural Clean Water Program.

When I joined the Soil Conservation Service (SCS) in 1980, water quality had the lowest priority of USDA programs, and the service was continually attacked for drainage projects that destroyed wetlands and adversely impacted our water resources. As policy changed over time, so has our reputation. With water quality being more closely tied to non-point-source inputs, our expertise is valuable to both other federal and state agencies alike. Our grassroots organization with technical field staff in over 3,000 counties, when coupled with the field staff of the Agricultural Stabilization and Conservation Service and the Cooperative Extension Service, provides for coordinated educational, financial and technical assistance to interested agricultural producers.

For your education and benefit, let me run through a list of programs and initiatives that have focused our efforts on coastal water quality concerns. The first was the 1980 Experimental Rural Clean Water Program.

Three projects were selected that addressed marine shellfish contamination resulting from agricultural animal waste runoff, and a fourth addressed the phosphorus problems of the Great Lakes. These were 10-year projects that were monitored by state water quality agencies. A fifth project was in Lancaster County, Pa., and became our first Chesapeake Bay effort. Congress earmarked dollars for the Chesapeake Bay starting in 1988. Our 1992 level is $4.7 million supporting 66 staff-years. We also provide direct staff support to the EPA Chesapeake Bay office in Annapolis, Md.

The reauthorization of the Clean Water Act in 1987 sparked renewed interest in supporting state non-point-source programs initiated under Section 314 of the Clean Lake Program, Section 319 of the non-point-source program, and Section 320 of the National Estuaries Program. We established liaison positions at each EPA regional office and with the Office of Water in Washington, D.C. The Forest Service and the Extension Service have also provided details at several locations. In addition, we detailed over 35 people to state water quality agencies to assist in planning development.

In 1988, we initiated a major effort to ensure that the *Field Office Technical Guide*, our how-to bible, was updated to address water quality concerns. This included the development of new standards and specifications for nutrient and pesticides and the development of a screening procedure that estimates the leaching potential of pesticides as a function of the soil series. This was done through internal redirection of funds. A budget initiative was put forward by SCS but not approved by the department.

While all this was going on, we were implementing the provision of the 1985 Food Security Act, which for the first time included environmental provisions.

Over 34 million acres of highly erodible cropland was taken out of production and placed in permanent vegetative cover. This had an attendant reduction in the usage of agricultural chemicals and fertilizers. With urging by EPA, changes were made to give priority to the drainage basin for the Great Lakes and the Chesapeake Bay and, filter strips adjacent to water bodies were authorized.

With President Bush's election came a desire for environmental initiatives and the 1988 budget proposal was picked up and expanded to include eight USDA agencies. These were not new funds but redirected funds from USDA's total budget. SCS funding for the water quality initiative for FY 92 is $46.0 million. The Extension Service has a similar amount and over $23.0 million was used to cost-share for conservation treatment.

With this dedicated funding going to water quality activities, we developed a five-year plan to guide this activity. The plan identifies five activities:

Hydrologic Unit Areas. Watersheds with impaired water uses identified in state 319 assessments and management plans. There are 74 funded now, they are five-year in nature and include dedicated resources for educational, financial and technical assistance. ($10 million);

Demonstration Projects. Designed to demonstrate new technologies that have not been accepted or adopted by agricultural producers. We have 16 funded now and plan to add 8 more in future years ($4.6 million);

Regional Programs. Direct SCS technical support to identified regional programs. ($8.3 million)

Great Lakes
Puget Sound
Gulf of Mexico
Chesapeake Bay
EPA-Designated National Estuaries
Lake Champlain
Louisiana Coastal Marsh Restoration Task Force
Liaisons to EPA;

Base Program Support. Resources to support ongoing water quality activities of a nonproject nature, such as details to state agencies, project plan development and training ($13.0 million);

Technology Development. In-house and contractual efforts to provide tools to field offices to address water quality concerns and to support technical staff at five technical centers located in:

Bromhall, Pa.
Fort Worth, Texas
Lincoln, Neb.
Fort Collins, Colo.
Portland, Ore.

Examples of activities here include:

Development of a precipitation database for use with runoff models;

The screening procedure for estimating runoff and leaching potentials for agricultural chemicals;

Nutrient and pesticide training workshops;

Standards and specifications for constructed wetlands;

Plant species development for shoreline stabilization in estuaries;

GIS capability at field office level;

ARC-Info GIS and database for program management at national level; and

Program evaluation activities.

1990 also saw legislative action in the form of the Food, Agriculture, Conservation and Trade Act (FACTA), which extended some programs and established others. The Conservation Reserve Program was continued and refocused to deal with environmentally sensitive lands contributing to water quality problems. Six million acres will be retired between 1990 and 1995. The act also created a Wetland Reserve Program that will allow farmed or prior converted wetlands to be restored under an easement program. Ten million acres will be eligible over the life of the program. The program will be implemented in eight states this year and expanded later. $46 million is available this year. Congress also authorized the Water Quality Incentives Program, which called for full farm water quality plans with the incentives to be supplemental to existing cost-share dollars. However, in the appropriations process, the funds were tied to the existing Agricultural Conservation Program and its rules and regulations. $6.5 million was made available but limited to existing water quality projects.

While we were not involved in the Coastal America Initiative, SCS liaisons at EPA regional offices helped develop the first set of projects being considered or funded.

USDA was not directly mentioned in Coastal Zone Management Act amendments but we have provided much of the technical materials used in the management measure guidance for agricultural sources and are participating in the boundary review. We have also been contracted by EPA to do the economic affordability analysis for the erosion measure.

In 1992, we face the reauthorization of the Clean Water Act with the potential of $600 million being dedicated to non-point-source activities. Current versions project $200 million for USDA to carry out a modified version of a Rural Clean Water Program. That is the program I started with, so we've come full circle.

Coastal Resource Management

IMPLEMENTING ENVIRONMENTAL PROVISIONS OF THE 602 GUIDELINES FOR FISHERY MANAGEMENT PLANS[1]

Gregory Mannesto
National Marine Fisheries Service

Executive Summary

The "602" guidelines were designed to improve understanding of what is required for secretary of Commerce approval of fishery management plans (FMPs) and their amendments. If the guidelines were fully implemented, habitat factors would be fully considered in all FMP actions. In order to obtain secretary approval of any FMP action the following factors must be considered:

The FMP or amendment must be based on the best available environmental information. Habitat information could be gathered in habitat assessment workshops (similar to stock assessment workshops) and incorporated into required Stock Assessment and Fishery Evaluation (SAFE) reports, which should be reviewed annually and updated if any significant, new information becomes available;

The "overfishing" definition for each managed species must be objective and measurable, defined biologically and related to reproductive potential;
All environmental factors affecting stock size must be assessed and explicitly included in FMPs and amendments. An extensive, long-term monitoring and research program relating environmental factors to fish stocks must be developed;

Management of overfished stocks must include conservation and management measures for protecting habitat to reverse a downward trend. Measures must be implemented in a timely manner; and

Risk (uncertainty in estimating domestic harvest and environmental degradation) must be figured into stock assessments and rebuilding plans. One method of allowing for uncertainty is to allocate a conservation reserve. This will keep the stocks from continual being driven to an overfished state.

The Fishery Management Councils (habitat committees) and the National Marine Fisheries Service (NMFS) should provide leadership in identifying information deficiencies in assessing habitat quality or quantity, its trends, and its relationship with fish stocks. A long-term monitoring and research program is needed to gather this information. With it, fishery managers will be able to include changes in natural mortality in stock assessments. Also, this information can provide the basis for

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[1]Opinions expressed in this paper are those of the author and do not necessarily represent those of the National Marine Fisheries Service.

making recommendations to action agencies on projects having the potential to degrade marine habitat.

The councils and NMFS must cooperate to restore degraded habitat and prevent further habitat degradation. Healthy habitat enables fish stocks to rebuild to their maximum sustainable yield. Fully implementing the environmental provisions of the guidelines makes habitat an important issue in fish management. The use of a habitat-based approach to fisheries management will improve the long-term viability and harvest of marine resources.

Introduction

The Magnuson Fishery Conservation and Management Act (16 *U.S.C.* 1801 *et seq.*) requires that fishery management plans (FMPs) be consistent with seven national standards in order to be approved by the secretary of Commerce. In 1989, the secretary revised the guidelines for implementing National Standards 1 and 2 to improve the quality and consistency of FMPs. These 602 guidelines explain the secretary's basis for approving FMPs. The goal is responsible conservation and management of living marine resources. This paper explains the environmental responsibilities of the Fishery Management Councils concerning the revised guidelines. It is important for council members to understand their legal obligation to implement all aspects of the 602 Guidelines.

New Council Focus

Appendix A to Subpart B of the guidelines states "changes in the guidelines emphasize the resource, not its allocation and focus on overfishing, not on Optimum Yield." In the past, the councils concentrated on allocating the resource to maximize benefits to the fishing industry. This resulted in many fish stocks being overexploited. The guidelines require that degraded stocks and their habitat be restored. The new management focus should be from a biological perspective. The fully implemented guidelines should eventually restore stock health and maximize long-term benefits to the nation. In the short term, fishermen will probably have to reduce their fishing effort, and some will be urged to switch to less exploited species or to another career.

Defining Overfishing in Terms of Maximum Sustainable Yield

The guidelines provide some flexibility in defining overfishing. Congress recognizes that fisheries and fish population dynamics vary from stock to stock. Thus, it would be hard to apply one definition to every species. Section 602.11(c) states, "Overfishing is a level of fishing mortality that jeopardizes the long-term capacity of a stock or stock complex to produce maximum sustainable yield (MSY) on a continuing basis." It leaves specification of overfishing to the individual FMP.

Defining overfishing is aided by the guidelines that identify economic, social and ecological factors to consider in modifying MSY to arrive at optimum yield (OY). Section 602.11 (f)(3)(iii) of the guidelines states that the ecological factors to consider when setting MSY are "the vulnerability of incidental or unregulated species in a mixed-species fishery, predator-prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Equally important are environmental conditions that stress marine organisms, such as natural and man-made changes in wetlands or nursery grounds, and effects of pollutants on habitat and stocks." This section clearly specifies that environmental factors should be considered in setting MSY. Fishery managers must consider habitat that varies from wetlands and nursery grounds to open ocean. They should consider switching from single-species management to management from an ecosystem perspective. They could then consider competitive interactions, unmanaged species important to the food chain, and endangered species.

OY is based on MSY. Section 602.11(d)(3) states, "MSY may need to be adjusted because of environmental factors, stock peculiarities, or other biological variables prior to the determination of OY." Each FMP or amendment must explain how MSY was adjusted to consider environmental factors and how the choice of OY will prevent overfishing. This will be easy if OY is determined from a measurable, biological standpoint; then if fishing effort exceeds the effort level associated with OY, the stock is considered to be overfished.

Status of the Stock

Section 602.11 (c)(5) states, "Secretarial approval or disapproval of the overfishing definition will be based on consideration of whether the proposal: ... (iii) provides a basis for objective measurement of the status of the stock against the definition." The Northeast Fisheries Center hosts stock assessment workshops to assemble species experts to determine the status of each managed species. The assessment allows managers to determine if a stock is overfished by comparing current fishing mortality rates with the target rate in the overfishing definition.

One problem with the current assessment technique is that habitat and non-fishing mortalities are considered constant when calculating natural mortality in fish populations. If habitat quality is held constant, then changes in habitat will not be reflected in stock assessments. Appendix A to Subpart B of the guidelines states, "Councils should attempt to obtain estimates of all sources of mortality and consider these estimates in adjusting directed fishing levels." Habitat variability should be added to population models in order for habitat to assume importance in fish management. Unfortunately, information linking habitat factors to stock changes is usually not available.

Habitat Assessment

Habitat assessments are needed for each species. One way to gather the best available information on habitat, its trends, and its link to stock sizes is to hold a habitat assessment workshop similar to a stock assessment workshop. The experts should assess the status of the habitat and what information is lacking to complete a good assessment. A research program should be designed to address these information deficiencies. Until there is sufficient information linking habitat factors and stock size, habitat factors will not be fully considered in stock assessments and fish management.

Stock Assessment and Fishery Evaluation Reports

The guidelines require the preparation of periodic Stock Assessment and Fishery Evaluation (SAFE) reports. These SAFE reports must be prepared by the secretary but may incorporate information from any source. According to the Section 602.12(e), SAFE reports should be based on "the best available scientific information concerning past, present, and possible future condition of the stocks and fisheries being managed under federal regulation." The guidelines require the reports to be reviewed annually and changed as necessary for each FMP.

Habitat assessment workshops would be a good method of collecting information for these reports.

Appendix A to Subpart B, (Standard 2—General) states, "Each SAFE report should contain information on which to base harvest specifications, such as ... significant changes (if any) in the habitat or ecosystem since it was last described in the FMP, an amendment to the FMP or previous SAFE report." The reports should document current ecosystem and habitat descriptions, significant trends, and deficiencies in habitat information. These reports could be used by other agencies to improve environmental and regulatory impact documents. The SAFE reports should explain the relative health of stocks, how OY was determined, and stock estimates relative to the overfishing definitions. Also, the reports need to evaluate the effectiveness of the conservation and management measures in preventing overfishing.

Monitoring to Determine Sources of Downward Trends

Section 602.11(c)(7) states, "care should be taken to identify the cause of any downward trends in spawning stock size or average annual recruitment; ... (i) whether these trends are caused by environmental changes or by fishing effort." To determine the causes of any downward trend, the stock and its habitat must be closely monitored over many years. This monitoring requirement is delineated in Section 602.11 (2): "Overfishing must be defined in a way to enable the council and secretary to monitor and evaluate the condition of the stock or stock complex relative to the definition." An extensive habitat and stock monitoring and research program is clearly needed to determine if overfishing is occurring and to identify the causes of stock decline. This information allows management decisions to be placed on a sound biological foundation.

Measures to Prevent Overfishing

According to National Standard 1, all FMPs or amendments must contain conservation and management measures to prevent overfishing while achieving OY on a continuing basis. Implemented conservation and management measures must be capable of being monitored to determine their effectiveness.

The councils should be innovative in developing approaches to conserve and manage stocks. These approaches should include habitat improvements. Without good quality habitat in sufficient quantity, individual species will be unable to reach their maximum potential. If stocks are approaching or have reached an overfished state, the conservation and management measures, according to the guidelines, must be more restrictive.

Rebuilding Program Must Be Timely

The concept of overfishing is based on the premise that irreversible damage to a resource's ability to recover in a reasonable period of time is unacceptable. Therefore, if the stock is overfished, a rebuilding program must be implemented in a timely manner. The rebuilding program may require drastic cuts in fishing effort and the restoration of degraded habitat. The period of time required to cut fishing effort must be specified even if there is uncertainty in estimation of parameters. The secretary will determine if the rebuilding schedule adequately addresses overfishing and habitat issues in a timely manner.

Uncertainty and Conservation Reserves

The guidelines require that risk (uncertainty associated with either environmental factors or estimates of domestic harvest) be considered in stock assessments or rebuilding plans. Section 602.11(c)(4) states "Councils must build into the definition appropriate consideration of risk, taking into account uncertainties in estimating domestic harvest, stock conditions or the effects of environmental factors." One method of allowing for uncertainty in stock estimates is to allocate a conservation reserve as an ecological safety net. Appendix A to Subpart B states "Buffers to protect against overfishing because of uncertainty in estimating stock size or domestic harvest may be established in the form of reserves or a reduced OY." Most estimates of spawning stock biomass have large variances, therefore an ecological safety net (reserves) should be established for all fisheries with large uncertainties in spawning stock biomass.

The concept of establishing reserves is stated clearly in National Standard 6. Section 602.16 (c)(2) states "Every effort should be made to develop FMPs that discuss and take into account these vicissitudes. To the extent practicable, FMPs should provide a suitable buffer in favor of conservation. Allowances and uncertainties should be factored into the various elements of an FMP. Examples are: ... (ii) Establish a reserve. Creation of a reserve may compensate for uncertainties in estimating domestic harvest, stock conditions, or environmental factors." Therefore, besides protecting against uncertainties in stock estimates, conservation reserves can be justified for rebuilding stocks degraded by man's activities. Conservation reserves are needed so that stocks are not continually driven to, or maintained at, the threshold of overfishing.

Quotas as Conservation Reserves

Optimum yield may be expressed as a formula that converts periodic stock assessments into quotas. If FMPs are quota based then it is possible to adjust OY based on environmental conditions. Therefore, if the habitat is degraded, an adjustment can be made in the quota to help conserve the stock.

Habitat Degradation

Healthy habitat is essential to healthy fish stocks. Appendix A to Subpart B states "NOAA [National Oceanic and Atmospheric Administration] also recognizes that a decline in stock size or abundance may occur independent of fishing pressure and that adverse changes in essential habitat may increase the risk that fishing effort will contribute to a stock collapse." To guard against a stock collapse, the quality and quantity of a species habitat must be maintained. The loss of habitat has lead to the decline of many species and the disappearance of others.

Section 602.16 (c)(2)(iv) states "FMPs may address the impact of pollution and the effects of wetland and estuarine degradation on the stocks of fish; identify causes of pollution and habitat degradation and the authorities having jurisdiction to regulate or influence such activities; propose recommendations that the Secretary will convey to those authorities to alleviate such problems; and state the views of the council on unresolved or anticipated issues." It is clear the councils must be actively involved in the process of preventing and restoring degraded habitat. The councils and NMFS can contribute to the process by monitoring the habitat of living marine resources and identifying the causes of degradation.

Comment Authority

Section 602.11(c)(7)(iii) states "If man-made environmental changes are contributing to the downward trends, in addition to controlling effort councils should recommend restoration of habitat and other ameliorative programs, to the extent possible, and consider whether to take actions under Section 302(i) of the Act." Section 302(i) gives the councils comment authority on federal and state activities that may affect the habitat of any species under its jurisdiction. This Magnuson Act mechanism provides the councils the authority to influence decisions impacting living marine resources outside of their direct control. The councils must take an active role by providing comments on federal and state actions that impact living marine resources and their habitat. The action agency must provide a substantive response to council comments within 45 days. No penalties are imposed on the action agencies if they do not respond. Therefore, this comment authority needs to be strengthened legislatively or the councils need to work aggressively to get action agencies to accept their recommendations to protect or restore degraded habitats.

Conclusion

The environmental provisions of the 602 guidelines are not being fully implemented. The councils need to shift their management perspective from an economic to a biological basis. Stock rebuilding programs should err on the side of conservation instead of exploitation. Councils must fully integrate environmental and habitat factors into management of the fisheries.

Councils need to do a better job of habitat assessment. Habitat assessment workshops are a good mechanism to gather the best available information. The councils and NMFS must identify information deficiencies and conduct a research and long-term monitoring program to develop the linkage between habitat quality and stock changes. The monitoring program will establish baseline information so changes in habitat will be documented and factored into stock assessments. This will provide a good foundation for biological management of the fisheries.

Full implementation of the guidelines means fishing effort on overfished stocks must be reduced. Councils need to make the tough decisions now to reduce fishing effort. Also, the councils and NMFS should identify who is degrading marine habitats. With this information, the councils, NMFS and other agencies can work together to minimize or eliminate human degradation of marine environments. Healthy habitats allow fish stocks to rebuild to their maximum sustainable yields, thereby increasing the long-term viability and harvest of marine resources.

ENTERPRISE BUDGETS FOR OYSTER RELAYING

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Abstract

Oyster landings in many regions are in persistent decline. At the same time, the extent of oyster grounds where harvest is restricted for sanitary reasons is expanding. This resource may provide an alternative to revitalize the ailing oyster industry. A joint two-year pilot oyster relaying program was undertaken by oyster fishermen and local, state and federal governments in Mississippi. The results of this public relaying program were compared with relaying activities in a hypothetical private lease. Harvest projections are limited to two years due to the lack of reliable basis for estimation beyond this period. The presence of juvenile oysters in the public relaying site, however, indicates that more harvests are expected in the future. With good management and suitable environmental factors, the public relaying site could develop into a sustainable oyster fishery. Average harvests from the public reef were relatively higher than from the private lease. Fishermen harvest 264 sacks per acre from the public reef. A harvest of 125 sacks per acre is sustainable in the private lease. Private relaying is a relatively cheaper method than public relaying. The estimated average total costs in a new 14-acre private lease are $17 per sack or $2,095 per acre in Year I and $5 per sack or $576 per acre in Year II. Public relaying in a new 10-acre reef costs $20 per sack or $5,244 per acre in Year I and $7 per sack or $1,950 per acre in Year II. However, the expected average gross receipts are greater in public relaying than in private relaying. At $24 per sack, annual gross receipts average $6,342 per acre in the public enterprise and $3,000 per acre in the private enterprise. Both investment alternatives could be profitable enterprises. The expected average returns to capital and management skills in private relaying are $905 per acre or $7 per sack in Year I and $2,424 per acre or $19 per sack in Year II. The estimated average returns to capital of all participating institutions and oystermen's labor and managerial skills in public relaying are $1,099 per acre or $4 per sack in Year I and $4,393 per acre or $17 per sack in Year II. The estimated net returns for both enterprises, however, are sensitive to variations in ex-vessel prices and annual harvests.

Introduction

Mississippi oyster landings have declined since the latter part of the past decade. Landings in 1990 was 147,517 pounds of meat, which is less than 14 percent of the average over the past decade. The value of the 1990 landings was $402,976, representing about 31 percent of the average during the past decade. The average ex-vessel price increased from $1.06 per pound in 1980 to $2.73 per pound in 1990. Effort varied widely reflecting wide fluctuations in oysters available for harvest. An average of 805 fishermen participated in the oyster fishery annually. The reduction in landings adversely affected fishing income of fishermen. The average fisherman landed 1,376 pounds of oyster meat valued at $1,791 per year.

Loss of habitat was identified as the most serious problem contributing to the dismal state of the oyster industry (GSMFC, 1991). Habitat loss may be attributed to the loss of cultch, salinity fluctuations, reef destruction, disease and pollution. The increase in coastal populations has placed pressure on the estuaries from sewage disposal, industrial activities, increased runoff from urban areas, and agricultural and livestock activities (Broutman and Leonard, 1988). Public health concerns are aggravated because many of the best growing waters are located near discharges of sewage and other wastes (GSMFC, 1991).

For management purposes, the shellfish growing areas in Mississippi are classified as approved, conditionally approved, restricted, prohibited and unclassified areas (MCWFP, 1990). Several sections of the state oyster-growing areas are classified as restricted waters (MCWFP, 1990) covering about 2,000 acres in 1985 and 57,000 acres in 1990 (USDC, 1991). Not all water bottoms classified as restricted for water-quality reasons are productive oyster reefs and annual production varies significantly. For example, a restricted shoreline safety zone is essentially devoid of oyster production.

Oyster relaying was recognized as one of the measures to increase the use of oyster resources from restricted areas (GSMFC, 1991). It involves the removal of oysters from restricted waters and transfer to approved or conditionally approved waters for natural biological cleansing using the ambient environment as a treatment system (USDC and USDHHS, 1985). The oysters may be directly spread on the new bottom or suspended in various types of containers. When suspended in containers, mature oysters are allowed to cleanse themselves in approximately 15 days (GSMFC, 1991). Materials spread on the new bottom consist of mature and juvenile oysters and empty oyster shells. The mature oysters are harvested later when the oyster season opens. The empty shells may become cultch materials for spat spawned by mature oysters. The juvenile oysters may be harvestable after one or two years from relaying.

Management Alternatives

In a public relaying enterprise, oyster resources are transferred to public water bottoms and harvested by licensed fishermen during open seasons. The relayed oysters become a common-property resource, while the revenues accruing from the harvest and sale of oysters belong to individual fishermen. State revenues associated with relaying come from oyster fishing licenses, seafood dealer and processor licenses, and shell retention and sales taxes (GSMFC, 1991). The decision to undertake public relaying enterprises is dependent upon the economic benefits and costs of relaying oysters (Burrage et al., 1991).

When oysters are relayed by a private enterprise, materials are moved to a privately leased oyster growing area. The revenues earned from the harvest and sale of oysters belong to the owners of the private enterprise. Private relaying enterprises are financially feasible if the net present value of future income is positive, or the internal rate of return is greater than the cost of borrowing.

Relaying Process

Oysters are dredged and planted during the establishment year (Year I). The monitoring of oyster resources and harvesting of mature oysters occur during the establishment (Year I) and production (Year II) years. Harvest projections are limited to two years due to the lack of reliable basis for estimation beyond this period. The presence of juvenile oysters in the relaying site, however, indicates that more harvests are expected in the future. With good management and suitable environmental factors, the relaying site could develop into a sustainable oyster fishery.

Dredging. A relaying permit issued by the Mississippi Commission on Wildlife, Fisheries and Parks (MCWFP) is required before any person or entity other than the Bureau of Marine Resources (BMR) can relay oysters in the state of Mississippi (MCWFP, 1990). Further, only two dredges weighing not more than 115 pounds each and not having more than 16 teeth are allowed on each vessel for dredging oysters. A BMR officer must be present during dredging of oysters in restricted waters until their transfer to privately leased oyster grounds (MCWFP, 1990).

In public relaying, a 65-foot boat is used in dredging oysters from restricted Mississippi waters (Table 1). The dredge boat can transfer an average of 250 barrels per trip. The dredge boat is operated by four state employees and assisted by four volunteer inmates. In each dredging trip, the dredge boat operates for more than 19 hours. An employee guards the boat during evenings when it is loaded with oysters.

In the example used of private relaying operations undertaken in Mississippi, a 67-foot vessel is used in dredging and planting oysters. This vessel can move 500 barrels per trip, depending on the availability of materials. The vessel is operated by three people who spend about 18 hours each per dredging trip.

Planting. The planting rate for new oyster reefs is about 500 barrels per acre (Table 2). The oysters relayed in a public enterprise are loaded onto motorized skiffs. Contract oystermen shoveled these materials at designated areas each planting day. This planting technique is suitable in relaying areas with shallow waters.

In private relaying, oysters are sprayed overboard by a fire cannon from the dredge boat directly to designated areas on the relaying site. This planting method is appropriate in oyster reefs accessible by large dredge boats or barges.

Monitoring. The monitoring of the oysters and growing areas is necessary to assess the biological characteristics of oyster resources to ensure compliance with existing oyster fishing regulations and management practices. Both private and public relaying areas are susceptible to poaching, and steps must be taken to deter theft of the relayed materials.

An oyster biologist, a BMR officer and project manager monitor the oysters in the public relaying area 10 to 12 times per year (Table 3). Oyster samples are taken from the relaying area to determine size composition, mortality rates and other biological indicators.

For about two months after relaying, an employee of a private relaying enterprise watches the oyster grounds from the beach. When the shrimping season opens, monitoring is stopped since the risk of losses due to poaching is greatly reduced.

Harvesting. Mature oysters over three inches long can be harvested during open season (MCWFP, 1990). An annual oyster fishing license is required when harvesting oysters from the state water bottoms. Fishermen need to register at the designated check-in station before and after harvesting oysters every harvest day. A shell retention tax of 50 cents is imposed on every sack landed in Mississippi.

Harvesting in the public relaying site is undertaken by fishermen using motorized skiffs (Table 4). Each skiff is equipped with one set of tongs. One fisherman harvests the oysters while the other culls them. Over three sacks are harvested by each boat daily, which is below the sack limit for commercial fishermen using tongs.

The harvesting of mature oysters in a private lease requires written permission from the BMR (MCWFP, 1990). Each boat uses two dredges and five people to harvest 14 sacks of oysters per hour. The actual harvesting rate, however, is generally adjusted to the actual condition of the oysters.

Enterprise Budgets

Enterprise budgets for oyster relaying in Mississippi are estimated for the establishment (Year I) and production (Year II) years. Computer simulation models were developed to estimate the enterprise budgets. The biological, technical and economic aspects of public oyster relaying are based on the actual results of the oyster relaying program in Jackson County, Miss. (Burrage et al., 1991; Posadas et al., 1991). Additional information was collected from a private oysterman who has undertaken private relaying operations in Mississippi to develop enterprise budgets for an hypothetical private enterprise.

Users of these budgets are cautioned to use them only as guides in preparing financial projections, and estimates must be adjusted to circumstances surrounding individual enterprises. The assumptions used in budgeting are based on actual relaying operations, but differences in the underlying circumstances and management practices of planned enterprises might require adjustments in the planning assumptions. Estimates depend on the assumed environmental conditions in the oyster reefs and fluctuations beyond the critical limits may lead to inaccurate results.

Annual Costs and Returns. The two consecutive years of oyster harvests from the oyster-relaying area in Jackson County, Miss. (Burrage et al., 1991) provide strong empirical evidence for a successful public relaying enterprise. Fishermen harvest an average of 2,643 sacks of oysters per year for two years from the new 10-acre public reef. The reported harvest of a commercial fishing boat averages 3.2 sacks per day. With an ex-vessel price of $24 per sack, the expected gross receipts for public relaying are $63,423 per year (Tables 5 and 6). Public relaying costs $52,435 in Year I and $19,496 per year in Year II. The estimated combined net returns to capital of all participating institutions and oystermen's labor and managerial skills are $10,988 in Year I and $43,928 in Year II.

However, there are some distributional issues involved in public relaying, since the state/local government provides funds for the public relaying enterprise. The state/local government undertakes the dredging, planting and monitoring, which cost $25,765, $6,884 and $1,744, respectively. In return, the state government expects to collect fishing licenses and shell-retention taxes from oyster fishermen, amounting to $1,198 and $1,321 per year, respectively. Additional revenues are anticipated from seafood processor and dealer licenses, sales taxes during the final sale of oyster products, property taxes and state income taxes.

Fishermen incur $18,042 per year to harvest oysters from the public relaying area. In return, fishermen receive $63,423 per year from the sale of oysters harvested. The net returns to their labor, capital and managerial skills are $45,381 per year. Essentially, the state/local government subsidizes the income of oyster fishermen by paying for the total costs of dredging, planting and monitoring amounting to $34,393 in Year I and $1,454 in Year II.

At 50 sacks per day, about 1,750 sacks can be harvested from a 14-acre private oyster lease. However, no reliable data substantiate this estimate from a private oyster lease. Critical fluctuations in environmental conditions in the private oyster reefs prevented the owner from sustaining oyster production. Nevertheless, the private lease is expected to generate gross receipts of $42,000 per year at a cost of $29,335 in Year I and $8,062 in Year II (Tables 7 and 8). The expected net returns to owners' capital and management are $12,665 in Year I and $33,938 in Year II.

Comparison Between Public and Private Relaying. Oyster harvests from the public reef are higher than from the private lease. Based on actual landings, oyster fishermen harvest 264 sacks per acre from the public relaying area. As suggested by the interviewed oysterman, a harvest of 125 sacks of oysters per acre is sustainable in the private relaying area.

The expected average gross receipts are greater in public relaying than in private relaying. At $24 per sack, annual gross receipts average $6,342 per acre in public enterprises and $3,000 per acre in private enterprises due to differences in recovery and harvesting rates.

Private oyster relaying is a relatively cheaper method than public oyster relaying. The estimated average total costs of relaying in a new 14-acre private oyster lease are $16.76 per sack or $2,095 per acre in Year I and $4.61 per sack or $576 per acre in Year II. Public relaying in a new 10-acre oyster reef costs $19.84 per sack or $5,244 per acre in Year I and $7.38 per sack or $1,950 per acre in Year II.

Private relaying generates higher average net returns per sack of oysters harvested due to lower average relaying costs. However, public relaying produces higher average net returns per acre planted because of higher average oyster harvest. The expected average net returns to capital and management skills for private relaying are $905 per acre or $7.24 per sack in Year I and $2,424 per acre or $19.39 per sack in Year II. The estimated average net returns to capital of all participating institutions and oystermen's labor and managerial skills in public relaying are $1,099 per acre or $4.16 per sack in Year I and $4,393 per acre or $16.62 per sack in Year II.

Sensitivity Analysis. The precarious nature of the oyster industry requires an evaluation of the possible effects of fluctuations in critical factors affecting the economic viability of oyster relaying (e.g., harvest, costs and prices. Annual harvests are determined by the availability of mature oysters in the relaying area. The survival of oysters depends on several biological and environmental factors (e.g., spawning, salinity, predation and pollution). The wide fluctuations in environmental conditions in traditional oyster growing areas make relaying a highly risky enterprise. To evaluate the sensitivity of the net returns from oyster relaying enterprises to price and harvest fluctuations, three output levels and three ex-vessel prices are assumed, namely: oyster harvest, 1,000, 2,000 and 3,000 sacks per year; ex-vessel price, $10, $15 and $20 per sack.

The combined returns to capital of participating agencies and labor-management of oyster fishermen are sensitive to fluctuations in ex-vessel prices and harvests (Table 9). In a new 10-acre public relaying enterprise, a total harvest of 3,000 sacks in Year I will generate positive net returns if ex-vessel price is at least $20 per sack. A total harvest of less than 2,000 sacks in Year I will produce negative net returns for the public relaying enterprise. At any harvest level, however, the harvesting of oysters from the public oyster reef brings more private benefits to the fishermen than the private cost of harvesting.

The returns to capital and managerial skill of the owners of the private relaying enterprise are sensitive to fluctuations in ex-vessel prices and harvests (Table 10). A harvest of 3,000 sacks and ex-vessel price of $10 per sack will produce net returns of $-2,464 in Year I. When harvest is 2,000 sacks and ex-vessel price is $15 per sack in Year I, net returns will be $-152. If harvest is 1,000 sacks and average ex-vessel price is $20 per sack, net returns will be $-6,876 in Year I. Positive net returns are expected at any harvest level from the private lease in Year II.

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Table 1. Dredging assumptions for public and private oyster relaying (Posadas et al., 1991).

Item	Public Relaying	Private Relaying
Dredging period	May-July	March-April
Dredging output	250 bbl/trip	500 bbl/trip
Dredging vessel	One 65-ft dredge boat	One 67-ft barge
Dredging gear	2 dredges	2 dredges
Regular crew	4 persons/trip	3 persons/trip
Volunteer crew	2-4 persons/trip	None
Dredging trips	20 trips/yr	14 trips/yr
Dredging hours	19.3 hr/trip	17.9 hr/trip

Table 2. Planting assumptions for public and private oyster relaying (Posadas et al., 1991).

Item	Public Relaying	Private Relaying
Planting area	Bangs Lake	Pass Christian
Lease size	10 acres	14 acres
Planting period	May-July	March-April
Planting method	Shoveled from skiffs	Sprayed overboard barge
Planting boats	5.8 skiffs/day	1 barge/trip
Planting gear	1 shovel/skiff	1 fire cannon/boat
Planting rate	500 bbl/acre	500 bbl/acre
Planting days	20 days/yr	14 trips/yr
Planting hours	3.1 hr/skiff/day	0.5 hr/trip
Regular crew	1.7 persons/skiff	3 persons/boat

Table 3. Monitoring assumptions for public and private oyster relaying (Posadas et al., 1991).

Item	Public Relaying	Private Relaying
Monitoring period	Monthly	April-May
Monitoring method	Collect samples	Monitor from beach
Monitoring boat	1 skiff	None
Monitoring trips	1 trip/month	60 trips/yr
Monitoring crew	1-3 persons	1 person
Monitoring hours	3 hr/trip	4 hr/trip

Table 4. Harvesting assumptions for public and private oyster relaying (Posadas et al., 1991).

Item	Public Relaying	Private Relaying
Harvesting period	December-April	December-April
Harvesting days	35 days/yr	35 days/yr
Harvesting boats	24 skiffs/day	1 dredge boat/day
Harvesting gear	1 set of tongs/skiff	2 dredges/boat
Harvesting hours	2.8 hr/skiff/day	3.6 hr/boat/day
Harvesting rate	3.2 sacks/skiff/day	50 sacks/boat/day
Regular crew	1.7 persons/skiff	5 persons/boat

Table 5. Summary of estimated costs and returns of public relaying in a new 10-acre oyster reef, Year I. Values and costs are given in dollars (Posadas et al., 1991.)

	Dredging	Planting	Monitoring	Harvesting	Total
Gross Receipts					
Oyster harvest	0	0	0	63,423	63,423
Variable Costs					
Labor services	13,703	3,685	491	0	17,879
Fuel and oil	1,695	619	60	3,133	5,507
Repair and maintenance	1,142	244	25	2,016	3,427
Food supplies	1,865	0	0	0	1,865
Launching fees	20	117	12	839	988
Land transport	560	233	336	3,356	4,485
Interest on operating capital	949	245	46	467	1,708
Total Variable Costs	*19,934*	*5,143*	*971*	*9,810*	*35,858*
Income Above Variable Costs					27,565
Fixed Costs					
Licenses	0	0	0	1,198	1,198
Depreciation	2,130	428	65	4,061	6,685
Insurance and taxes	639	17	3	155	815
Interest on investment	663	87	16	776	1,542
Management	2,398	1,208	689	720	5,015
Miscellaneous	0	0	0	1,321	1,321
Total Fixed Costs	*5,831*	*1,741*	*773*	*8,232*	*16,577*
Total Costs	25,765	6,884	1,744	18,042	52,435
Net Returns	(25,765)	(6,884)	(1,744)	45,381	10,988

Table 6. Summary of estimated costs and returns of public relaying in a new 10-acre oyster reef, Year II. Values and costs are given in dollars (Posadas et al., 1991).

	Dredging	Planting	Monitoring	Harvesting	Total
Gross Receipts					
Oyster harvest	0	0	0	63,423	63,423
Variable Costs					
Labor services	0	0	409	0	409
Fuel and oil	0	0	50	3,133	3,183
Repair and maintenance	0	0	21	2,016	2,037
Food supplies	0	0	0	0	0
Launching fees	0	0	10	839	849
Land transport	0	0	280	3,356	3,636
Interest on operating capital	0	0	39	467	506
Total Variable Costs	*0*	*0*	*809*	*9,810*	*10,619*
Income Above Variable Costs					52,804
Fixed Costs					
Licenses	0	0	0	1,198	1,198
Depreciation	0	0	54	4,061	4,115
Insurance and taxes	0	0	3	155	158
Interest on investment	0	0	14	776	790
Management	0	0	574	720	1,294
Miscellaneous	0	0	0	1,321	1,321
Total Fixed Costs	*0*	*0*	*644*	*8,232*	*8,877*
Total Costs	0	0	1,454	18,042	19,496
Net Returns	0	0	(1,454)	45,381	43,928

Table 7. Summary of estimated costs and returns of private relaying in a new 14-acre oyster reef, Year I. Values and costs are given in dollars (Posadas et al., 1991).

	Dredging	Planting	Monitoring	Harvesting	Total
Gross Receipts					
Oyster harvest	0	0	0	42,000	42,000
Variable Costs					
Labor services	7,210	158	1,032	3,500	11,900
Fuel and oil	3,187	89	0	1,005	4,281
Repair and maintenance	1,831	51	0	76	1,958
Food supplies	1,260	0	0	875	2,135
Launching Fees	0	0	0	0	0
Land transport	112	0	120	140	372
Interest on operating capital	680	14	58	90	841
Total Variable Costs	*14,280*	*312*	*1,210*	*5,685*	*21,487*
Income Above Variable Costs					20,513
Fixed Costs					
Licenses	100	0	0	100	200
Depreciation	1,221	34	0	102	1,356
Insurance and taxes	1,465	41	0	61	1,567
Interest on investment	1,831	51	0	76	1,958
Management	1,826	53	0	0	1,878
Miscellaneous	0	14	0	875	889
Total Fixed Costs	*6,442*	*193*	*0*	*1,214*	*7,848*
Total Costs	20,722	505	1,210	6,899	29,335
Net Returns	(20,722)	(505)	(1,210)	35,101	12,665

Table 8. Summary of estimated costs and returns of private relaying in a new 14-acre oyster reef, Year II. Values and costs are given in dollars (Posadas et al., 1991).

	Dredging	Planting	Monitoring	Harvesting	Total
Gross Receipts					
Oyster harvest	0	0	0	42,000	42,000
Variable Costs					
Labor services	0	0	1,032	3,500	4,532
Fuel and oil	0	0	0	1,005	1,005
Repair and maintenance	0	0	0	76	76
Food supplies	0	0	0	875	875
Launching Fees	0	0	0	0	0
Land transport	0	0	120	140	260
Interest on operating capital	0	0	58	90	147
Total Variable Costs	*0*	*0*	*1,210*	*5,685*	*6,895*
Income Above Variable Costs					35,105
Fixed Costs					
Licenses	0	0	0	100	100
Depreciation	0	0	0	102	102
Insurance and taxes	0	0	0	0	0
Interest on investment	0	0	0	76	76
Management	0	0	0	0	0
Miscellaneous	0	14	0	875	889
Total Fixed Costs	*0*	*14*	*0*	*1,153*	*1,167*
Total Costs	0	14	1,210	6,838	8,062
Net Returns	0	(14)	(1,210)	35,162	33,938

Table 9. Estimated net combined returns from public relaying in a new 10-acre oyster reef at different ex-vessel prices and oyster harvests, Years I-II. Values are given in dollars (Posadas et al., 1991).

	OYSTER HARVEST (SACKS)		
EX-VESSEL PRICE	**1,000**	**2,000**	**3,000**
Year I			
$10/sack	-31,666	-28,220	-24,773
$15/sack	-26,668	-18,223	- 9,778
$20/sack	-21,668	- 8,223	5,222
Year II			
$15/sack	6,271	14,714	23,162
$20/sack	11,271	24,714	38,162
$25/sack	16,271	34,717	53,162

Table 10. Estimated net returns from private relaying in a new 14-acre oyster reef at different ex-vessel prices and oyster harvests, Years I-II. Values are given in dollars (Posadas et al., 1991).

	OYSTER HARVEST (SACKS)		
EX-VESSEL PRICE	**1,000**	**2,000**	**3,000**
Year I			
$10/sack	-17,463	-9,959	-2,464
$15/sack	-11,877	- 152	11,574
$20/sack	- 6,876	9,850	26,576
Year II			
$10/sack	3,810	11,315	18,810
$15/sack	9,371	21,131	32,891
$20/sack	14,371	31,132	47,893

ECONOMICS AND THE ENDANGERED SPECIES

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Introduction

The Endangered Species Act of 1973 (Pub. L. 93-205, 1973, 87 *Stat.* 884-903 as amended; 16 *U.S.C.* 1531-1543, 1988) (ESA or "the act") is one of our nation's strongest and most controversial environmental laws (Pub. L., 1973; 16 *U.S.C.* 1531-1543. 1988). Often the controversy is framed in terms of "nature vs. economics." For example, there have been numerous debates on topics such as the snail darter vs. the $100 million Tellico Dam project (*TVA v. Hill*); sea turtles vs. the economic survival of shrimp fishermen and the shrimp industry; the Spotted Owl vs. thousands of timber-related jobs; and Pacific salmon in the West and Northwest vs. significant economic consequences for utilities, farmers and other water users. This article focuses on the role of economics in the ESA.

A commonly held view is that the ESA precludes consideration of economic factors (*Wall Street Journal*, 1992). This article suggests that the common impression is overly simplistic and that it is legitimate and appropriate to consider economics at certain stages of the ESA process. It provides a general description of the ESA and reviews six types of determinations or actions that may occur as a part of the ESA process. In each case, the permissibility of considering economic factors at that stage is analyzed, and if economics can be considered, the importance of economics in that decision is summarized.

Faced with the need for a methodological approach that can deal with the inevitable economic questions and uncertainties encountered in the ESA process, this article then suggests that mathematical models should be considered. These models address the need for explicit and objective analysis of economic costs and benefits associated with species preservation at appropriate points in the ESA process. In addition, using the listing of salmon in the Columbia River Basin as an illustration, the article outlines several economic evaluation approaches and their appropriateness in various stages of the listing and recovery process.

Legal Constraints and Considerations

A General Description of the ESA. The ESA is jointly administered by the secretaries of the Interior and Commerce, with most responsibilities delegated to the Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS), respectively. (The term "service" is used to refer to either FWS or NMFS.) The ESA protects a population of fish, wildlife or plants if that population is officially listed as an "endangered" or "threatened" species. The act also provides for the designation of critical habitat. Among the ESA's most significant provisions are the protections of

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[1]The views expressed in this article are solely those of the authors and do not purport to represent those of the National Oceanic and Atmospheric Administration, the National Marine Fisheries Service, or any other agency or person.

Section 7. This section includes a requirement that federal agencies, in consultation with FWS or NMFS, ensure that their actions are not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Section 9 prohibits actions such as the taking of endangered fish and wildlife (in most cases, similar restrictions apply to threatened species). Unlike Section 7, these prohibitions are not limited to agency actions but apply to all persons subject to U.S. jurisdiction.

Proposed and Final Listing Decisions. Typically, the ESA process begins when the service begins to review the status of a species, either on its own initiative or in response to a petition that presents substantial information. The statute does not specify time schedules if the service initiates the status review. However, if the service receives a petition, a proposed listing decision is required within one year. A final listing decision is required within two years after receipt of a petition providing substantial information. These time constraints are infrequently extended.

Economics are not relevant and cannot be considered as a part of the listing process. These determinations shall be made "*solely* on the basis of the best scientific and commercial data available ..."[2] The legislative history of the 1982 amendments states explicitly that "*economic considerations have no relevance to determinations regarding the status of a species. ...*" Consequently, the listing process is exempt from various laws and executive orders that otherwise would require an economic analysis. In addition, the listing is exempt from the requirements of the National Environmental Policy Act (NEPA).

Proposed and Final Critical Habitat Designations. Under the ESA, critical habitat should be designated at the time of the final listing of a species but can be delayed as long as one year if it is not determinable at that time (16 *U.S.C.* 1531(b)(6), 1988).[3] The first step in designating critical habitat is to determine the physical and biological features that are essential to the conservation of the species and whether they may need special management consideration and protection. In the second step economics are to be considered. "The secretary shall designate critical habitat ... on the basis of the best scientific data available after *taking into consideration the economic impact*, and any other relevant impact, of specifying any particular area as critical habitat."

Consideration of economic impacts is required before final designation of critical habitat. However, the joint NMFS and FWS regulations appear to allow proposed designations to go forward prior to completion of that analysis. FWS was threatened with litigation in the spotted owl case because it did not provide adequate notice nor the opportunity to comment on the economic analysis component of the

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[2]The use of the word "commercial" is not intended to authorize the use of economic considerations in the process of listing a species. The term is used to allow for the use of trade data.

[3]Until recently, many critical habitat designations were delayed using this rationale. A recent decision indicates that delays are appropriate only under limited circumstances and that this one-year extension should not be considered automatic. *Northern Spotted Owl v. Lujan*, 758 *F. Supp.* 621 (W.D. Wash. 1991).

proposed critical habitat designation. Subsequently, FWS re-proposed critical habitat, and that proposal included an analysis of economic impacts.[4]

While critical habitat designations must involve the consideration of economic impacts, evaluating the extent of these economic impacts is problematic. As interpreted by the service, the critical habitat designation by itself may have little direct economic impact. Most of the economic consequences are derived from listing the species and are not directly attributable to the critical habitat designation. When a species is listed, prohibitions against the taking of that species usually become effective, and the no-jeopardy standard of Section 7 becomes applicable to agency actions. The prohibition on destroying or adversely modifying critical habitat, as interpreted by regulation, provides protection that is very similar, if not the same, as the protection provided by the no-jeopardy standard. In addition, the prohibitions under Section 9 and associated regulations often protect habitat, regardless of whether the habitat is officially designated. The fact that the designation of critical habitat provides for little or no additional protection has been criticized by commentators (Rohlf, 1989).

In some cases, the economic impact of the critical habitat designation, apart from the impact of the listing and other protections provided for the species, can be expected to be minimal. For example, the final listing of the Steller sea lion as a threatened species under the ESA also prohibited shooting at these animals and provided for a three-mile no-approach buffer area around certain key rookery sites in order to protect the animals from unauthorized takings. Another rule implemented restrictions on trawl fishing around key rookeries in order to conserve the species and to avoid any possibility that commercial fishing could jeopardize its continued existence. The 3-mile buffers and 10-mile no-fishing zones may have significant economic repercussions, but these are consequences of regulations to prevent takings and to ensure that agency actions will not jeopardize the species. The economic impacts are not the result of critical habitat designations; critical habitat has not been designated for this species. Clearly, while economics must be considered in designating critical habitat, the relevance and importance of economics in the designation process may be limited.

Jeopardy Determinations and the Mandate to Avoid Jeopardy. Once a species is listed under the ESA, the mandatory provisions of Section 7(a)(2) apply. Federal agencies are required to ensure that their actions are not likely to jeopardize the continued existence of listed species. Similarly, once critical habitat is designated, agencies must avoid the destruction or adverse modification of these areas. The no-jeopardy obligation and the duty to avoid destruction or modification of critical habitat are to be carried out in consultation with NMFS or FWS. In making determinations under Section 7(a)(2), the best scientific and commercial data available are to be utilized. Consequently, FWS and NMFS do not consider economics in issuing biological opinions or making jeopardy determinations as a part of the Section 7 consultation process. The Supreme Court decision in the Tellico

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[4]It appears various laws and executive orders that require an economic analysis apply to the designation of critical habitat. Under FWS policy, NEPA does not apply to critical habitat designations; this policy is under legal challenge.

dam case indicated that economic consequences are irrelevant to the Section 7 mandate to avoid jeopardy. "The value of this genetic heritage is, quite literally, incalculable." The court went on to state:

> Quite obviously, it would be difficult for a court to balance a sum certain—even $100 million—against a congressionally declared "incalculable" value, even assuming we had the power to engage in such a weighing process, which we emphatically do not." (*TVA v. Hill*, 1978).

Thus, the no-jeopardy mandate does not provide for the consideration of economic factors; except in the extraordinary economic factors are irrelevant in making jeopardy determinations under Section 7; or in a situation where an exemption is sought from the Endangered Species Committee.

Alternatives to Avoid Jeopardy and the Duty to Conserve. As a practical matter, economic considerations are important in the evaluation of alternatives that are acceptable under the ESA. Normally, economic factors are considered when an agency proposes an action, and, if applicable, economic and environmental documents are prepared as a part of the administrative process. During consultation with FWS or NMFS, the impact of the proposed action on endangered and threatened species and their habitat is evaluated, and sometimes the proposed action is modified to mitigate adverse impacts. Often economic factors are considered in this process. While the language in some earlier cases suggested that the duty to conserve species under Section 7(a)(1) imposed a stringent obligation, a more recent decision indicates that there is a large degree of latitude in fulfilling this duty if that action is consistent with a biological opinion issued through the consultation process (*Pyramid Lake v. U.S. Navy*, 1990). Provided the action agency complies with the no-jeopardy mandate and does not adversely modify critical habitat, there is a great deal of latitude in choosing a preferred alternative, and economics or other factors may be considered in making this choice.

If a biological opinion concludes that an agency action is likely to jeopardize a listed species or to destroy or adversely modify critical habitat, reasonable and prudent alternatives to avoid this conclusion must be suggested. In fact, jeopardy opinions are relatively infrequent. But even with a jeopardy opinion, nothing restricts or prohibits the consideration of economic factors in selecting among the acceptable reasonable and prudent alternatives. In a very few cases, the alternatives may be viewed as so costly or undesirable that the action is blocked by the Section 7 process. But obviously, an evaluation of cost is an important consideration in deciding whether to cancel an action. A recent study concluded that blocked actions are very infrequent (Berry et al., 1992).

The Endangered Species Committee and the Exemption Process. In response to *TVA v. Hill*, the 1978 ESA amendments created an Endangered Species Committee and provided a mechanism for obtaining an exemption from the no-jeopardy mandate of Section 7. Economic factors are considered in the exemption process.

The exemption process begins upon application to the Endangered Species Committee, following completion of the normal consultation process. This committee, sometimes referred to as the "God Committee," consists of the secretaries of Agriculture, Army and Interior, the chairman of the Council of Economic Advisors, the administrator of EPA, the administrator of NOAA, and an individual to represent the affected state. Five of the seven members must vote in person to allow for an exemption. Before a waiver may be granted, the Endangered Species Committee must determine on the record that: first, there are no reasonable and prudent alternatives; second, the benefits of such action clearly outweigh an alternative course of action that would preserve the species or its critical habitat, and the action would be in the public interest; and third, the action is of regional or national significance. After making those determinations, the committee is required to establish reasonable mitigation and enhancement measures to minimize adverse effects on the species and habitat concerned.

Since the creation of the exemption process, the Endangered Species Committee has voted in only two cases: the Tellico Dam project and the Graylocks dam project, which was granted an exemption. Because the exemption process has been used so rarely, there is little information available on how it functions in practice. This situation may change in the near future.

Recently, the Bureau of Land Management (BLM) applied to the Endangered Species Committee for an exemption concerning timber sales on 44 tracts of land in the Pacific Northwest on which FWS had issued jeopardy opinions. According to FWS, these timber sales are likely to jeopardize the continued existence of the Spotted Owl. The secretary of the Interior has determined that the BLM application is complete, and hearings were conducted on this matter. The secretary of the Interior is expected to submit a report in late March 1992, although the report may be delayed by mutual agreement between BLM and the committee. The Endangered Species Committee must make its decision within 30 days after receiving that report.

In summary, the exemption process is atypical, but it represents a situation where economics can be used to justify activities that may jeopardize the continued existence of endangered and threatened species.

Recovery Plans and Management Actions. The ESA requires the development and implementation of recovery plans. Timing is not specified by statute, although certain priorities are established; a high priority is specified for species in conflict with construction, development, or other forms of economic activity. Economic considerations are relevant to the recovery planning process. Plans are to include site-specific management measures and *estimates of the time and costs* required to carry out those measures. The NMFS or FWS is responsible for the development and implementation of a recovery plan for a listed species, although the responsibility for many management actions and conservation measures may rest with other agencies, with FWS or NMFS acting in a consulting capacity.

A recovery plan is subject to public notice and public comment prior to final approval. The issue of whether a complete economic analysis is required is undecided. In addition, it is unresolved as to whether executive orders 12291, 12612, 12630, the Regulatory Flexibility Act, the Paperwork Reduction Act, or NEPA apply to the plan, or only when the plan is implemented. The answer to this question probably depends on the nature of the plan. If the plan itself includes only research objectives, goals and general recommendations, most of the requirements and procedures of these various executive orders and acts may be inapplicable.

Implementation of management actions, especially regulatory actions, probably would need an economic analysis and would be subject to various executive orders and statutes requiring the preparation of this type of analysis. The ESA does not specify a schedule for implementing management actions. Management actions could be taken as a part of the recovery planning process, or under other statutory authority.

In general, consideration of economics and other factors may be most important and relevant during the recovery planning process and when specific management and conservation measures are being implemented. While the mandate to avoid jeopardy establishes a legal minimum, recovery planning and conservation management options involve more latitude. The consideration of various options should involve the evaluation of broader social and economic costs and benefits as well as the narrow evaluation of the impact on the listed species.

Economic Analysis

Informal Economic Evaluations and the Need for an Objective Methodology. While the law restricts the role of economics in certain decisions and determinations under the ESA, such as the listing process, informal economic evaluations and assessments often are conducted and published (Buck et al., 1991). Special interest groups often weigh the costs and benefits of a proposed listing. While the evaluations occur outside of the formal listing process, these groups often attempt to influence ESA decisions based on their economic assessments.

Unfortunately, such assessments are often based on inappropriate use of economics and the results presented out of context. One of the most frequent errors is the use of regional economic impact measures to represent overall implications to society resulting from an ESA listing decision. Often costs are evaluated only in the short term and in isolation, without consideration of associated economic benefits. In other cases, these assessments are unsophisticated or erroneous. If, in fact, economic factors enhance political impacts on the ESA process, then there is an obvious need for a rational application of economic analysis to ESA decisions using a comprehensive and consistent approach.

As suggested above, even if economic factors cannot legally influence listing decisions or the obligation to avoid jeopardy, the ESA provides for the consideration of these factors in the designation of critical habitat and, perhaps more importantly, in the implementation of recovery planning and specific management measures. In the case of Columbia River salmon, an economic analysis might attempt to explore the costs and benefits associated with alternative actions to promote recovery, such as habitat protection, efforts to maximize natural spawning and promote propagation, river management measures to facilitate upstream and downstream migration, and other mechanisms to enhance survival and promote recovery. In terms of economic efficiency, the objective is to promote the recovery of the salmon resource at minimum economic costs. For example, certain minimum river flows and maximum temperature requirements are essential for the survival of salmon; certain flows and temperatures may be required to avoid jeopardizing the continued existence of the listed salmon. Additional flows may promote recovery. In evaluating the efficacy of flows, at the margin, the survival of juvenile fish and other environmental and economic benefits resulting from increased flows, including increased production and survival of non-listed fish, must be evaluated in the context of additional environmental and economic costs. These costs would include direct capital, operation and maintenance costs, as well as the opportunity costs of removing resources from existing uses. More explicitly, these costs might include the loss of hydroelectric energy production resulting from increased flows, which might in turn require production from other energy sources, such as increased reliance upon fossil fuels, nuclear, solar, geothermal, or wind power generation.[5] If these costs are overlooked and economic efficiency is neglected in the implementation of the recovery plan, unnecessary opportunity costs may be borne by society.

Measuring Economic Implications. There are four levels of economic evaluation that may be applied to salmon recovery decisions. They are, in order of decreasing economic involvement: benefit-cost analysis, cost-effective analysis, cost-sensitive analysis, and cost-oblivious analysis (Whittlesey and Wanderschneider, 1990; Yallup et al., 1984).[6] An initial decision will be to determine which of these models is most appropriate, given the environmental conditions, knowledge about the effectiveness of the actions, and the implicit budget constraints for carrying out the specified goals.

Benefit-cost analysis. A benefit-cost analysis (B/C) is a classical, fully monetized approach to measuring social welfare of development plans. It is the preferred alternative by economists when economic efficiency is the major concern. B/C is best carried out in a "with vs. without" framework to determine the social welfare implications of a proposed undertaking.

Many biologists and environmentalists are persuaded that B/C has no place in wildlife management planning because of the difficulty of attaching dollar values to non-market resources. For example, it may be difficult to place an economic value on a species' continued existence.

Nonetheless, it may be argued that B/C does have a place in the evaluation of projects that are unaffected by the ESA or other legislative mandates or where wildlife concerns are of secondary importance. Moreover, if salmon recovery efforts are successful, at some point it may be appropriate to evaluate certain fish enhancement and production projects as economic endeavors utilizing a B/C-type analysis. In addition, it could be argued that B/C would be appropriate in evaluating conservation and recovery efforts that are economically motivated.

Cost-effective modeling. Cost-effective modeling in general is appropriate when applied to some legislatively determined goal and when there are alternate means for achieving that goal. Following this paradigm, the specific goal or project benefits have been evaluated through the political process and found to be worth undertaking. Cost-effectiveness avoids the issue of evaluating benefits (especially for non-market resources) by establishing the desired objective *a priori* and by searching for the least-cost methods of achieving this objective. This model thus

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[5]Columbia River hydropower production provides electricity equal to the needs of 12 cities the size of Seattle; completely replacing this power capacity would require 15 to 20 coal-fired or nuclear plants.

[6]Whittlesey and Wandschneider (1990) followed the suggestion of Yallup et al. (1984).

facilitates comparisons among available alternatives. For example, this approach would not provide a means of deciding how many fish to produce or at what cost, but it would provide a mechanism to eliminate options that cost more than equally and more efficient alternatives, or to eliminate options that cost the same as other alternatives but are not as efficient.

A cost-effective model may be particularly useful in evaluating acceptable alternatives to avoid a jeopardy situation. In addition, a cost-effective model may facilitate comparisons among alternative recovery options. This approach would allow decision makers to build a "frontier" of cost-effective actions that would highlight the marginal costs associated with additional recovery efforts. At some point, the small increase in productivity associated with the increased recovery effort may not justify the increased cost (Hyman and Weinstedt).

Cost-sensitive analysis. Cost-sensitive analysis is generally less restrictive than the two previous models and better describes the process of meeting the goals of maintaining environmental quality and protecting wildlife. It is assumed that the goals have been legislatively determined but there are some alternatives for their achievement. Also, there may be some budget constraints that implicitly influence the choice of action. Choices frequently will be based on biological or politically determined criteria but, where alternatives are equally satisfactory in terms of these criteria, economic efficiency can play a role. Similar to cost-effective modeling, a cost-sensitive analysis may be useful in evaluating alternatives that are equally satisfactory in avoiding a jeopardy situation.

Cost-oblivious analysis. Finally, a cost-oblivious approach may be used to address societal issues. In this case a goal has been politically established that is so extreme that there is no room for alternate paths of action or concern about economic efficiency (Whittlesey and Wandschneider, 1990). This approach may be appropriate in listing decisions under the ESA. The statute and legislative history indicate that a decision that a species is endangered or threatened should be based on biological data and should not be influenced by economic considerations. This approach is also appropriate in decisions concerning whether an action is likely to jeopardize the continued existence of a species. These are biological decisions and there is no room in the decision-making process to consider B/C or social welfare functions.

The cost-oblivious model, however, is not required for other decisions in the ESA process. In terms of ensuring the survival of an endangered or threatened species, there are usually alternatives or choices that avoid jeopardizing the species and that allow for a cost-effective or cost-sensitive approach. In terms of providing for the recovery of these species and in providing for special management measures, even greater latitude is generally available, and a cost-effective analysis appears most appropriate. In the special cases, such as an application to the Endangered Species Committee, or where economic considerations are of paramount importance, a B/C analysis may be most appropriate.

Conclusion

Economic considerations are not relevant to determinations that are part of the ESA listing process. Likewise, economic impacts are not considered in making jeopardy or adverse modification determinations. Except in extraordinary circumstances, economic considerations may not be used to excuse compliance with the duty to avoid agency actions that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. In the rare case where an application for an exemption is submitted to the Endangered Species Committee, economic factors are considered in determining whether to allow an action that is likely to result in jeopardy or in the destruction or adverse modification of critical habitat.

Three other ESA actions involve the consideration of economic consequences. Economic impacts must be considered in the designation of critical habitat although the relevance and importance of economics at this stage of the ESA process may be limited. As a practical matter, the consideration of economics probably is very important in evaluating options that are available to avoid jeopardy. Where two or more alternatives exist that would comply with the mandates of the ESA, it is appropriate to consider economics in making a choice. Finally, economic considerations may be especially relevant and important during the later stages of the ESA process and should be considered during the recovery planning process and in implementing management actions and conservation measures.

Economic considerations are not ignored by the ESA. The role of economics, while circumscribed in some instances, is an important part of evaluating projects that may affect listed species or their habitats and is valuable in the implementation of recovery actions. However, if economic factors are considered, a systematic and rational approach is encouraged. Decisions should be based on a comprehensive economic analysis that is used consistently, rather than in an ad hoc fashion. While some feel that "contaminating biological decisions"" with economic considerations should be discouraged, relying on a faulty economic analysis may pose an even greater threat to the integrity of the ESA. If the Columbia River salmon debate is viewed by the public in terms of "salmon vs. economics," then it is imperative that the economic analysis be theoretically sound, thorough and objective.

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ECOTOURISM DEVELOPMENT AND MANAGEMENT: A DISASTER WAITING TO HAPPEN?

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Tourism has become an economic panacea for many countries struggling against the debt grip. Worldwide travel and tourism is the largest industry in the world. In 1987 alone, 364 million international tourists spent a total of $150 billion. If domestic spending is included, approximately $2 trillion were spent on tourism that year. As a result, the tourism industry directly or indirectly creates 65 million jobs and accounts for 25 percent of world trade as the third largest export industry (Kutay, 1989).

The benefits of international tourism to a nation's economic growth and development seemingly outweigh the costs. Tourism does have a great impact on a national economy by producing much-needed revenues for investment and development. With relatively little expense, national governments can develop their tourism industries and expand their economic opportunities.

Nevertheless, tourism has not been considered a satisfactory basis for long-term economic stability. The tourism industry is an unstable source of currency and revenues for national governments. It is an industry extremely vulnerable to changes in the general health of the global economy. It typically provides primarily unskilled, low-paying jobs, adding little to the development of a highly industrialized nation. Often, the successful promotion of tourism produces environmental devastation, when the popularity of a region causes overcrowding and degradation.

Despite the drawbacks of tourism, an increasing number of developing countries are attempting to claim a portion of this growing industry by exploiting one of their seemingly underutilized resources: wildness. Though perhaps not wild in the American sense of wilderness, there are places to escape from the industrial world and enjoy the glories of nature. Unchecked development and the many environmental disasters aside, there are still many natural wonders in the developing nations. This tourism to the natural and relatively undisturbed areas has been termed "ecotourism" and has become increasingly popular.

Citizens from many nations, especially the developed or industrialized countries, are willing to spend large sums of money to visit these remote areas of the world. They frequently come bringing the ethic of only leaving footprints. Other times, the impacts to the environment are more negative. If relatively little investment in new infrastructure is needed and little long-term change in the land results, these visitors can indeed come and look at these natural treasures, leave money behind, and then go home without inflicting pain on the area. This benign view of tourism is how many members of the tourism industry, governmental agencies, and citizens define "ecotourism."

Is ecotourism, in fact, benign? Or is this just another buzzword presented by the tourism industry trying to capture a new market consisting of affluent travelers eager to add bird species to their life-lists, to see unusual plants, or to snorkel in exotic waters? This paper will attempt to answer these questions through an analysis of the ecotourism movement. It will describe, from the point of view of a hardened conservationist and environmentalist, some of the pitfalls and drawbacks of ecotourism.

Two Approaches to Ecotourism: The Tourist's and the Environmentalist's

The recent popularity of tourism to natural areas is due for the most part to the increasing global awareness of environmental problems and the fragility of the planet. Travelers are eager to see the endangered areas of the world—the rainforests, deserts and polar regions—while they are still pristine and relatively free from degradation. One of the more often quoted definitions of ecotourism, or nature tourism as it is sometimes called, incorporates the above approach. Nature tourism is

> tourism that involves traveling to relatively undisturbed or uncontaminated areas with the specific object of studying, admiring, and enjoying the scenery and its wild plants and animals, as well as any existing cultural areas (Cabellos-Lasurian, 1988).

From this perspective, ecotourism, on the surface, appears to be a free lunch, the creation of much-needed revenues without damaging environmental effects. The lure of this "free lunch" is attracting the interests of all parties—the tourism industry, travelers, government officials and environmentalists. For tourist planners, ecotourism is the perfect industry: it doesn't pollute, it attracts plenty of foreign currency, and it gives an economic boost to regions that would otherwise remain undeveloped.

"It doesn't make any sense to make the Amazon an untouchable area that no one can see, and forget the people who live there have economic needs," noted Ronaldo do Monte Rosa, president of Embratur, the national tourism board of Brazil. "Ecotourism is ideal because it can substitute a few of the more predatory activities, such as agriculture, cattle-raising and mining, yet it allows an area to develop at the same time."

Ecotourism, however, involves much more than economics and development. Environmentalists and conservationists view ecotourism as incorporating an ethic of environmental protection into the tourism industry and its promotion. The description of ecotourism formulated by the Talamanca Association for Ecotourism, a Costa Rican non-governmental organization, is indicative of this environmental perspective.

> Ecotourism means a constant struggle to defend the earth and to protect and sustain traditional communities. Ecotourism is a cooperative relationship between the non-wealthy local communities and those sincere, open-minded tourists who want to enjoy themselves in a Third World setting and, at the same time, enrich their consciousness by means of a significant educational and cultural experience. Real ecotourism is a phenomenon that produces tangible political and economic results, educated and motivated tourists who return to their homes ready to do something about our common crises on spaceship earth, and educated and economically viable communities whose residents have the commitment and the resources to exercise an ongoing, ecologically sound stewardship of the rainforests, beaches, and wetlands (Salazar et al., 1991).

Central to this approach to ecotourism is the emphasis on environmental education about endangered areas and the conservation and protection of those areas. Tourism to endangered areas, termed ecotourism, should be centered around the idea of protecting those areas. As Eric Werner notes, conservation groups see ecotourism as a potentially viable alternative to the agricultural and commercial development that endangers many pristine lands (Werner, 1991).

In one sense, ecotourism makes it profitable for developing communities to protect and preserve the environment. However, by promoting these endangered areas as tourist attractions, governments and communities run the risk of destroying the object they are trying to promote. The history of the preservation of natural wonders in the United States exemplifies this point.

The U.S. Experience: Insight on the Future of Ecotourism?

The first national park in the world was Yellowstone, where the magnificent geysers, waterfalls, and relict ungulate herds commanded the attention of the public. However, even Yellowstone could not be set aside for its own sake, but needed to be created and promoted as a tourist destination before the concept of a national park gained widespread acceptance. The first directors of the U.S. National Park Service spent more energy promoting the parks and trying to attract visitors than they did trying to protect the parks from unneeded development.

Still today, the debate continues. The recent purchase of the parent company that runs the concessions at Yosemite National Park in California has raised important questions surrounding the role of tourism in the protection of natural wonders. The group that wanted to remove the most massive of the tourist development from the park is supported by the U.S. environmental movement. Those who wanted to maintain the development found support within the levels of the U.S. government. The question remains: can an area be simultaneously protected and developed? With development, there seems to be only incentives for more people to visit; in essence, we love our parks to death.

Another example of this dilemma between environmental protection and tourist development from the United States experience is Niagara Falls, perhaps the most visited ecotourism site in the world. In this area, the abundant waters of the upper Great Lakes drop approximately 99 meters (326 feet) through the Niagara Escarpment and then into Lake Ontario. Niagara Falls is seldom visited because of its natural wonder, despite its pre-European colonization wonderment. The area is despoiled with one of the greatest concentrations of chemical industries and concurrent toxic emissions in the world, as well as with unaesthetic trinket shops, fast-food restaurants, and towers.

In other areas of the globe, the balance between adequate environmental protection and appropriate development poses similar dilemmas. In Tierra del Fuego in Argentina, the issues of protecting this fragile environment as a tourist attraction confront the tourism industry, government officials, and the public alike. Basic infrastructure improvements are needed in the area in order to accommodate additional tourists. This is a disaster waiting to happen.

During the 1970s, government policy favored settlement of Tierra del Fuego, several thousand kilometers south of Buenos Aires. The government-initiated development has left a legacy of toxic contamination and economic distress. Now, non-indigenous beaver, peat mining, clear-cutting, overfishing of the endemic spider crab, raw sewage, and open garbage disposal greet tourists, instead of the once-open and relatively undeveloped land.

Tourism is considered the single available alternative if there is to be any economic base for the area. As a result, the construction of hotels and casinos is underway in order to attract and accommodate tourists. The environmental impact of this development has the potential to be devastating. In fact, the first five-star hotel and casino are being built at the base of the same glacier whose melt waters provide the drinking water for the community. Thus, the potability of that water supply is becoming increasingly questionable.

The promoters of ecotourism suggest that this form of tourism does not entail an all-or-nothing choice between economic development and environmental preservation. The ecotourism supporters take the position that ecotourism can be a win-win situation because the land does not have to be developed to attract visitors. Visitors, ecotourism promoters argue, will pay for the opportunity to see the land in its primitive form.

Nevertheless, the development of ecotourism as a viable economic alternative is not as simple nor as environmentally sound as its supporters suggest. Ecotourists require the same basic infrastructure services as other tourists—airports, ground transportation, lodging, communications and the bureaucracy to maintain these facilities. Investments in water and sanitation are often needed to ensure the health and well-being of the tourists (Boo, 1990). This investment in infrastructural development necessarily involves a sacrifice of land and resources and the possibility of environmental degradation in the process.

Given these examples of the dilemma created by tourism, in particular ecotourism, is it possible to strike a balance between environmental protection and sustainable development? Who should be responsible for doing so? Any decisions about how much protection an area needs, and whether that protection is at all realistic in the political milieu of a region, naturally should be made by local leaders and citizens.

However, in many instances, local citizens are excluded from decisionmaking by developers with an abundance of projects and capital to finance them and by national officials with hopes of attracting them. When a local community is involved, the promise of economic success and development often outweighs any concern for the protection of the environment. As the experiences of the U.S. National Park Service reveal, even public concern for the protection and preservation of natural wonders is not enough to prevent the environmental degradation created by uncontrolled ecotourism. What is needed for successful environmentally sound tourism is widespread planning and foresight.

Planning for Ecotourism

All environments are fragile to a certain extent and all have an inherent carrying capacity. This capacity refers to a "certain threshold level of tourist activity [or any activity for that matter] beyond which there will occur physical deterioration of the resource, or damage to natural habitats ..." (Miller, 1988). Therefore, all ecotourism promotion and development must be grounded in an understanding of the region's carrying capacity.

An ecotourism planning mechanism should allow for the control of the scale and amount of development appropriate to the particular site and should guarantee that no pollution would result from this development. However, the best planning cannot take the place of understanding carrying capacity. How much is too much requires a case-by-case analysis. Nevertheless, even in places such as the Galapagos Islands where tourism is carefully planned and monitored, the environment has been threatened by too many tourists and the resulting overdevelopment of the infrastructure.

Fragile areas need special management. Examples of this kind of management include wetland and coastal dune areas in the United States where boardwalk systems have been designed to keep people from trampling the very resources that are being protected and visited. Another example is the seasonal closing of bird nesting areas, which has been important in the preservation of viable populations of these creatures.

The careful planning that is necessary for any ecotourism project to be successful must include local governments and citizens in the decisionmaking. An informed population with rights to participate in the development process is essential before any proposals can be given approval. However, this has not been the case. Without local involvement, projects attempting to be environmentally sensitive are doomed to failure as ultimately only the eyes and ears of the surrounding population can protect and have protection enforced. This is especially true where outside resources are severely limited, resulting in very few rangers and other professional managers.

In Africa, the establishment of game reserves without local involvement has been detrimental to the preservation of both the human and animal communities. The local citizens, having no positive stake and losing both their grazing areas and hunting rights, often became poachers. Success in the African reserves has been accomplished only when the local population became the wardens and staff, helping to create an association whereby the reserve became something positive in the lives of the surrounding population. This is not to suggest, however, that the African game parks are now functioning as healthy ecosystems. Poaching and other problems still plague the areas, and many of the natural resources are still in decline.

Proper planning is necessary to ensure that the parks and natural areas are managed and protected. People come to visit these regions in order to see them at their best. Simply delineating an area on a map is not protection. The crush of visitors will destroy the resource that is being protected. As Boo (1990) notes,

> As a resort's attractiveness declines, frequently as a direct result of tourism, tourists move on to new sites, sometimes leaving behind polluted beaches, a disillusioned local population, and a devastated local economy...this situation can also imply the end of the protected ecosystem.

A tragedy of the commons will occur when visitors overwhelm park areas lacking adequate infrastructure and enough staff to supervise and control the tourist activities.

To promote ecologically sound tourism, which balances economic development with environmental protection, financial resources must be available to local communities and national governments. Money for these ambitious undertakings unfortunately is scarce and, at times, nonexistent, even in the United States. The tourist dollars generated by ecotourism can be a substantial monetary resource to towns and cities surrounding the natural sites. However, these profits from ecotourism are often diverted to foreign entrepreneurs as a return on an investment and other vital economic interests by local and national governments.

As a result, profits from ecotourism must be invested in the preserved area and not in unrelated needs. Park management is costly, though these initial costs will repay themselves many times over in the future. The tourist dollars should be invested in the preservation, protection and management of the resources so that they will remain attractive to tourists and environmentally sound. Planning is essential to the success of any project having widespread impact, especially in ecotourism. There are too many examples of environmental exploitation and degradation of protected natural areas. The preserves have suffered and cease to provide any long-term protection for the wildlife and naturalness that prompted them to be set aside initially.

Conclusions

Ecotourism has been promoted as the new wave in tourism, incorporating both environmental conservation and economic development. Supporters argue that ecotourism is the model for economic success in Third World nations. It attracts foreign investment and helps to diversify national economies without entailing huge start-up costs or causing widespread environmental damages. As a result, developing nations, such as Costa Rica and Belize, are attracted to this new tourism phenomenon and are encouraged by the potential economic benefits to develop ecotourism attractions.

At present, ecotourism makes up a very small percentage of all travel and its promise of immediate economic benefits is illusory. As Karen Ziffer notes, true ecotourism based on true economic development can take a long time while market forces are looking for immediate satisfaction. She adds that the wise approach must be broader from the beginning, for if nature and local development are dependent solely upon tourism, they may well be once again endangered after ecotourists have all packed up and gone home (Stutz, 1990).

Nevertheless, the tourism industry and many developing nations continue to view ecotourism as a path to economic success and as a marketing concept to attract increasing numbers of tourists to Third World areas to ensure that success. The stated environmental concerns and goals are secondary to the development of economically viable tourist attractions. This is a problem common to tourism industry development in general.

Developers in the rush to make profits ignore the potential environmental, not to mention social and cultural impacts, of their projects on local communities. The creation of these tourist attractions skews development away from the most needy areas of a nation's economy and toward the development of additional amenities for tourists, amenities that even the locals may not have. As an area's popularity increases, not only does the number of tourists increase but also the volume of the internal immigration of citizens seeking better incomes and opportunities. These increases often overwhelm the carrying capacities of the tourist areas and have detrimental effects on their environmental soundness. Local interests in protecting natural areas are overtaken by those of the developers and their supporters and lure of potential profits. In ecotourism projects, the result is often "exploitation hiding behind the green mask of tourism" (Stutz, 1990).

True ecotourism does have the potential to be both economically viable and environmentally sound. However, true ecotourism development requires a long period of time for planning and cooperation between tourists and local communities. Travelers from the industrialized nations have much more to offer to local communities than money. Very often, travelers bring expertise in solving environmental problems that they will share willingly with local populations. However, these tourists must come solely as educators, allowing local governments, citizens and non-governmental organizations to adapt methods that have been explained to them. The key to successful ecotourism is the empowerment of the local population and its involvement in any kind of development project. Successful ecotourism can occur only when there are strong and sufficiently numerous local non-governmental organizations to carry the burden as watchdogs and protectors of their lands.

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Public Participation

DEVELOPMENT OF A DEMONSTRATION PROJECT TO INVOLVE CITIZENS AND LOCAL GROUPS IN THE CONTROL, MONITORING AND REPORTING OF MARINE DEBRIS

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Abstract

MARPOL (Marine Pollution) Annex V regulations apply to all U.S. ships (except certain government-owned or -operated ships), including commercial fishing vessels and privately owned recreational boats, wherever they operate; and to every port and terminal in the nation. All foreign vessels operating in U.S. waters including the Exclusive Economic Zone (200 miles) must also comply with these regulations. The Marine Plastic Pollution Research and Control Act of 1987 is the U.S. implementing legislation for Annex V and extends the dumping regulations to all navigable waters of the United States.

Recognizing the importance of citizen monitoring to help reduce the marine debris problem, Section 2204 of the Marine Plastic Pollution Research and Control Act requires the U.S. Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the U.S. Coast Guard to conduct programs to encourage the formation of "Citizen Pollution Patrol" volunteer groups to assist in the monitoring, reporting, cleanup and prevention of ocean and shoreline pollution.

The Center for Marine Conservation (CMC) received a grant from the EPA to design, test, and evaluate a demonstration project designed to increase awareness of the marine debris problem within the maritime community and to enlist citizen participation in a pilot program to report violations of the Marine Plastic Pollution Research and Control Act. CMC conducted this "Citizen Pollution Patrol" project in the Annapolis, Md., region. Coastal Environmental Services, Inc. and the New Jersey Sea Grant Marine Advisory Service conducted a similar program in cooperation with the CMC in the Port of Manasquan/Greater Barnegat Bay region of New Jersey. Both projects offered a unique perspective on implementation of a federal program at the state and local level and could serve as a model for coastal communities throughout the United States.

Introduction

In 1987, the Marine Plastic Pollution Research and Control Act (MPPRCA) provided for U.S. ratification of MARPOL (Marine Pollution) Annex V, the International Regulations for the Prevention of Pollution by Garbage from Ships. These regulations apply to all U.S. ships, except certain government-owned or -operated ships, including commercial fishing vessels and privately owned recreational boats, wherever they operate; and to every port and terminal in the nation. In addition, all foreign vessels operating in U.S. waters including the 200 mile Exclusive Economic Zone (EEZ) must comply with these regulations.

Under the regulations it is illegal for any vessel to dump plastic trash anywhere in the ocean or navigable waters of the United States. In addition to prohibiting the discharge of plastics in coastal and ocean waters, MARPOL Annex V makes it illegal to dump all other types of trash in inland waters and ocean waters out to three miles from shore. Further offshore various other disposal restrictions apply.

Final interim regulations promulgated by the U.S. Coast Guard require vessels that are 26 feet or more in length to display placards that notify passengers and crew of marine debris discharge regulations and possible penalties for violations. Furthermore, the regulations require oceangoing vessels of 40 feet or more in length to have written waste management plans on board.

The U.S. Coast Guard is responsible for enforcing MARPOL Annex V regulations. Civil and criminal penalties have been authorized for violations. Recognizing the importance of citizen monitoring to help reduce the marine debris problem, Section 2204 of the MPPRCA requires the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and the Coast Guard to encourage the formation of volunteer groups, designated as "Citizen Pollution Patrols" (CPP), to assist in the monitoring, reporting and prevention of ocean and shoreline pollution.

In 1991, the Center for Marine Conservation (CMC) received a grant from the EPA to design and test a CPP project. Working in conjunction with the New Jersey Sea Grant Marine Advisory Service and Coastal Environmental Services, Inc. two demonstration projects were conducted, one in the Port of Annapolis region of Maryland and one the Port of Manasquan/Greater Barnegat Bay area of New Jersey. The projects were designed to:

Increase awareness of the marine debris problem in the maritime community;

Educate the boating population in the project areas about MARPOL Annex V;

Bring members of key marine user groups into compliance with MARPOL Annex V; and

Test a pilot program in which citizens report violations.

Overview of Marine Debris Laws

Since the Coast Guard has issued the final interim rules for implementation of MARPOL Annex V and the MPPRCA, guidance concerning vessel enforcement policy, vessel discharge violation investigation, and reporting requirements for the discharge provisions of Annex V has been developed by Coast Guard Headquarters in Washington, D.C. In the field, each regional Coast Guard Captain of the Port or Marine Safety Office (MSO) determines the optimum approach to encourage compliance.

The Coast Guard regulations on garbage disposal at sea became effective with the 1989 boating season. Presently, the Coast Guard does not conduct boardings exclusively for the enforcement of Annex V. Search and rescue operations, drug interdiction, and enforcement of customs and immigration laws remain their highest priorities. Compliance with MARPOL Annex V regulations is mainly determined during other operations including regular boardings and safety inspections. Violations by ships at sea are identified during these boardings, or through interviews of ship personnel or investigation of passenger reports. While ships are in U.S. navigable waters or the EEZ, they may be inspected by the Coast Guard. On routine inspection, patrols check to see that ships have not discharged plastics or other garbage in violation of the MPPRCA or Annex V.

Besides MARPOL Annex V and the MPPRCA, a variety of other legislation and regulatory agency initiatives address debris in the marine environment. For example, in Maryland part of the state litter law applies to state waterways and in New Jersey provisions of the state fish and game statutes prohibit the introduction of any material, including debris of any kind, into fresh or tidal waters of the state. In addition, many municipalities have also adopted ordinances and regulations in an attempt to control littering within their communities. While approaches vary, they all generally prohibit the disposal of waste materials defined as litter within the boundaries of that municipality including marinas and dockage facilities, along the waterfront, or in water bodies within the community. Many municipalities have also adopted recycling ordinances as elements of their solid waste management plans. The implementation of source separation and recycling and enforcement of local litter-related ordinances can provide municipalities with mechanisms to combat marine debris along the waterfront. However, at present these programs are not in existence in all coastal communities.

Development of the Citizen Pollution Patrol

The two primary purposes of the CPP project were to design, test, and evaluate a method for citizens to report illegal garbage dumping incidents from vessels, and to conduct a concentrated education and outreach campaign for maritime user groups.

The education efforts were targeted at three main audiences: the project team, marine user-groups and the volunteer compliance reporters. First, the project team had to be fluent in details of the regulations, implementation and education efforts of MARPOL/MPPRCA. Second, education of marine user groups in the Annapolis and Manasquan/Barnegat Bay project areas was important in order to gain voluntary compliance with the regulations. Finally, education of potential citizen reporters was necessary, so that those people could know what was legal and illegal under these laws.

Existing educational materials were utilized for the project outreach. In addition, several new customized information pieces were developed. Throughout the education and outreach aspect of this program, tens of thousands of copies of educational materials were distributed to maritime interests in New Jersey and Maryland. This information helped expose these boaters to the problems and solutions to marine debris, as well as to opportunities for compliance and citizen monitoring.

In order to enable citizens to document and report suspected violations of MARPOL Annex V and other marine debris laws, a mechanism to facilitate an effective response to citizen reports was developed. Meetings with interested local, state and federal regulatory and enforcement agencies operating in the project area were held in order to enlist their participation in the CPP Program and to develop an effective citizen reporting mechanism. At these meetings the possibility of establishing a procedural protocol for reporting violations of MARPOL Annex V and the MPPRCA regulations to local and state agencies was discussed.

All of the local and county agencies contacted indicated that generally, local jurisdiction along the waterfront is considered to end at the shoreline, and that marine debris-related incidents would likely be referred to the marine law enforcement unit of the state, and, where appropriate, to the Coast Guard. In addition, although the project was of interest to many of the agencies, most were unwilling to commit to active participation in the CPP Program because of questions related to jurisdiction, and staffing and budgetary constraints. During the discussions with the Coast Guard it was noted that a number of factors make enforcement of Annex V difficult. These factors include the great number of ships affected by the regulations, a huge enforcement area, the difficulty in determining the source of plastic and other debris once it is dumped overboard, and concern over how high of a priority plastic and garbage control should be, when compared to search-and-rescue missions and control of illegal drug traffic by Coast Guard personnel.

In both New Jersey and Maryland the local Coast Guard stations indicated that they could not take on enforcement activities related to reports of marine debris, especially reports received from citizens, in light of all of their other responsibilities. In Maryland, the Coast Guard requested that the smaller violations be reported to another enforcement agency like the Maryland Natural Resources Police. In contrast, the New Jersey Marine Police suggested that violations of MARPOL Annex V and the MPPRCA should be reported to the Coast Guard. Thus, the development of similar projects in different coastal regions reflects quite a dichotomy.

As a result of these efforts, the Coast Guard MSO in Philadelphia and the Maryland Natural Resources Police did agree to participate in the project and a final strategy to facilitate citizen reports of violations of MARPOL Annex V and the MPPRCA was developed. A citizen pollution report form was developed to provide all of the information needed by the cooperating enforcement agencies. Both state and federal agencies assisted in the development of this form. Once printed, it was distributed to thousands of interested boaters and anglers in both project areas. Arrangements were made to forward CPP reports to the Coast Guard MSO Philadelphia Office (New Jersey project) or the Maryland Natural Resources Police (Annapolis project). These agencies would then track the owner of the reported vessel via the vessel registration number and forward a packet of educational materials to the vessel owner or determine if enforcement action would be taken.

Results of the Citizen Pollution Patrol Project

Few citizen reports of MARPOL Annex V violations were received as a result of the CPP. However, it should be noted that the project did enable thousands of boaters to learn of the opportunities and benefits of individual citizen involvement in compliance monitoring. In addition, the Coast Guard MSO Philadelphia, Coast

Guard Group Sandy Hook, and Maryland Natural Resources Police have indicated that they will consider participating in various aspects of the CPP in the future.

The CPP project revealed many difficulties in enforcing Annex V regulations. However, voluntary compliance through education has been shown to be an effective means of achieving the policy objectives of MARPOL Annex V during the CPP Program. The one-year pilot project alerted thousands of boaters and marina operators to the subject of garbage in our waters. Information on the problems caused by marine debris, as well as solutions to the problems, was widely disseminated. MARPOL Annex V and regulations were explained to environmental, fishing, and boating organizations in the project areas through seminars, workshops, media presentation and attendance at trade shows and local forums. The project also assisted boaters and fishermen in complying with the placarding and waste management plan requirements of MARPOL Annex V.

Several of the educational materials developed for the pilot project are now being considered for use at a national level. The citizen report form has been adapted for use across the United States, and a new MARPOL Annex V placard may be utilized by a national information office.

Project staff also facilitated the inclusion of Annex V information into permanent types of educational materials. For example, Coast Guard volunteers provide free courtesy marine exams on about 300,000 recreational boats each year. These safety and equipment surveys are designed to help the individual boat owner learn about his/her boat's deficiencies in required equipment. The checklist that these volunteers followed has not included requirements for compliance with MARPOL Annex V. Through the pilot project, this problem was addressed, and the next edition of the national booklet will include information on complying with the federal marine debris law.

Conclusions and Recommendations

Through the CPP projects a great deal was learned about local implementation of the federal law restricting overboard garbage disposal. A number of factors make enforcement of this law fairly difficult. These factors, including the large area of coastal water in the United States, and the large number of vessels covered under the law, are explained in the Coast Guard's "Report to Congress on Compliance with the Marine Plastic Pollution Research and Control Act." The Coast Guard, which is charged with enforcement of the federal law, has not received many additional resources (people or funding) in order to work on these new regulations. One measure that might overcome some of the current difficulties, would be to increase funding to the Coast Guard. It that were to occur, that funding should be directed into specific programs and positions at Coast Guard national headquarters and regional/local offices. In the last few months additional billets were created to help increase USCG manpower for MPPRCA. However, the effects of these additional resources on MARPOL/MPPRCA enforcement have not yet been seen.

Besides MARPOL Annex V and the MPPRCA, a variety of other international agreements and federal legislation and regulatory agency initiatives address marine debris. Several states have regulations restricting the overboard discharge of garbage. Local littering ordinances may also serve to reduce dockside littering. The existence of several layers of regulatory protection to reduce marine debris will aid in preventing plastics and other debris from entering the marine environment. However, at all regulatory levels, enforcement and compliance monitoring agencies must have adequate resources to meet the mandate of environmental protection laws.

Although enforcement of Annex V may be difficult, educating the public about the problems of marine debris and the requirements of Annex V offers an effective means to combat the problem at the source by influencing compliance decisions. Voluntary compliance through education has been shown to be an effective means of achieving the policy objectives of MARPOL during the CPP Program and in a number of demonstration projects conducted at U.S. ports.

Informal surveys conducted before presentations on the CPP reveal the need for education on marine debris issues to more than 45 million boaters in the United States. In Maryland and New Jersey, similar responses were obtained while talking with commercial, recreational, sailboat and motorboat operators. Approximately 25 percent of the audiences indicated some knowledge of a recent federal law controlling debris disposal in the marine environment. This law applied to every member of these boating audiences, yet three-quarters of the boaters did not know what they needed to do to comply with it.

Clearly, education on marine debris issues and laws restricting overboard garbage disposal must be continued and bolstered. In addition, educators must remember to emphasize the meaning of the law, rather than the name of the law, which only 5 to 10 percent of the audiences recognized. The user groups regulated by Annex V require continuing education about marine debris and the regulations to control it. These groups include commercial fishermen and recreational boaters, as well as merchant shipping crews, passenger ship crews, research ship personnel, offshore oil crews, marina managers, and port and terminal operators. Other groups needing objective education about MARPOL Annex V include the staff at federal and state agencies, consumer interest groups, and industry representatives.

The International Maritime Organization "Guidelines for the Implementation of Annex V, Regulations for the Prevention of Pollution by Garbage From Ships" recommend a variety of methods for distributing information to a wide audience to raise the level of compliance with Annex V including radio and television public service announcements, articles in periodicals and trade journals, public projects like beach cleanup days and adopt-a-beach programs, posters, brochures, workshops, and teaching materials for public schools. The CPP Program utilized most of these methods to educate marine user groups in Annapolis and the Port of Manasquan/Greater Barnegat Bay project areas.

Compliance with the federal marine debris law is lagging at the operational level in both the recreational and commercial fleets seen in the CPP project. Many marine user groups have voluntarily complied with the law, once they became aware of it, through national efforts or those of smaller programs like the concentrated outreach conducted in New Jersey and Maryland. Voluntary compliance through education is one of the most economical forms of encouraging maritime interests to obey the law. Increased enforcement, through more effective agency participation and through the use of citizen reporting, can also serve to foster compliance. Although it may take years to change the public's habits, the two-pronged approach of a broad based, well designed educational program and a reinforced, efficient citizen's reporting and enforcement program, is a recommended method to reducing the amount of garbage entering our coastal waters.

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ESTUARINE WATER QUALITY MONITORING USING VOLUNTEERS

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The demand for improved management of the nation's coastal areas increased greatly in the 1980s. Environmental deterioration has become more obvious and visible to the public. People have seen garbage, some of it hazardous, washing up on our beaches. Finfish and shellfish harvests have decreased or been banned. People are unable to swim in their local waters. Eutrophication has led to unpleasant sights and smells.

Citizens are putting pressure on public officials to act on their promises to clean up the environment. Interjurisdictional agreements have been made in the Great Lakes region and the Chesapeake Bay. The Environmental Protection Agency's National Estuary Program (NEP) and the National Oceanic and Atmospheric Administration's estuary program now involve many more of the nation's coastal areas in cleanup programs. The public has expressed a clear desire for more consistent and effective enforcement of environmental regulations.

These activities have led to the realization that there is a lack of reliable and credible information on the status of the nation's coastal areas on which to base acceptable enforcement actions.

As the public has become more environmentally aware, a certain segment of this interested public has developed a desire to get directly involved by volunteering to collect data and information about water quality and living resources near their homes and businesses.

This is not really a new phenomenon in our country. Volunteers have been collecting climate data for the National Weather Service for 100 years, and birdwatchers have been active for a long period. Members of the Izaak Walton League have been checking the health of streams for 20 years, and residents of lakeshores in New England and the Midwest began testing lake waters in the early 1970s.

In the 1980s citizen groups and individuals began sampling estuarine waters in tributaries of the Chesapeake Bay and the coastal lagoons of Rhode Island. Also, there was increased emphasis on ensuring that the data collected by volunteers is quality assured and controlled, thereby ensuring acceptance for use by scientists and managers. Demonstrating that volunteers can collect data of known quality is slowly dispelling skepticism. EPA's Office of Water officially endorses the use of citizen volunteers to collect water quality data and promotes public participation in the NEP newsletter *Coastlines.*

Volunteer monitoring programs in estuaries have concentrated on measuring standard water quality variables, such as temperature, water clarity (Secchi depth), pH, salinity, dissolved oxygen and, when possible, nutrients. Emphasis has been on tracking changes in water quality over time and has required volunteers to sample frequently (weekly in many areas) over several years. Rhode Island and Chesapeake Bay monitors are now in their seventh year.

These successful programs have spun off similar efforts around the U.S. coast from Maine to Florida, across the Gulf of Mexico and up the Pacific Coast to Washington. Nearly all the NEP, NCW and NOAA programs have either organized or are planning to organize some sort of volunteer monitoring project.

The 3rd National Volunteer Water Monitoring Conference was held last week in Annapolis and was attended by 325 people—and at least 50 were turned away due to lack of meeting space. The theme of this meeting was "Building Partnerships in the Year of Clean Water." Some 70 of these participants attended a workshop on techniques for sampling estuaries. Regional workshops for volunteer monitoring managers and citizens also have been held around the country.

The most important thing that keeps volunteers sampling is demonstrating that their data are being used. A few states now include, or are planning to include, the data in the State of the States' Waters report to Congress. Other states and local governments have used volunteer-collected data to close shellfish beds, screen for problems like poor or ineffective sediment/stormwater control, and identify areas that are unsuitable for development. In the Chesapeake region the data collected in shallow water detected very low dissolved oxygen concentrations nearshore where it had been assumed that tide and wind would keep the water sufficiently mixed to prevent such problems. Volunteers have also documented insufficient mixing of sewage treatment plant effluent in the James River, Va., leading to levels of very high concentrations of ammonia. Such findings can be used in permit renewal stipulations. Volunteers are even more important because of fiscal constraints in states.

Let us assume that you have been convinced that volunteer monitoring is a great way to document the cleanup efforts of your local estuarine waters, as well as to garner support for the necessary funding. What has the Alliance for the Chesapeake Bay learned that can help you?

Clarify your goals. Are you undertaking this project to gather useful quality-controlled data? Or is your main goal to educate the citizens who will support the clean-up effort and change their daily habits to ones that are more likely to provide clean water?

Volunteer water monitoring projects whose primary goal is good data also deliver an informed public. However, one can educate many students and adults with less rigorous procedures. It is very important to decide which goal comes first. Many people are interested in learning how to monitor by participating in a one-day demonstration project. Only a fraction of them will be willing or able to carry out a regular sampling routine that includes rigorous quality control measures.

Careful and thorough planning is essential. Involve everyone from the beginning, including potential volunteers, researchers, regulators, elected officials, potential users, environmental groups, civic associations, polluters and fishermen.

Be sure that the tests you plan to carry out will answer the question you are asking. This is more difficult than you might think. It may seem that pH is something you really want to track, when in fact estuarine systems are usually well buffered and pH may not tell you much about water quality.

There is a need to develop biological indicators for estuaries analogous to the "bug counts" or counts of macrobenthic invertebrates used by Save Our Stream programs. Delaware Inland Bays Volunteer Monitoring Program plans to start a pilot benthic worm counting project this summer.

Put each variable that is being proposed to rigorous testing. You don't want to waste enthusiastic volunteers' time.

Give a lot of thought to just how good the data need to be to meet your established needs. Most technically trained people assume that collected data must be as accurate as is technically possible. This is not always necessary for screening or tracking.

Prepare a quality assurance plan and adhere to it. This will include thorough method comparisons so that data collected by volunteers can be integrated and compared with those collected by professionals. Professional oversight is necessary for ongoing quality control.

Start smart: Begin with a pilot in one area with only a few sites. Make your mistakes and work out bugs before you invest in expensive equipment.

People involved in these activities agree that successful restoration and protection of coastal resources will take the full cooperation of citizens working in partnership with governmental jurisdictions charged with regulating and enforcing environmental practices. Being involved in volunteer monitoring activities is a constructive and personally satisfying way to contribute to this.

EFFECTIVE CITIZEN PARTICIPATION IN THE MANAGEMENT AND PROTECTION OF NATURAL RESOURCES

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As environmental awareness increases throughout the globe, a continuing issue surrounding the implementation of environmental protection measures is the involvement of citizens. Citizen involvement is essential for the development of successful and long-term environmental programs, including the protection of coastal areas. Without local involvement, projects attempting to be environmentally sensitive are doomed to failure, because ultimately only the eyes and ears of the surrounding population can protect fragile areas and have protection enforced.

This paper will focus on the issue of effective citizen participation in managing and protecting natural resources, particularly coastal areas. It will do so by analyzing the issues surrounding the protection of natural resources—particularly people and policies—and will illustrate successful protection projects initiated by citizens. Finally, recommendations will be made for present and future citizen involvement in preserving unique and sensitive ecosystems.

Since the 1970s citizens have been effective in slowing down the degradation of coastal areas by implementing their right to sue violators of the Clean Water Act (CWA). Albeit, traditionally the right of citizens of "standing to sue" has been quite narrow. Today, we have the misfortune of witnessing citizen rights of standing to sue become more and more narrow. The courts have uniformly viewed citizens as secondary enforcers of the act, with the primary enforcement responsibility vested in the Environmental Protection Agency (EPA) and the states (Benson, 1988). Section 505 of the Clean Water Act authorizes any citizen to file suit against any person alleged to be in violation of certain portions of the act. The act defines citizens as "a person or persons having an interest which is or may be adversely affected." Thus, Section 505 gives citizens the basic power to enforce the Clean Water Act but places limits and conditions on their authority to sue. Difficulties for citizens intending to enforce the act arise due to tight specifications as to when they can do so (i.e., in general, when discharges lack required permits or are in violation of the permits). They may not enforce against violations of information request, record-keeping or reporting. In addition, the prospective citizen plaintiff must give notice of a violator to the EPA, to the state in which the alleged violation occurs, and to the alleged violator at least 60 days prior to filing suit. (Miller, 1988). This time span would work in favor of defendants and give them incentives to delay pending litigation in order to achieve compliance. Finally, citizens may not sue purely for past violations of the act. Citizens who clear the preliminary statutory hurdles will generally do well under Section 505.

One such hurdle that was not overcome was in *Gwaltney v. The Chesapeake Bay Foundation Inc.*, in which the court focused on the language of Section 505; Gwaltney is a meat-packing plant in Virginia that had 150 violations between 1981 and 1984:

> The court remanded the case for a determination of whether the complaint contained a good-faith allegation of an ongoing violation. The citizen suit was

determined moot, even though the complaint contained a good-faith allegation of an ongoing violation, if prior to final judgement defendant can show that it is "absolutely clear that the allegedly wrongful behavior could not reasonably be expected to recur." (Benson, 1988)

This application of mootness is troubling because it may discourage private enforcement, i.e., citizens will be less likely to file suit.

With such hurdles to overcome, why do citizens become involved? Initially, citizens become involved when something goes wrong in their immediate surroundings. They may, however, be compelled by the feeling of spiritual connectedness with nature and share the Amerindian holistic perspective in which human beings and other forms of life are one. Saroj Chawla (1991) in an article titled "Linguistic and Philosophical Roots of Our Environmental Crisis" makes the link between language, philosophy and our handling of the environment. She believes that, in order to get to a holistic perception of the environment, we must become aware of our unconscious habit of fragmenting reality in speech and thought. This goal would necessitate a change in our language habits. She makes the following analogy: "As long as we think of the water in the home and the industrial waste water in the rivers and ocean as distinctly separate, it will be difficult to avoid water pollution." Chawla believes that the well-being of American society is measured in terms of uninterrupted growth in consumer goods and permanently rising levels of production and consumption. As this occurs, people and the natural environment are frequently injured by industrial pollutants. She argues that, instead of separating ourselves from the biosphere, keeping financial statements of progress, and maintaining quantitative measures of our well-being, we need to develop a comprehensive experiential vision of the natural environment. Some citizens do visualize need for this new ideology and holistic spiritualism.

A similar ideology is held by the "deep ecologists," who stand in opposition to the view of nature as object and as an economic resource, although they are not necessarily connected to the idea of the sacredness of nature. Deep ecology, coined and articulated by Norwegian philosopher Arne Naess and American philosopher and environmental activist George Session in 1984, exchanges anthropocentrism for biocentrism. Such organizations as Greenpeace and Earth First! have the ethic of deep ecology. Killingsworth and Palmer (1992) speak of Greenpeace:

> In dramatizing the radical biocentrism of deep ecology, Greenpeace has nevertheless kept open the possibility for forming links with more moderate conservation groups as well as groups with distinctively different view points, such as organized labor.

On the other hand, Earth First! has a no-compromise deep ecology position, based on refusals to be "appropriated by mainstream political interest and human-centered environmentalist projects" (Killingsworth and Palmer, 1992). When non-violent protest fails to accomplish a local purpose, Earth First! encourages acts of "ecotage," the purposeful sabotage of the machinery of development.

The focus of this paper is the grassroot activists—those who get involved because they see a threat to their health, their livelihood or their surrounding environment. Whether one becomes involved for spiritual, deep-ecological, economic or health reasons, his or her voice must not only be heard but also listened to and supported.

Support is needed for the individual citizens who travel down the rocky road of politics and preservation. Citizen activists who are effective in opposing policies, government and industries often are viciously attacked by these institutions. Common attacks are job blackmail (being blackballed) and SLAPP (Strategic Litigation Against Public Participation) lawsuits. Citizens often cannot afford attorneys or lose even with legal counsel. In addition to harassment, violence and economic blackmail by industries, citizens are at risk of losing their jobs because industries may threaten to move to other countries unless environmental constraints are weakened.

Creating links can ease the citizens' challenge of overcoming these obstacles. Non-profit environmental organizations have the resources to facilitate citizen involvement. One may ask: Why should I make a linkage to an environmental organization? A linkage with an organization may provide education, resources—e.g., consultation and technical assessment—and power through numbers.

Although the major environmental groups (Sierra Club, founded in 1892; National Audubon Society, 1905; National Parks and Conservation Association, 1919; Isaak Walton League of America, 1922; Wilderness Society, 1935; National Wildlife Society, 1936; Defenders of Wildlife, 1947; Environmental Defense Fund, 1967; National Resources Defense Council, 1970; and Environmental Policy Institution, 1972 [Reem, 1987]) often do not connect with citizens individually, they are an excellent resource for scientific studies, litigation and media attention. Ultimately, it tends to be the smaller environmental organizations—that were formed nationwide in the late 1970s and early 1980s—that are the most supportive and effective locally.

A smaller-scale, environmental organization that has proven effective is the Atlantic States Legal Foundation (ASLF) located in Syracuse, N.Y. The non-profit, membership-based corporation was founded in 1982 to implement a proactive program to protect and restore the environment. The unique focus of ASLF is to help local communities with local environmental problems. ASLF has directed its resources to a range of situations including the cleanup of toxic hot-spots in the Great Lakes Basin, promoting safe and economical solid and hazardous waste disposal alternatives, and enforcement of the Clean Water Act (ASLF Newsletter, Winter 1991).

For many citizens, ASLF provided the missing link. An example of ASLF's encouragement of citizen involvement in environmental concerns is its enforcement efforts of the Clean Water Act Program in Fort Wayne, Ind. Acting on requests from a number of its members in Indiana, ASLF began investigating pollution problems at the Fort Wayne Water Pollution Control Plant in December 1990. They reviewed the monthly discharge reports of Fort Wayne industries and found an extensive history of Clean Water Act violations by almost one-quarter of those industries. After ASLF reported the high level of toxics on the Maumee River Flood Plain—used as a storage site by the Fort Wayne Water Control Plant—Fort Wayne activists declared the need for tougher enforcement. ASLF's research brought to the forefront discharge data supporting citizen enforcement actions against 20 of Fort Wayne's most egregious pre-treatment violators. Subsequently, ASLF put 20 pre-treaters on notice of its intent to sue for Clean Water Act violations.

A specific result of ASLF's actions was the installation of a "closed-loop" wastewater recirculation system by a number of Fort Wayne pre-treaters. In addition, a number of settlements totalling more than $100,000 were, by citizen consensus, to be allocated to the Indiana Nature Conservancy, earmarked for the Conservancy's Fish Creek Project. That project is an effort to preserve Fish Creek, the sole remaining habitat of the White Cat's Paw Pearly Mussel. Through the efforts of the citizens of Fort Wayne and the staff of ASLF, the Maumee River may again be clean enough to support the endangered mussel.

In addition, ASLF created the Lake Ontario Organizing Network (LOON) Directory project, funded in part by the Laidlaw Foundation. Due to ASLF's work, many citizens now empower themselves by using the LOON project as a database for information and connection to other concerned citizens. This network allows citizens to effectively become involved in the protection of Lake Ontario.

Another critical example of ASLF's dedication to citizen participation is the work being done in Puerto Rico to protect and restore some of the natural resources. Concluding an evaluation by ASLF, the severe deterioration of the island was recognized. Some areas were subject of tremendous development pressure as a result of population growth and tourism, and a near crisis was developing regarding water resources. Maintaining an adequate supply of safe potable water was and is a major concern for Puerto Rico (Sage, 1992). ASLF researched permit files and observed major industrial violators of water discharge permits. Subsequently, the citizens initiated projects for the organization to study.

In recent years, ASLF has focused much of its efforts on the Great Lakes. Through its extensive work in all eight Great Lakes states, especially New York, Michigan, Wisconsin and Indiana, ASLF has earned a growing reputation as an innovative, results-oriented organization capable of translating abstract ecological objectives into practical policy initiatives.

ASLF has been directly involved with several programs stemming from the Great Lakes Water Quality Agreement. ASLF has received $48,553 from the Charles S. Mott Foundation for water quality work in the Lake Ontario and Niagara River basins. Under the 18-month Mott grant, ASLF used the National Pollution Discharge Elimination System (NPDES) permit renewal as a tool to achieve the zero discharge objective of the Great Lakes Water Quality Agreement. ASLF conducted a successful public education program to assist citizens within the Niagara River and Lake Ontario basins in commenting on NPDES permit renewals in order to lower permitted discharge limits.

Most recently, ASLF received $117,832 from the Joyce Foundation for a two-year program focused on Lake Michigan. Under the Joyce grant, ASLF has participated in the development of the first official Lakewide Management Plan in the Great Lakes. In addition, ASLF is creating a Citizen's Resource Guide for Lake Management. The purpose of this guide is to help citizens understand the relevant environmental issues and regulatory structures. Also, ASLF will hold a series of workshops around the basin aimed at educating citizens about public participation in the NPDES (Clean Water Act) permitting process.

Technical support is also offered for those who are interested in commenting and monitoring these permits. Often citizens of the communities affected by pollution in the basin are knowledgeable about sources of pollution and impaired uses of their waterways but lack the technical skills to analyze data and effectively address their concerns. Retired workers, for example, can often present first-hand knowledge of industry practices and areas for improvement. They only need guidance through the process, orientation with the documents, and assistance in preparing public comments.

Save the Bay is another "gem" of a non-profit environmental organization, founded in 1972 in Tiverton, R.I. Save the Bay is working toward a clean and healthy Narragansett Bay through public support and participation. One project was the publication of annual surveys of bay and watershed sewage treatment plants titled "The Good, the Bad and the Ugly." The surveys heightened public awareness by exposing the inefficiency of sewage treatment plants. As a result of the ensuing public and political pressure, many plants began to address and correct their problems, and in some areas the water quality of Narragansett Bay started to improve.

One recommendation to citizens is to learn to be automatically suspicious of the perceptions that ecosystems have direct and simple relationships. On the contrary, environmental systems are intricate and cyclical. Coastal waters receive a range of contaminants, including discharges from industrial and municipal water, dredge material, atmospheric fallout, and polluted rivers. The distribution, fate and effects of contaminants in coastal environments are governed by natural processes that influence their persistence in the ocean and their availability to marine organisms. As toxic chemicals make their way through the marine food chain many ecological changes may occur at each trophic level, "including changes in specific distributions and abundance, habitats, and biogeochemical cycles" (Capuzzo, 1990). Non-profit environmental organizations like Atlantic States Legal Foundation, are empowering citizens with the ecological information and technical consultation necessary for preserving our precious coastal areas.

Secondly, we must take the initiative to learn how to monitor our natural resources so that we may practice "regulation" ourselves. An example is the self-monitoring relationship between the pollution industries and the EPA. This allows polluting industries to test their own pollutant emissions and periodically report the test results to the regulatory agency. A pollution industry, under this system, is expected to voluntarily report itself in violation of the standards. Peter Steinhart (1990), writer for *Audubon*, reports on the growing number of citizen enforcers patrolling the air and waterways of the nation: "There is now a Hudson Riverkeeper, a Long Island Soundkeeper, a Delaware Riverkeeper, a Puget Soundkeeper, and a NY-NJ Harbor Baykeeper. [The citizen patrollers] are moved by the conviction that state and federal agencies aren't adequately enforcing environmental laws." Steinhart also notes a remark by Sharon Moreland, who works in the compliance section for wetland-fill permits for the Army Corps of Engineers in the San Francisco Bay region. Her section has a staff of three; she states: "If I had eight, possibly I could do a barely adequate job. It's vastly more work than any of us can handle." Thus, the need for citizen environmental monitors is explicit.

In a nutshell, it is critical that we not get caught up in bureaucracy, but rather that we find out who the polluters are and bring the violators' actions to a halt.

Citizens understand that we cannot continue to practice development as it has been practiced for the past 5,000 years—especially the last 50. This young citizen activism movement comprises people of all races, people of all ethnic backgrounds, people of all regions, urban and rural people, both formally educated and those lacking any formal education. They understand also that the economic system is not one that can sustain itself, and they realize that as technology grows and we become more reliant upon it, the environmental damage increases. In summary, the greater the citizen involvement, and the better developed the symbiotic relationships between citizens and grassroots organizations, the greater our potential for effecting structural reform on toxic polluters. And with these grassroots movements, class-consciousness on environmental ethics can emerge. Emel (1991) states quite eloquently, "Ecological or environmental politics are politics of place, body, mind and heart, survival, dignity, and control." I argue that it is the individual citizen who is the most in touch with the aforementioned and, therefore, precisely the impetus in our society for the defense and preservation of our natural resources and environment.

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Research in the National Estuarine Research Reserve System

TEMPORAL AND SPATIAL CHANGES IN PLANT DIVERSITY IN CHESAPEAKE BAY TIDAL WETLANDS: MANAGEMENT IMPLICATIONS

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Abstract

Vegetation composition of tidal marshes plays an important role in Chesapeake Bay wetlands. In general, plants provide wildlife habitat, help water quality, provide erosion and flood control, and are important as a carbon-based food source. Since different plants may provide different functions, change in the composition of the vegetation may alter the function that a particular wetland may provide an estuarine ecosystem. Management objectives of wetlands are oriented toward protecting the functions of a wetland valuable to our society. Since little is known of the probability of occurrence, cause or extent of these vegetation changes, or the role they may play in estuarine wetland functions, management planning for these areas becomes difficult. A long-term study is underway to quantitatively assess changes in vegetation patterns in the tidal wetlands of the Chesapeake Bay. Changes in each site can then be quantified and used to indicate long-term trends by comparing year-to-year data. By better understanding long-term vegetation trends, long-term management planning may become possible.

Introduction

Wetlands are valued for the functional roles they play in providing wildlife nesting, breeding and foraging habitat, in water quality and flood control processes, and as shoreline erosion buffers. Which function(s) and/or value(s) a wetland serves depends on several factors, including vegetative structure. In part, the functions and values of a wetland are tied directly to the types, numbers and distribution of plant species within that wetland, i.e., the vegetation pattern of that wetland. For example, the foraging, nesting and breeding potential of a forested wetland differs from that of a saltmarsh due, in part, to the different plant species dominating the systems. Similarly, the ability of a saltmarsh to buffer shoreline erosion differs from that of a tidal freshwater marsh due to the herbaceous habit of the dominant species of the latter (Odum et al., 1984; Odum, 1988). Therefore, a large number of wetlands with varying vegetative structure is necessary to maintain the number and types of functions and values provided by wetlands to a watershed.

Tidal wetlands of the Chesapeake Bay, our nation's largest estuary, are distributed along both tidal and salinity gradients within the Bay. The vegetation pattern of an individual wetland depends on its location along these gradients. Tidal and salinity gradients vary both spatially and temporally (Environmental Protection Agency (EPA), 1987; Perry, 1991). These gradients produce a large number of diverse habitats, which, in turn, are vegetated by a diverse array of vegetation.

Spatial and temporal changes in the distribution and relationship of plant species become important when considering such long-term processes as sea level rise, hydrologic and salinity alterations (e.g., through reservoir construction), and groundwater removal. All could alter the functions and/or values provided by impacted wetland areas. Thus, to éffectively manage our resources, it is important that we have a working knowledge of these vegetation changes.

In 1991 we began a vegetation analysis of the tidal wetlands of the York River components of the Chesapeake Bay National Estuarine Research Reserve in Virginia. The work will be continued over the next several years to determine and describe yearly quantitative vegetation data. Analysis of the data will provide seasonal, yearly, and long term changes in the vegetation patterns of four wetland systems distributed along a salinity gradient. The purpose of our research is to determine and quantify spatial and temporal changes that may occur within the vegetation patterns of the Reserve sites. The purpose of this manuscript is to discuss the importance of this research as it may pertain to policy and management of wetland resources.

Site Description

The York River component of the Reserve comprises four sites (Figure 1). Each site is located within a different salinity regime of the York and Pamunkey rivers (U.S. Dept. Comm., 1991). All sites have approximately the same tide range (one meter) (U.S. Dept. Comm., 1987).

High-salinity conditions are represented by the Goodwin Islands, the southernmost of the York River Reserve sites. The islands are marine sand deposits formed through beach deposition during a late Pleistocene sea level regression. The wetlands used for this study were dominated by *Spartina* spp. and were inundated by semidiurnal (twice daily) tides that have a salinity of 18 to 22 parts per thousand (ppt).

The Catlett Islands Reserve site are located approximately 14.4 kilometers (9 nmi) upstream of the Goodwin Islands and represent mesohaline conditions (8 to 18 parts ppt) in the river. They have the same ontogeny as the Goodwin Islands. Mixed secondary pine-hardwood forest dominates the high relief zones and mesohaline *Spartina* spp. and *Juncus roemerianus* saltmarsh dominate the wetland areas.

Taskinas Creek is located 32 kilometers (20 nmi) upstream of the Goodwin Islands. The site represents the transitional area of the York River (EPA, 1983) with a salinity of 3 to 13 ppt. The wetland consists of a mosaic of plant assemblages that grade from brackish-water-dominated assemblages in lower reaches to freshwater-dominated assemblages in the headwater area.

Sweet Hall Marsh is a tidal freshwater marsh located on the Pamunkey River. It is approximately 62.4 kilometers (39 nmi) upstream of the mouth of the York River and has a salinity regime of 0 to 0.5 ppt. Classified as a point marsh, the entire marsh system is dominated by broadleaved herbaceous or graminoid plant species (Doumlele, 1981).

Methods

Transects were established within the wetlands of each site. The number of transects needed in each site was determined by the number of assemblages and their distribution within the site. Assemblages were identified by ground-truthing existing aerial photographs.

Species dominance and frequency data were collected from 1m x 1m plots arranged at 10-meter intervals along the transects in the summer of 1990. Cover data were recorded in the field and transposed to midclass ranges (Mueller-Dombois and Ellenberg, 1974) for data analysis. Density counts were made in 1/4m x 1/4m plots systematically arranged in one corner of the cover plots. The adequacy of sample size was tested with a running mean analysis for each site (Mueller-Dombois and Ellenberg, 1974).

Species importance values (IV), the sum of the calculated relative frequency, relative density, and relative dominance, (Curtis and McIntosh, 1950; Phillips, 1959; Mueller-Dombois and Ellenberg, 1974), were used to calculate the dominant species at each site. Species diversity for each site was calculated using the Shannon-Weaver index (Shannon and Weaver, 1949). Data were collected from mid-July to September 1990.

Results and Discussion

Salt-tolerant species dominated the Goodwin Islands, the Catlett Islands and Taskinas Creek (Table 1). Salt-tolerant species were poorly represented in Sweet Hall Marsh. Sweet Hall Marsh had the highest diversity of the four sites. The Goodwin Islands, with their large number of halophytes, were next followed by Taskinas Creek and the Catlett Islands.

The tidal marsh vegetation communities of the York and Pamunkey rivers can be divided into three components: halophytic, brackish and freshwater. The high diversity of the Goodwin Islands, the most saline site in the study, may be due to the presence of both the halophytic flora and the brackish flora. The halophytic flora did not occur or occurred in only very small numbers in the other sites. Brackish flora dominated the Catlett Islands and Taskinas Creek and was also present on both the Goodwin Islands and Sweet Hall Marsh sites. The freshwater flora component was found only in Sweet Hall Marsh. Since the Catlett Islands and Taskinas Creek contain only the brackish floral component and the other two sites constituents of at least two of the components, the diversities of the sites were low in comparison.

The change from brackish to freshwater flora occurs along a very short reach of the river between Taskinas Creek and Sweet Hall Marsh (personal observations). The rapid change may indicate a threshold effect in distribution of the brackish and freshwater flora.

Vegetation Changes. The changes that can occur in Chesapeake Bay tidal wetlands can be due to yearly variation in population dynamics of the macrophytes; long-term variation in environmental parameters of the ecosystem; or a combination of the two. It is not known if yearly variation within a system could produce statistically significant differences in vegetation patterns of a wetland system as was found in this study.

Results from previous work in Sweet Hall Marsh (Perry, 1991) indicate that there was a noticeable difference in the distribution patterns of perennial vs. annual plants. In addition, while the species diversity of Sweet Hall Marsh did not change significantly after a 13-year period, the species components of the diversity index did change significantly (Perry, 1991). Annuals were more variable in their distribution dynamics than the perennials in the study. Since annuals are reliant upon open habitat at the time of germination, they can be considered the "opportunistic" strategist of the marsh. Perry concluded that yearly variation in distribution may be normal and the value of annuals as indicators of trends would be suspect. Perennials, on the other hand, would tend to stay in place. A temporal change in the distribution of a perennial could be seen as indicative of changes in the surrounding environment. In particular, Perry noted the increased importance in the salt-tolerant perennial tall cordgrass (*Spartina cynosuroides*) and hypothesized that an increase in the importance value of tall cordgrass over 13 years could indicate a shift in dominance within the vegetation pattern to salt-tolerant species.

Needless to say, the amount of time a species takes to react to changes would depend upon the degree of change and the adaptability of the species. Future work should be oriented toward investigating the response of perennial species to small changes in environmental parameters, particularly changes in salinity and inundation periodicity.

Salinity Stress. Salinity increases in an estuary can be caused by decreasing the dilution effect of freshwater input by decreasing the amount of fresh water that reaches the estuary. This increase is usually caused by natural (e.g., drought) and/or man-made processes (e.g., interbasin water transfer or dam construction on riverine tributaries (usually for water supply reservoirs)).

As fresh water enters an estuarine system, the salinity gradient of the estuary moves downstream (Knauss, 1978; Bradshaw and Kuo, 1987). However, as indicated in this study, this relationship is not always obvious. Even though rainfall in the watershed that includes Sweet Hall Marsh is highest in the summer (Brooks, 1983), salinity reaches its peak during the same time period (Perry, 1991).

The distance upstream that salinity stresses wetland vegetation is a function of basin volume and freshwater runoff. If a basin were to increase in size and/or if the runoff were to decline, the tidal volume would increase and, therefore, more salt water would enter the estuary. The net effect would be an increase in the reach of salinity stress farther upstream (Knauss, 1978). If the basin were to decrease in size and/or if the runoff volume were to increase, the effects of salt would not be observed as far upstream.

Changes in the basin size of an estuary may be brought about by eustatic sea level rise, isotectonic effects, and/or local events (groundwater withdrawal). Together, these three parameters control the relative sea level of the site to the extent they exceed sedimentation rates within the aquatic portion of the basin. Any change in these three parameters leading to an increase in the elevation of relative sea level, would increase the volume of water entering the basin and, therefore, increase the upstream reach of salinity. Research in the Chesapeake Bay indicates that relative sea level is rising (Hicks, 1972; Froomer, 1980). Thus, one would hypothesize that the salinity in the Sweet Hall Marsh area is increasing.

Vegetation Response to Salinity Stress. Plant cells cope with increasing salinity stress (i.e., increases in the salt concentration of the water column and/or soil) via osmosis (the active transport of water by a plant through a permeable cell wall). In the event of an increase in exposure to salt water, there is net loss of interstitial water from the plant to the outside environment. In macrophytes which have large amounts of parenchyma cells (thin-walled cells) an increase in the salinity stress could lead to a rapid desiccation and loss of turgor due to the loss of large amounts of water across the thin walls.

On the other hand, water loss would be minimized by plants that have a large number of cells with thickened cell walls. The thicker walls decrease direct contact between the living plant tissue and high concentration solute.

This could explain, in part, the dominance during the early growing season (time of low salinities) in tidal freshwater marshes by arrow arum (*Peltandra virginica*), a thin-cell-walled macrophyte, and the shift during the mid to late growing season (times of higher salinities) to thicker-walled species such as rice cut grass (*Leersia oryzoides*) and/or tall cordgrass (*Spartina cynosuroides*). The latter contain large numbers of collenchyma and sclerenchyma cells (thick-walled cells).

Tides and Inundation Stress. Daily, seasonal (steric) and yearly variations in tides can cause large changes in inundation periodicity (Perry, 1991). The effects of these seasonal changes will manifest themselves in two ways: changes in time of flooding and changes in salt stress. During the mid to late growing season, the time of highest inundation periodicity, the salinity of the estuary is also at its highest. Therefore, there will be an associated increase in salt (osmotic) stress. Thus, growth conditions in the marsh will be more stressed in the late than in the early growing season. The vegetative response will be toward more flood- and salt-tolerant macrophytes.

Implications for Wetland Management

Much could be learned of a wetland ecosystem by analyzing the spatial and temporal changes that occur in vegetation patterns. Small changes in macrophyte distribution, numbers and importance in a wetland vegetation pattern could indicate changes in environmental parameters of a wetland system. Thus, by monitoring the changes (or lack of changes) in wetland vegetation patterns we may be able to monitor changes in environmental parameters that we cannot directly observe with modern technology and databases.

Understanding the changes in wetland vegetation patterns could serve as an early detection and warning system for extremely subtle long-term climatic adjustments. Data suggest that we are in a period of global warming (Barnett, 1983; EPA, 1987). One potential consequence of warming would be a rise in sea level. The change in the climate would be reflected in wetland vegetation patterns as species shifts to better adapted populations occur.

Also of importance to the manager would be an understanding of the relationship of specific plant species to changes in environmental parameters. For example, as vegetation patterns change, the value of a wetland to specific animal species will change. If a specific waterfowl species relies on an abundance of a plant species not tolerant to high salinities for subsistence and/or habitat (e.g., northern wild rice), an increase in the salinity could lead to a stress in the waterfowl's population. Other wildlife, e.g., muskrats, could be affected as well by reductions in species preferred for food or den construction. Early detection of the changes in the vegetation would provide time for managers to plan for the loss of a food source. Corrective management steps, such as field or marsh plantings, could be put into action before, instead of after, the changes occur.

With further understanding of the trends seen in vegetation patterns, our ability to detect changes in our physical environment will improve. Furthermore, our ability to manage for these changes will be greatly enhanced.

Conclusions

Future research should include monitoring changes in the diversity and other vegetation parameters seasonally throughout the growing season. There is also a strong need for research that would concentrate on the investigation of the salinity and tidal inundation tolerance of individual plant species. The role that inter-species competition between plants plays in the distribution of plant species in these salinity regimes will also prove to be a field rich in valuable information.

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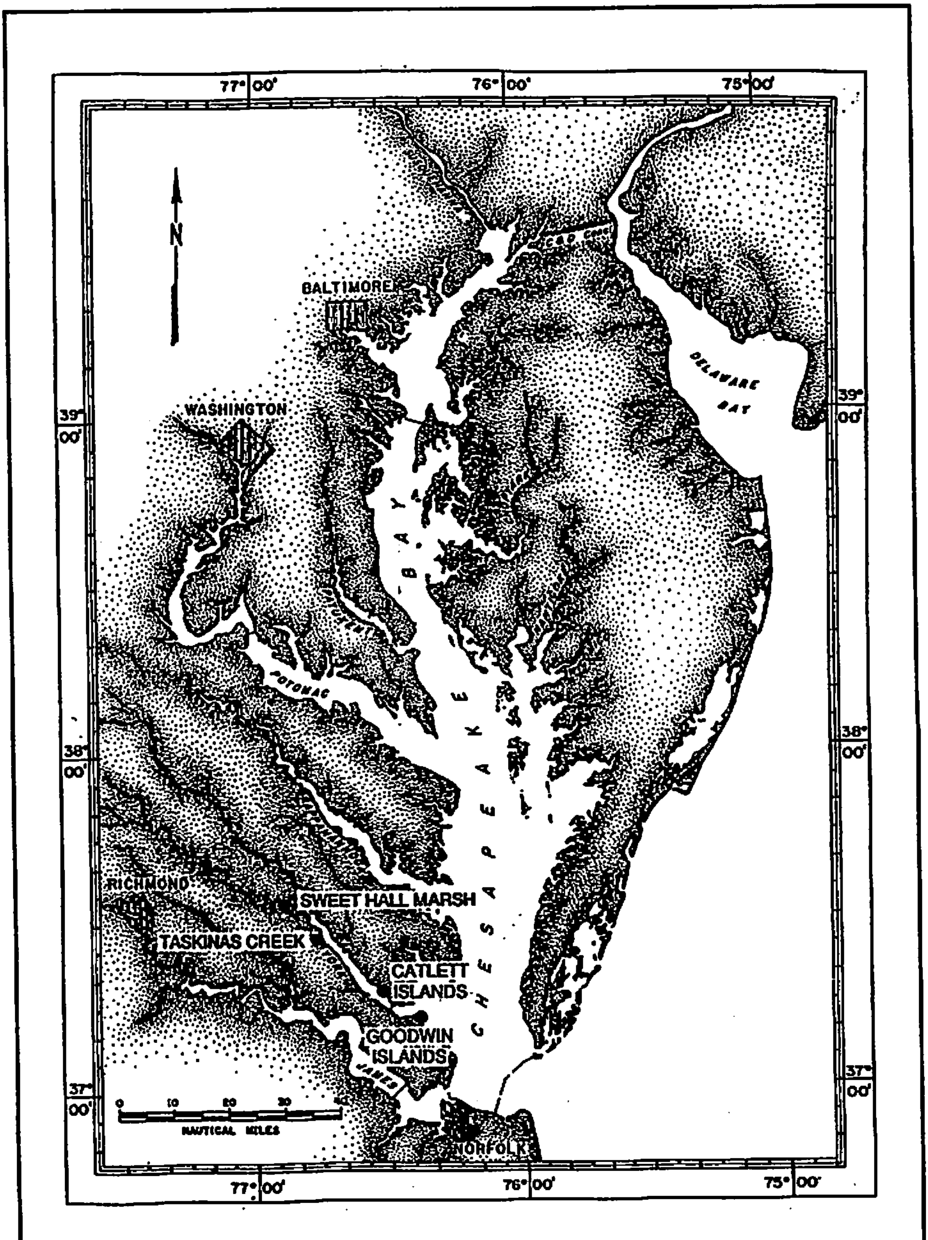

Figure 1. Location of the York River sites of the Chesapeake Bay National Estuarine Research Reserve in Virginia.

Table 1. Dominant plant species of York River Reserve components. Dominant species were calculated as the species that, after arranged in descending order of importance value, account for more than 50 percent of the total importance values of all species at the site. Species are listed in order of highest relative importance values.

Site	Dominant Species	% Total
Goodwin Islands	*Spartina alterniflora*	33.5
	Distichlis spicata	32.0
	Total percentage	(65.5)
Catlett Islands	*Distichlis spicata*	48.0
	Spartina alterniflora	30.7
	Total percentage	(78.7)
Taskinas Creek	*Spartina patens*	44.9
	Distichlis spicata	25.6
	Total percentage	(70.5)
Sweet Hall Marsh	*Peltandra virginica*	18.3
	Carex stricta	9.8
	Leersia oryzoides	8.8
	Polygonum punctatum	6.9
	Polygonum arifolium	6.7
	Total percentage	(50.4)

GROUNDWATER MONITORING STUDIES AT COMPONENTS OF THE CHESAPEAKE BAY NATIONAL ESTUARINE RESEARCH RESERVE IN VIRGINIA

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Abstract

The sites of the Chesapeake Bay National Estuarine Research Reserve in Virginia provide a unique opportunity for research on groundwater quality and quantity in shallow aquifers adjacent to the Chesapeake Bay. The ensured availability, protection and relatively undisturbed nature of these sites make them ideal locations for collecting baseline data, and establishing monitoring well networks to provide long-term monitoring of groundwater. Data from these sites can be used to study regional changes in groundwater quality due to acid precipitation, sea level rise and other natural and anthropogenic processes, and for investigation of localized impacts of human activity on groundwater quality throughout the Chesapeake Bay region. Data collected from these sites can also be used to help elucidate the role of groundwater in determining the abundance and distribution of terrestrial and submerged aquatic vegetation, and to estimate the sensitivity of this flora to future perturbations.

Monitoring well networks have been installed at the Goodwin Islands Reserve site at the mouth of the York river subestuary, and at the Catlett Islands Reserve site 19 nautical miles upstream in the mesohaline region. Groundwater samples were collected monthly over one year from Goodwin Islands and over six months from Catlett Islands and analyzed for dissolved nutrients, pH and salinity. Groundwater from Goodwin Islands was also analyzed to determine the possible presence of organic pollutants. Groundwater nutrient loadings at both Goodwin Islands and Catlett Islands were found to be well below those observed at agricultural or residential land use locations in the region. Nitrate, nitrite, ammonium and phosphate concentrations were below 3.0 mg/L and generally below 0.5 mg/L. Salinity of groundwater was highly variable between wells at each site, and showed considerable temporal variation. Observed salinity ranged from 0 to 14 parts per thousand (ppt). The groundwater pH varied between wells from 3.5 to 8. No chlorinated organic compounds were detected at concentrations greater than one part per billion.

Introduction

The National Estuarine Research Reserve program has designated selected estuarine areas for preservation and management for research and educational purposes. Areas included in the Reserve program were designed to be large and well enough protected to ensure their utility for long-term research and environmental monitoring. Research at these sites is directed toward national and regional environmental research priorities, and toward understanding the fundamental processes occurring in estuaries. These areas of research are intended to enhance scientific understanding of individual reserves and of estuaries in general, and to provide information needed by reserve managers and coastal zone decision makers (*Federal Register*, Vol. 55, No. 111, June 8, 1990). A lack of such data has begun to hamper planning efforts in Virginia. Policy-makers have been forced to rely on limited, provisional data on the effects of groundwater born nutrients on surface waters to support land use management decisions. Management of natural resources in estuarine and coastal regions is often hindered by a lack of reliable environmental data to support managerial decisions.

The input of nutrients and anthropogenic organic chemicals and the source of freshwater flow to estuaries is of interest to decision makers in the Chesapeake Bay area and throughout the nation. Because ecological processes in estuaries depend on the amount of the nutrient elements nitrogen and phosphorous in the system, management of estuarine resources requires an understanding of nutrient dynamics in the system. Establishment of the nutrient budget of an estuarine system requires a good understanding of all significant sources and sinks.

Groundwater has been recognized as a major source of nutrients into surface waters (Lee, 1977 and 1980; Valiela and Costa, 1988; Simmons, 1989). Discharge of nutrient-rich groundwater has been shown to cause significant changes in plant and animal communities in the affected waters (Johannes, 1980). Only a handful of studies have been undertaken to try to measure these effects (MacIntyre et al., 1989). The results of these studies suggest that groundwater seepage provides a significant portion of the fresh water entering the bay and is a major source of nutrients, supplying up to 30 percent of the total input (Simmons, 1989; Libelo et al., 1991). These estimates are based on an extremely limited amount of field data. The recent incorporation of the Goodwin Islands and Catlett Islands into the National Estuarine Research Reserve program provides a unique opportunity for additional long-term study of groundwater quality in the shallow near-shore aquifers. The decreasing access to shoreline areas for monitoring and the increasing development of coastal areas have made it difficult to find sites for installation of wells for groundwater monitoring. Since the Reserve sites provide long-term accessibility and are in relativity undisturbed condition, they are excellent locations for collection of data on the current quality of groundwater in coastal aquifers, and for continued monitoring to evaluate long-term changes. Accordingly, monitoring well networks have been installed in the Goodwin Islands and Catlett Islands sites, and groundwater samples have been collected for determination of selected water quality parameters. Additional monitoring networks are to be installed in the Taskinas Creek and Sweet Hall Marsh sites. This paper reports the preliminary results obtained from analysis of groundwater samples collected from the monitoring wells.

Methods and Materials

Site Descriptions. Four sites in the York River subestuary have been selected for inclusion in the Reserve system (Figure 1). Monitoring well networks were installed at the two sites closest to the mouth, Goodwin Islands and Catlett Islands. The Goodwin Islands Reserve consists of one large (1.6 km^2) main island and several smaller island separated by tidal channels in the Mobjack embayment at the mouth of the York River. The islands are made up of Pliocene and Pleistocene beach ridge deposits in a ridge and swale topography (Leonard, 1986). The islands are underlain by the early and middle Pliocene Yorktown formation. This formation is unconformably overlain by the late Pleistocene Poquoson Member of the Tabb formation which is exposed at the surface over most to the islands (Johnson, 1976). These formations consist primarily of fossiliferous silty sands along with some clay, and generally show high hydraulic conductivity. Goodwin Islands lie within the polyhaline region of the Bay, and are surrounded by water with salinity ranging from 16-22 ppt. Wells on the main island shows the presence of a fresh water unconfined aquifer that is hydraulically isolated from the mainland. All fresh groundwater water on the islands is provided by infiltration of local precipitation. This isolation makes the islands suitable for measurement of changes in groundwater quality in response to regional rather than local anthropogenic influences. Twelve monitoring wells have been installed on the main island in estuarine shrub scrub/forested wetlands and wooded upland areas (Figure 2).

The Catlett Islands Reserve site covers 690 acres and is located about 19 nautical miles upstream from the York River mouth on the north shore of the York river estuary between Timberneck and Cedarbush creeks (Figure 3). Geomorphology of the Catlett Islands is ridge and swale, and they are similar in topography to the Goodwin Islands. The site is located in the mesohaline portion of the York River surrounded by estuarine water with salinity ranging from 8 to 18 ppt. The degree of connection between groundwater on the Catlett Islands and the mainland has not yet been established, but initial observations indicate that shallow groundwater on the Islands is at least partially hydraulically isolated from the mainland by the bordering tidal wetland, and is predominantly supplied by local precipitation. At the Catlett Islands site, monitoring wells were installed in broad-leaved deciduous forested wetlands and coastal upland forest areas.

Sampling and Analysis. Groundwater samples were collected monthly over one year from Goodwin Islands and six times in the same year from Catlett Islands, and analyzed for pH, salinity and dissolved nutrients. Samples were withdrawn from each monitoring well with an inertial pump, placed in pre-cleaned polyethylene bottles, packed in ice, and transported to the Virginia Institute of Marine Science (VIMS) for analysis. One sample for organic analysis was collected with a stainless steel bailer and transferred to pre-cleaned glass jars. At least three well volumes were purged prior to sample collection.

Nutrient analysis was done at the EPA-certified laboratory at VIMS. Nitrate, nitrite, ammonia and phosphorus were determined by modified EPA methods (methods 352.2 and 350.1) using a Technicon Auto Analyzer. pH was determined with Beckman pHI 31 pH meter. Salinity was determined using a Reichert TS salinity refractometer. Samples were analyzed for trace organic compounds according a modified EPA standard method 625 (Greaves et al., 1991).

Results and Discussion

Concentration of nutrients from wells at Goodwin Islands is shown in Figure 4 for nitrate plus nitrite and Figure 5 for ammonium. Nitrate and nitrite were very low, generally below 0.2 mg/L in both wetland and upland wells. These concentrations are consistent with nitrate levels commonly observed in other areas in the region which are not impacted by local human activity (Libelo et al., 1991). Ammonium concentrations generally are higher than nitrate and nitrite. In wetland wells, ammonium levels ranged from 0.1 to 3 mg/L and were generally below 1 mg/L. In upland wells, ammonium ranged from 0 to greater than 2 mg/L and were generally below 1 mg/L. The data do not cover a sufficient period of time to allow analysis of variations with seasons.

Figure 6 shows the salinity of groundwater at the Goodwin Islands site. In upland wells, salinity ranged from 0 to 4.5 ppt. It was generally between 0 and 3 ppt and showed variation over time. In wetland wells, groundwater salinity varied over a wider range from 1 to 13 ppt. Salinity within wells and between wells varied considerably, probably due to recharge by infiltration of saline estuarine water.

The pH of groundwater at Goodwin Islands is shown in Figure 7. In upland areas, the pH was fairly constant between wells and within each over the period sampled. Values ranged from about 7 to 8. In wetland wells, the pH showed greater variation between wells and within individual wells over the period sampled. Values ranged from 3.5 to 7.5 and were consistently lower then those in upland areas.

Figure 8 shows nitrate and nitrite concentrations in groundwater from wells at the Catlett Island site. Concentrations ranged from 0 to 0.4 mg/L and were generally below 0.2 mg/L. These values were similar to observations at Goodwin Islands and are consistent with those expected from an area with little anthropogenic input. Ammonium concentration at Catlett Islands varied from 0 to 1.1 mg/L (Figure 9). Concentrations varied between wells and within individual wells. The pH in samples from Catlett Islands ranged from 4 to 8 and were similar to those observed in wetland areas at Goodwin Islands (Figure 10). Salinity in Catlett Island well samples varied from 0 to 13.5 ppt (Figure 11). Salinity varied considerably between wells and within each well, and this variation appears larger than that for the other water quality parameters.

Analysis of groundwater for chlorinated organic compounds indicated that none were present at concentrations greater than the detection limit of one part per billion.

The data collected at the Goodwin Islands and Catlett Island sites show the current quality of groundwater at these sites. The period of sampling is not long enough to allow evaluation of variations over time, such as seasonal variation. Nutrient element and organic compound concentrations suggest that these sites are not strongly impacted by local human activity. Precipitation and inflow of estuarine water are the only sources of recharge and of dissolved constitutions in these sites.

The Reserve sites in Virginia are good locations for monitoring groundwater quality in the shallow near shore aquifers in the Chesapeake Bay region. The data collected in this study provide information on the current quality of groundwater in the near shore shallow aquifers in the York River subestuary. This information can be used as a baseline for evaluation of future changes in groundwater quality in the Goodwin Islands and Catlett Islands sites, and as control or background data for studies of the effects of human activities on these and other sites in the Chesapeake region. Information on the quality of groundwater within the Research Reserve sites can also be used to correlate current and future biological processes with groundwater and study interaction between groundwater, surface water and biological activity. Continued monitoring of these sites should be conducted to ensure the long-term availability of such information.

Acknowledgements

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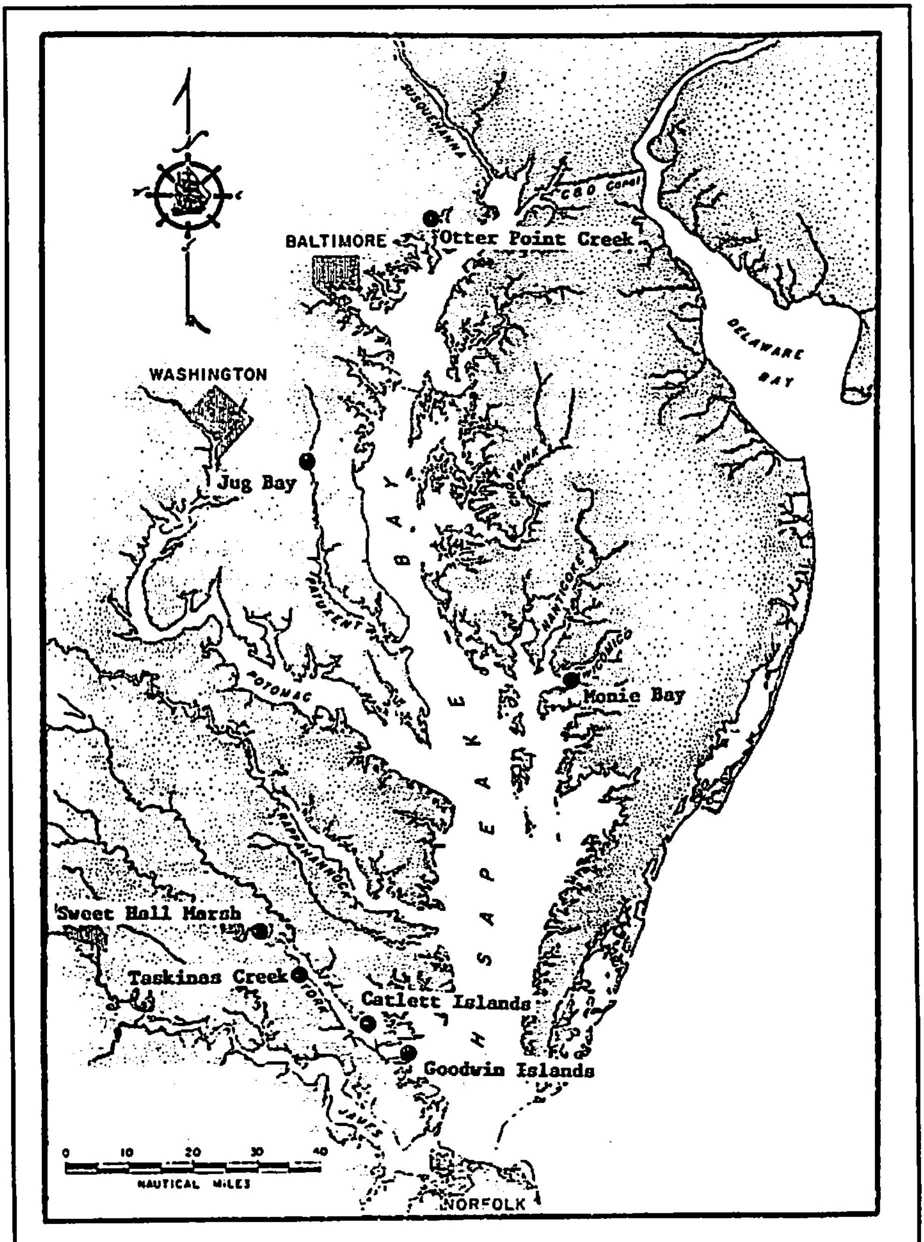

Figure 1. Chesapeake Bay National Estuarine Research Reserves in Virginia and Maryland.

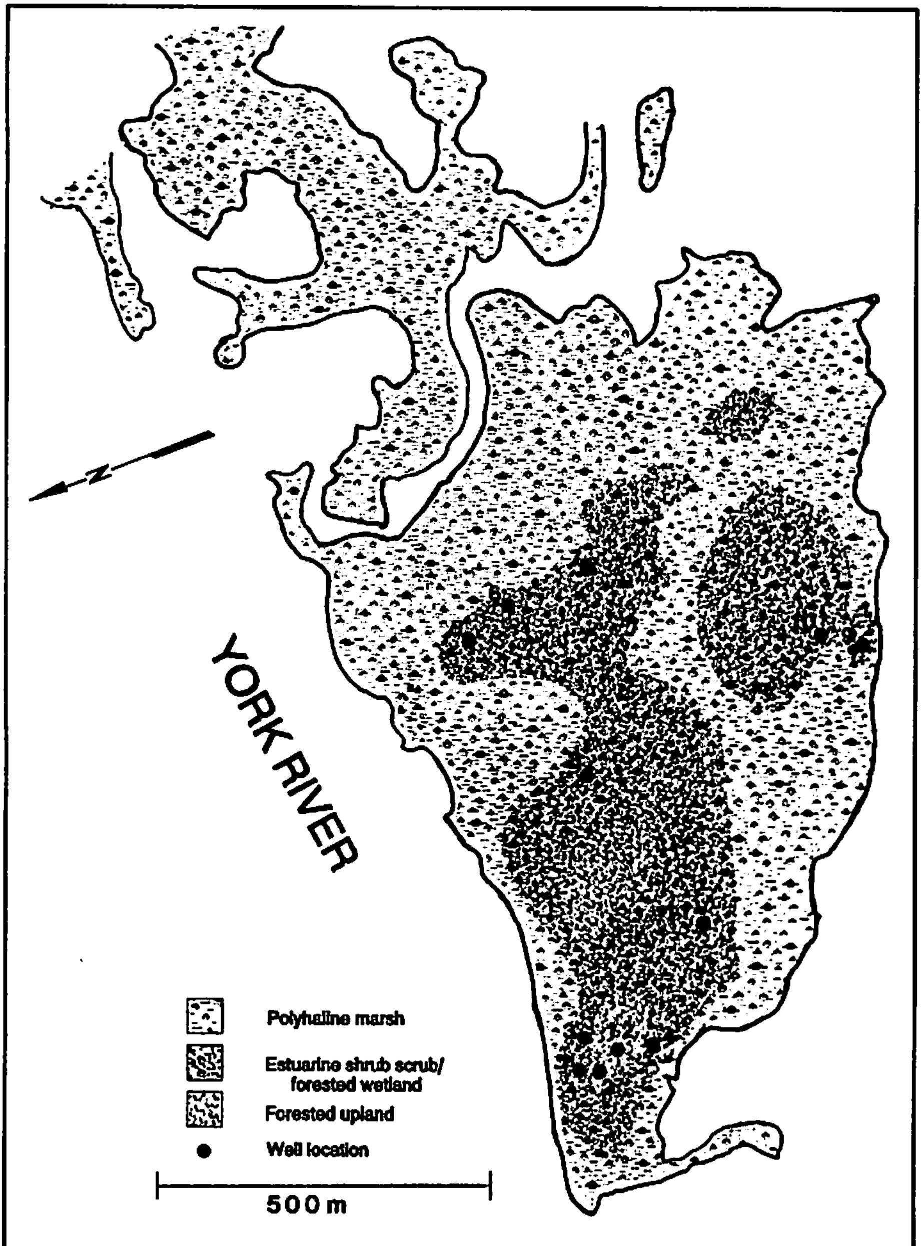

Figure 2. Well locations at Goodwin Islands Reserve component.

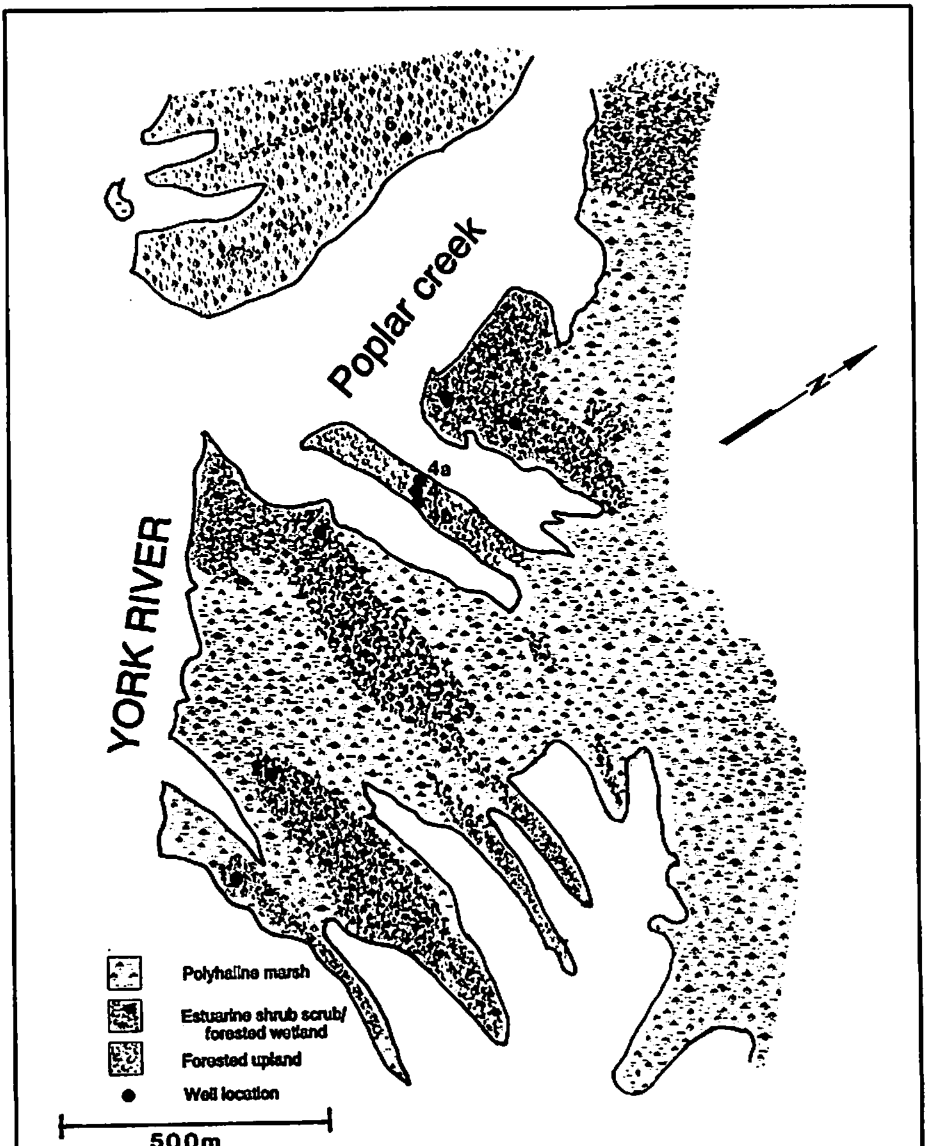

Figure 3. Well locations at Catlett Islands Reserve component.

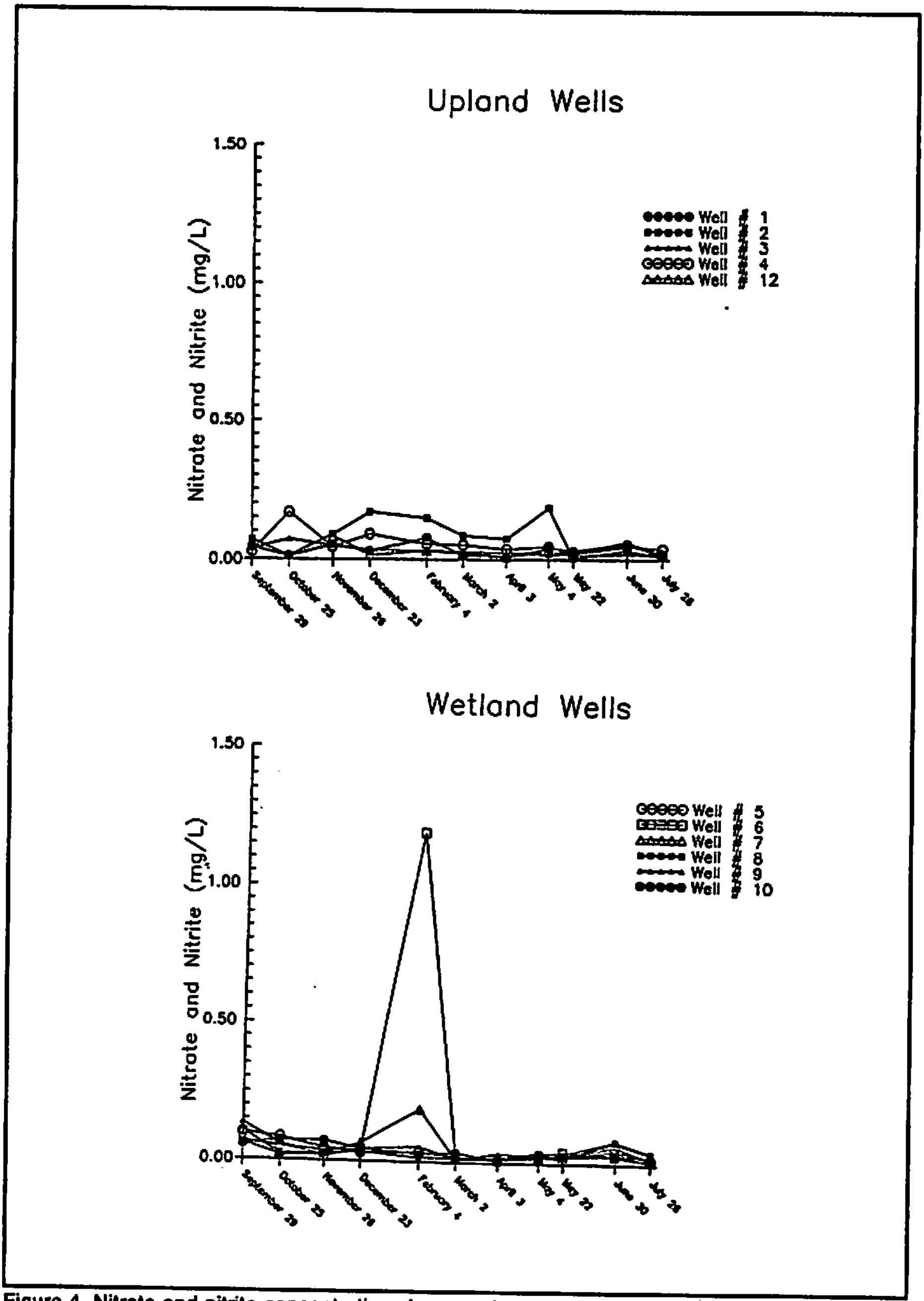

Figure 4. Nitrate and nitrite concentrations in groundwater samples from Goodwin Islands wells.

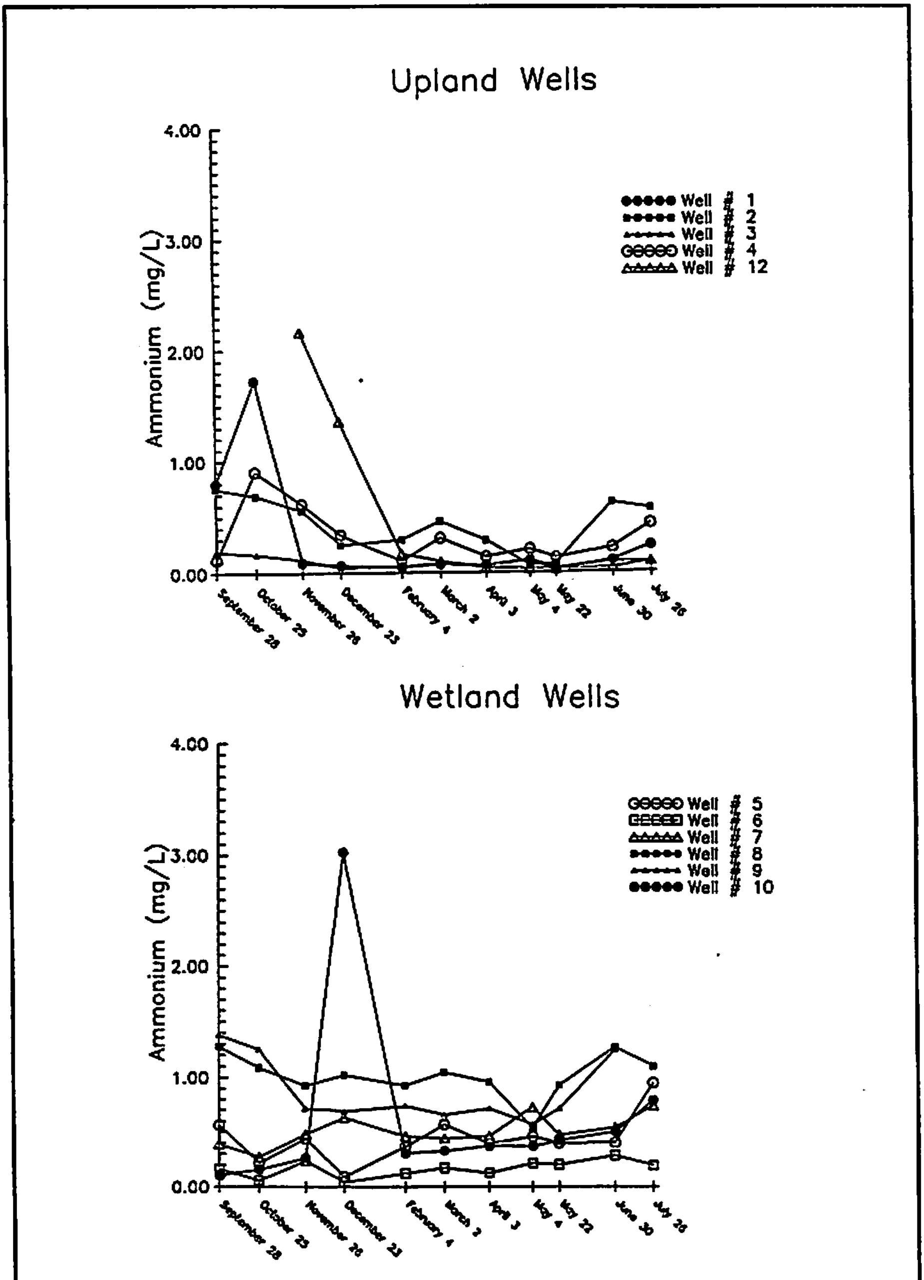

Figure 5. Ammonium ion concentrations in groundwater samples from Goodwin Islands wells.

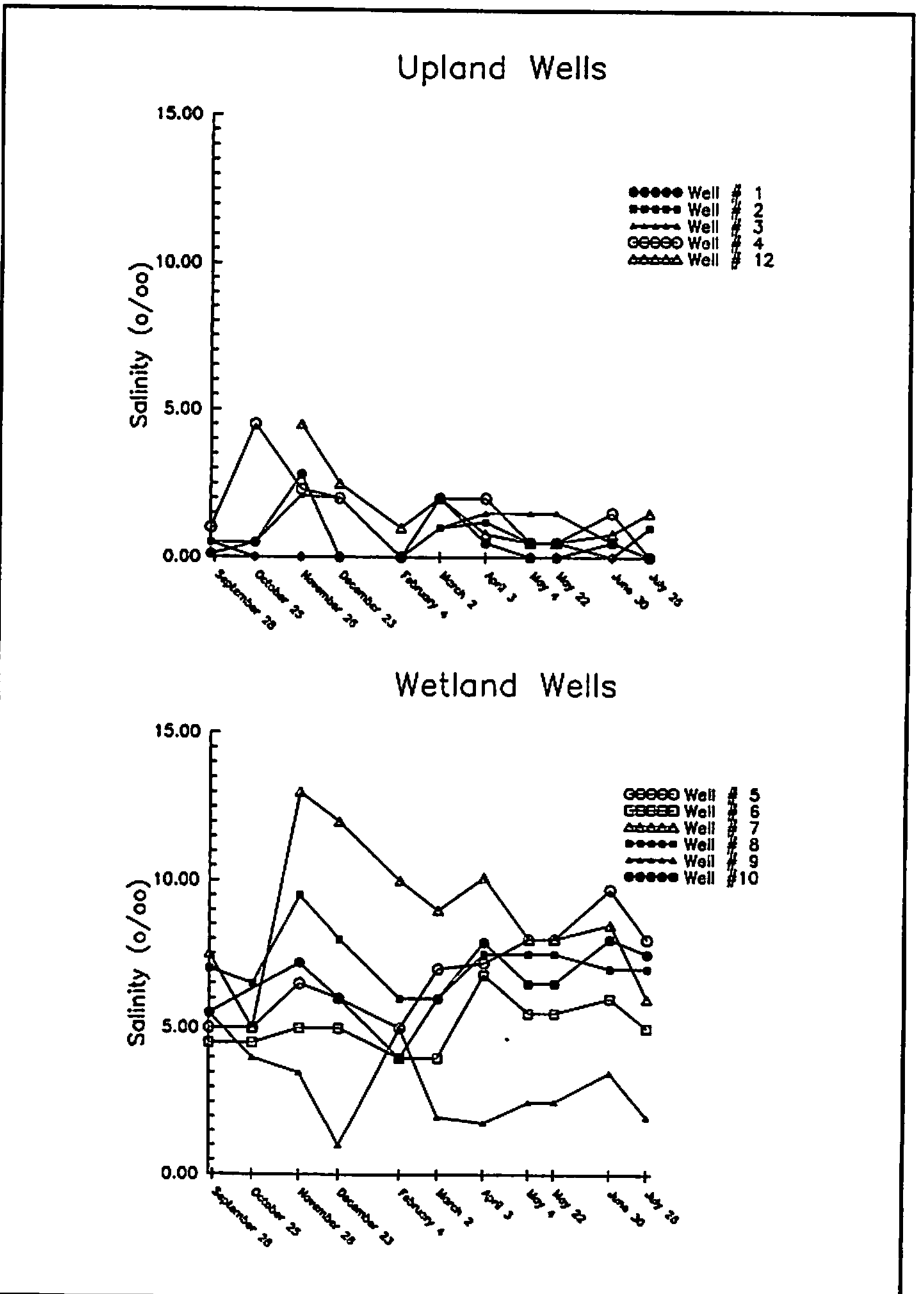

Figure 6. Salinity of groundwater samples from Goodwin Islands wells.

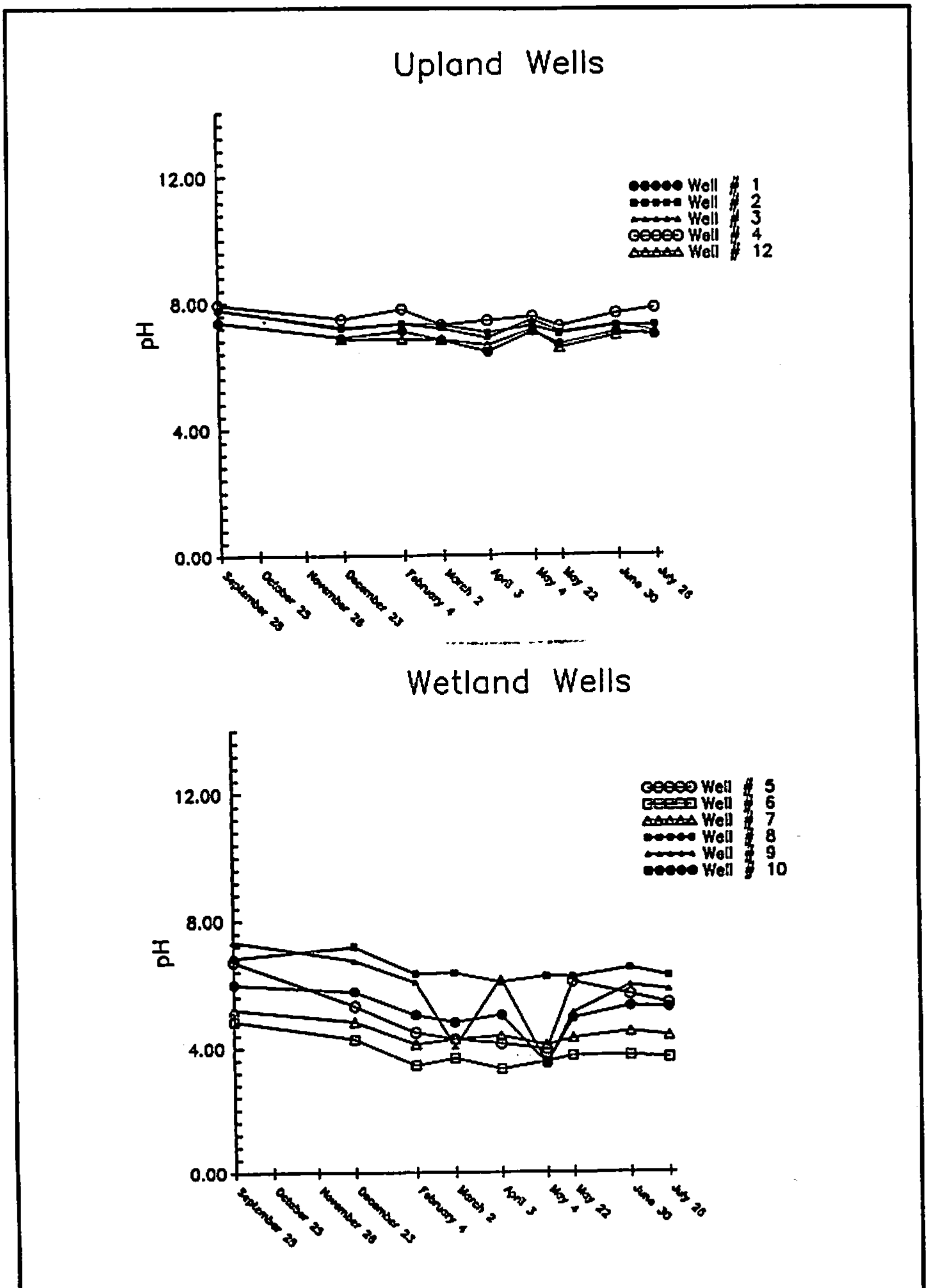

Figure 7. pH of groundwater samples from Goodwin Islands wells.

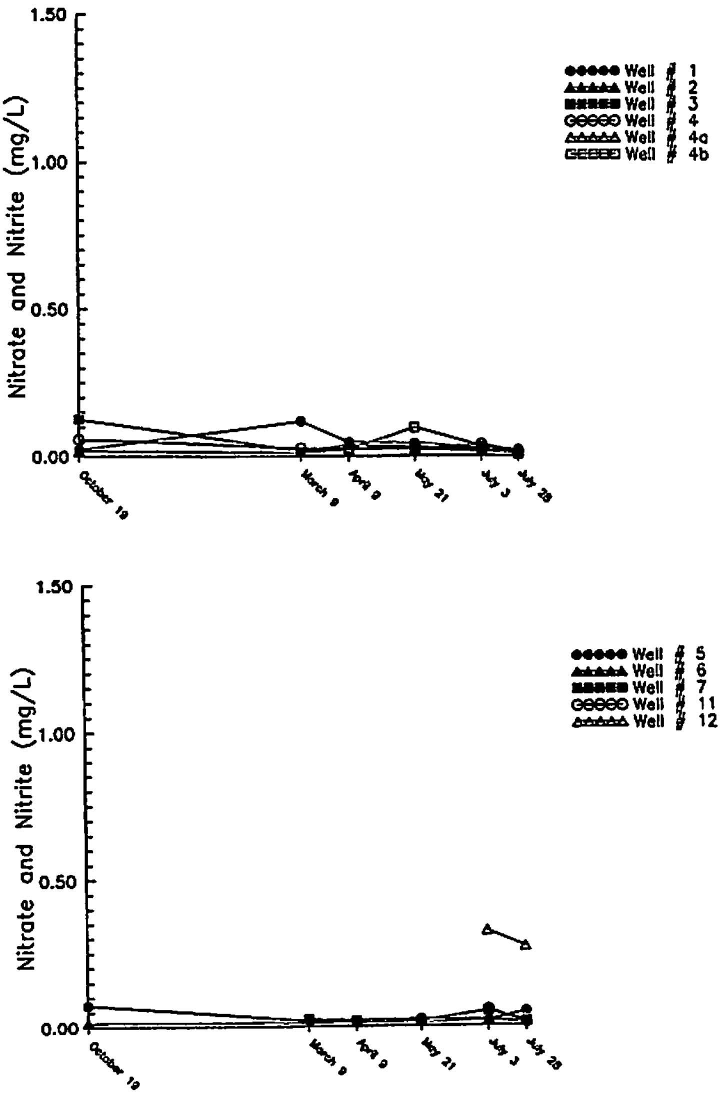

Figure 8. Nitrate and nitrite concentrations in groundwater samples from Catlett Islands wells.

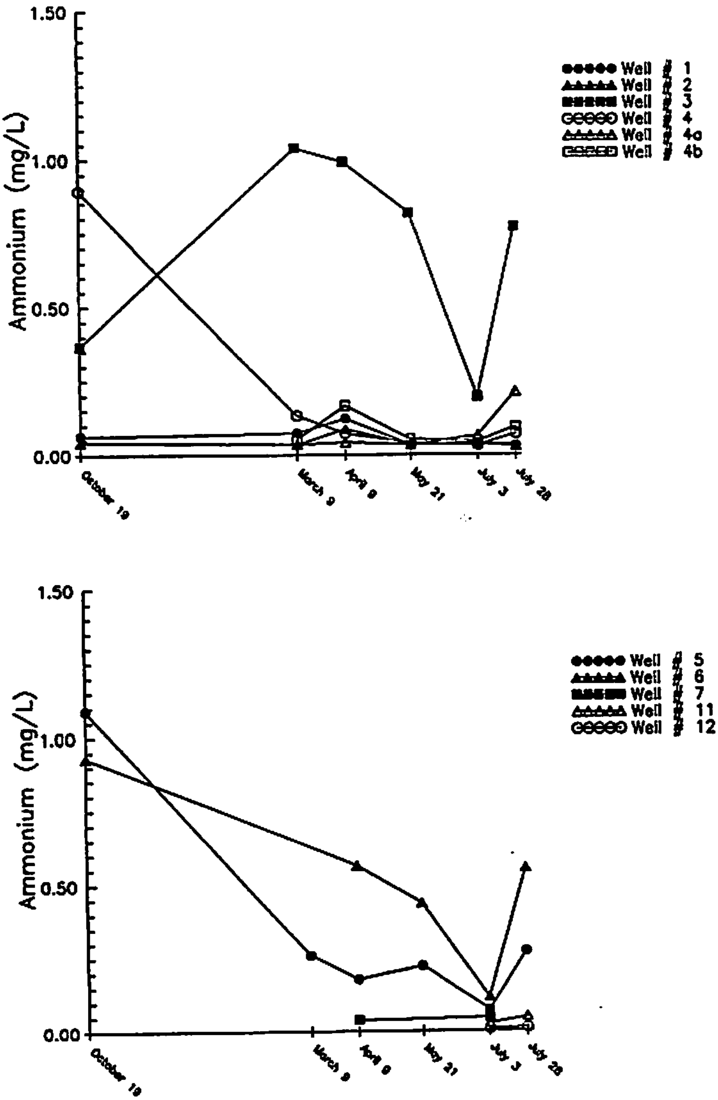

Figure 9. Ammonium ion concentrations in groundwater samples from Catlett Islands wells.

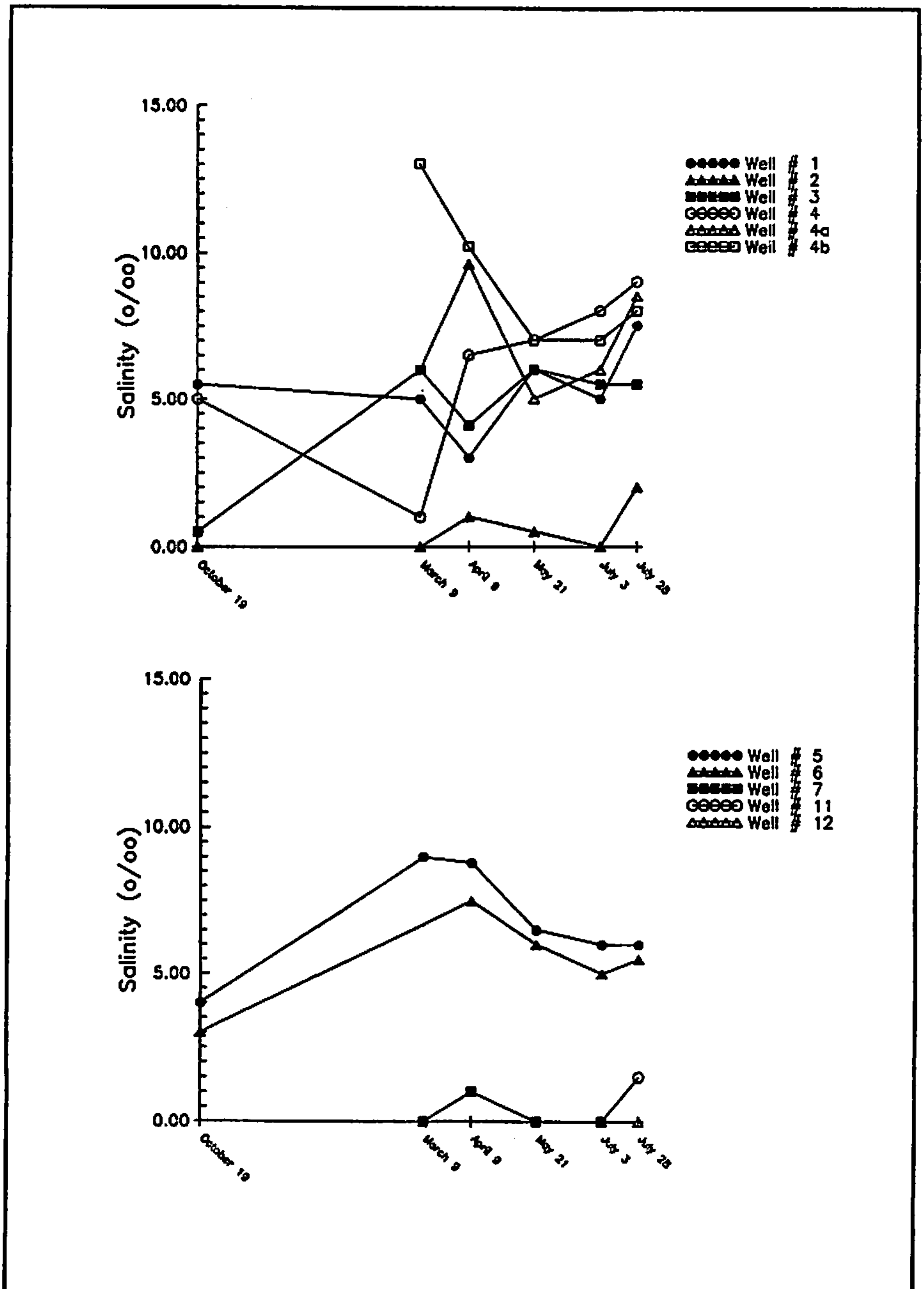

Figure 10. Salinity of groundwater samples from Catlett Islands wells.

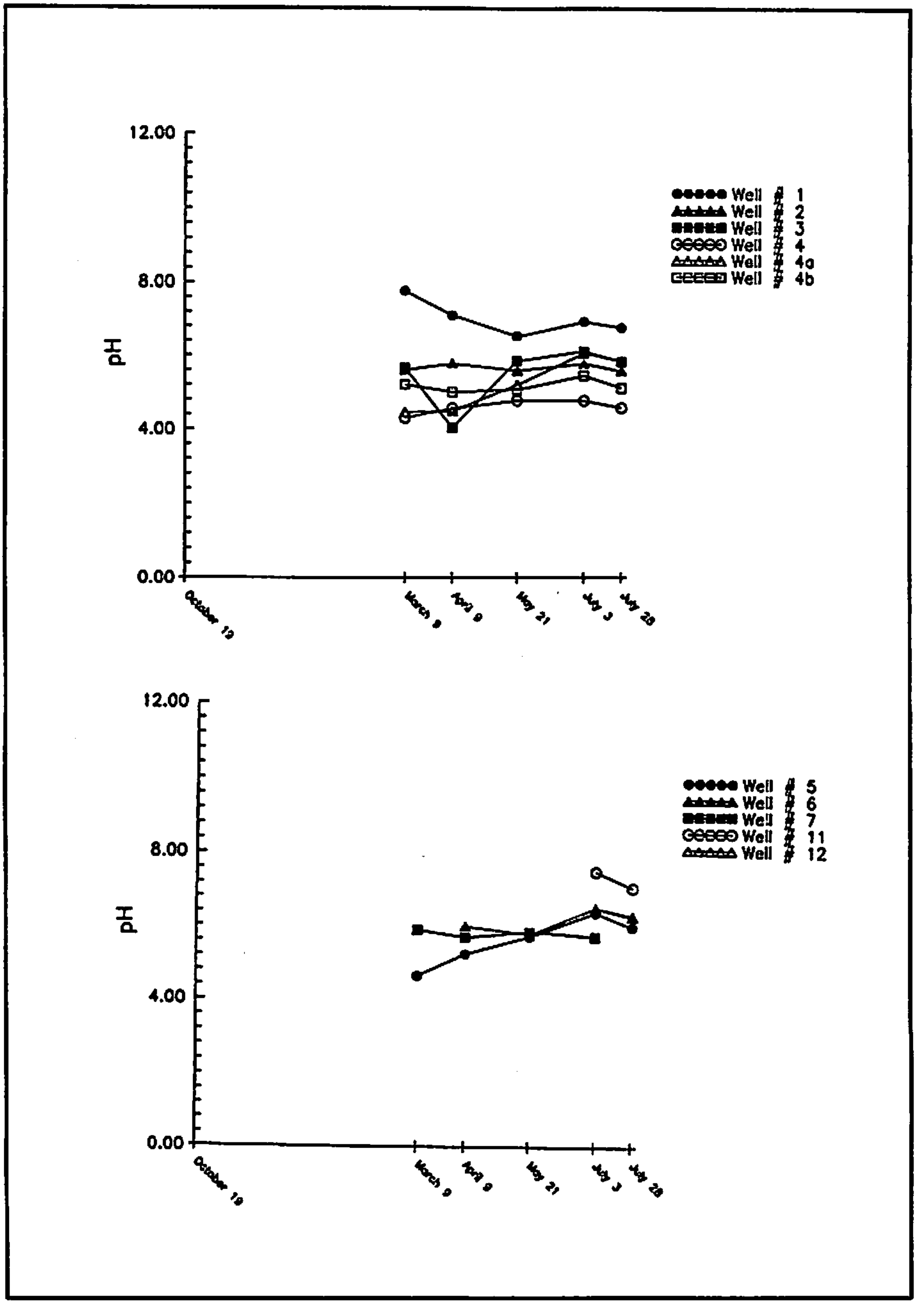

Figure 11. pH of groundwater samples from Catlett Islands wells.

BIOGEOCHEMICAL STUDIES AT THE MONIE BAY NATIONAL ESTUARINE RESEARCH RESERVE

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Introduction

The National Estuarine Research Reserve System designates and manages sites for long-term research and educational activities. Reserve sites represent critical habitat for ecologically and economically valuable species and communities and provide the opportunity for study of the impacts of such alterations as toxic contamination and eutrophication.

Coastal marshes can be important sites for the buffering of point and non-point nutrient inputs, and in providing nursery habitat and food sources for estuarine fishes. Although change is natural in marshes, the introduction of toxics, point-source and non-point-source nutrient inputs, the loss of habitat to development and the potential increase in rates of sea-level rise may lead to changes at a pace at which marshes cannot adapt. The understanding of basic marsh processes is critical for the prediction of marsh response to stress. The Reserve sites provide the potential for careful long-term study of these processes in systems with relatively low current levels of impact.

Marshes differ from open-water estuarine habitats because of their large standing biomass of primary producers, especially macrophytes, and increased importance of sediments in overall system metabolism (Howarth and Hobbie, 1982). Sediments are major sites for organic matter decomposition, nutrient recycling and mineral nutrition of macrophytes. As such, sediments are a key part of marsh ecosystems, and physical, chemical and biological processes that affect nutrient and organic matter cycling in sediments can greatly influence ecosystem function.

Our research program at the Monie Bay component of the Chesepeake Bay National Estuarine Research Reserve in Maryland was oriented toward understanding biogeochemical differences across an estuarine gradient. Spatial and temporal variability in water quality, plant species composition and sediment processes were studied within a brackish to mesohaline marsh system. Factors contributing to the sediment biogeochemical profile included pore water nutrients and sulfur and solid phase phosphorus, sulfur, iron, organic matter and sulfur stable isotopic composition across a salinity gradient. Our ongoing studies at Monie Bay provide a continuing baseline of nutrient, salinity and plant biomass measurements plus research on sulfur stable isotope-derived food chains, seasonal iron sulfide distributions and isotopic composition within sediments, and the influence of sulfide in sediments on marsh productivity.

Study Area

This study was conducted at the Monie Bay Reserve component, a marsh/bay complex located on the Delmarva Peninsula, along the Eastern Shore of the Chesapeake Bay in Somerset County, Md. (Figure 1). Its creeks are tributaries of Tangier Sound and ultimately of the Chesapeake Bay. The watershed of Monie Bay includes wetlands, farms, homesites and forests. Surrounding Monie Bay are submerged upland marshes of Holocene age that range, in a relatively short distance, from higher salinity marshes with few plant species to virtually freshwater tidal systems with greater macrophyte diversity. Anthropogenic impacts in the watershed largely consist of agricultural activities, including forest clearing. Perhaps the greatest human impact, then, is on nutrient input to the system, enhanced by modifications of hydrology by roadways, bridges and culverts and by land clearing.

The depth of Monie Bay proper is generally less than 2 m and the bay sediments are fine-grained. Salinity in the bay is typically 12 ppt in the spring and increases to 17 ppt during the summer. The tidal range is approximately 0.3 m. Ward et al. (1988) have identified three different subenvironments including bank marshes surrounding Monie Bay; tidal channel bank marshes along the two major tributaries, Monie Creek and Little Monie Creek; and back marsh areas. The back marsh areas are flooded less frequently and consist of fine-grained organic-rich muds. The dominant plant species in regularly flooded areas include *Spartina alterniflora*, *Spartina patens*, *Spartina cynosuroides* and *Amaranthus cannabina*, while *Juncus roemerianus*, *Distichlis spicata* and *Phragmites australis* are common in less frequently flooded areas.

Radiochemical (^{210}Pb) and palynological (*Quercus* and *Abrosia*) analyses by Ward et al. (1988) have shown that Monie Bay sediment accretion has a rather large range (0.15 - 0.63 $cm \cdot yr^{-1}$), with over half of the sites having accretion rates lower than required to match current rates of sea-level rise. While most marshes in the Monie Bay system appear to be keeping up with apparent sea level rise in this region, approximately 0.3 to 0.4 cm per year (Kearney and Stevenson, 1991), some isolated areas are subject to increased submergence and are now bare mudflat except for the diminutive *Eleocharis parvula*. The focus of this study is Monie Creek, one of the most extensive branches off the Bay. During our study, water quality and sediment samples were collected along the entire navigable part of the creek, including areas upstream of the Research Reserve.

Methods

Water samples were collected from Monie Creek in April, June, July and August 1990. Eight stations— "HWY" and Sites 1-7—were sampled. These samples were analyzed for concentrations of dissolved reactive P (PO_4), nitrate + nitrite (NO_3 + NO_2), ammonium (NH_4), chloride (Cl^-) and sulfate (SO_4^{2-}). Marsh cores were collected using a 7-cm-I.D. plastic core tube. Subtidal cores from Monie Bay were collected using a KB gravity corer. The analytical procedures used for chemical analysis are detailed in Cornwell et al. (1990).

Results and Discussion

Water Quality. Spring and summer precipitation was relatively high in the Monie Bay watershed in 1990. Nevertheless, salinity at centrally located Site 4 increased steadily over the summer and peaked at 6 ppt in July (Figure 2), which is centrally located on Monie Creek. In August, salinity declined earlier than expected, again reflecting high rainfall late in the summer.

Water column dissolved PO_4 at Site 4 decreased from almost 1.5 to 0.1 μM over the course of the growing season. In June, the molar N:P ratio at that site was approximately 40. Analysis of PO_4 plotted against Cl^- concentration (Figure 3) for the 1990 season shows a clear lack of a summer PO_4 maximum. Contrary to these indications of P limitation in the Monie Bay system, a summer increase in PO_4 has been well documented in other marsh systems in the mid-Chesapeake (Stevenson et al., 1977). The highest PO_4 in the Monie Creek system was found in April (2 μM) at Station 3. This high concentration may have resulted from localized agricultural runoff from pastureland next to the creek.

As with PO_4 at Site 4, NH_4^+ declined from 4 to 1 μM from April to August, most probably due to uptake by plants. In comparison, nitrate at Site 4 had the same pattern but dominated the DIN pool in April with a concentration of over 15 μM. However, NO_3^- became rapidly depleted to concentrations less than NH_4^+ (1 μM) by July and remained very low the rest of the growing season. The extremely low NO_3^- from mid to late summer along the entire upper creek may have resulted from a combination of denitrification, which is substantial in marshes (Seitzinger, 1988), and plant uptake. The low summer N concentrations force the system at least temporarily into N limitation; the molar N:P ratio was approximately 5 in July and 3 in August.

When April data for stations along the axis were plotted against Cl^- (Figure 3), NH_4^+ doubled at mid stations down Monie Creek; in contrast, NO_3^- appeared to be derived from upstream sources. The highest NO_3^- value (almost 30 μM) was clearly associated with the upland end-member. This pattern of upland NO_3^- loading is typical of other tributaries on the Eastern Shore of the Chesapeake Bay; in the Choptank River, maximum April NO_3^- exceeds 100 μM (Stevenson et al., 1991).

Monie Creek appears to have significant ammonification in spring when temperatures begin to rise, accounting for the increase in NH_4^+ in the mid-salinity stations during April (Figure 3). There was a suggestion of that in June as well, but not in July and August (Figure 3) when uptake by plants (either phytoplankton or macrophytes) may have suppressed NH_4^+ flux out of the sediments. In addition, our data show variable concentrations, which may be due to storm events that overwhelmed the short salinity gradient. Both minimum (ca. 1 μM) and maximum (ca. 10 μM) concentrations of NH_4^+ at Monie Creek were in the same range as found at a Choptank River marsh (Stevenson et al., 1977) with much the same seasonality. However, Monie Creek appears to alternate between P and N limitation, reflecting both lower agricultural inputs and a more pulsed nature of the system.

Sediment Biogeochemistry. The overall rationale for this sediment program was to provide an understanding of basic geochemical distributions and processes within Monie Creek and Monie Bay by examining both pore water and solid phase chemistry. Wetland sediments represent important sites for the remineralization of nutrients, which in turn support the seasonal macrophyte productivity of the system.

Initial sediment samples were collected from the creek bank at the eight sites used for water quality sampling. Later sediment sampling included three back marsh sites: a well-drained marsh bank site (DB1), a poorly-drained back marsh site (DB2) and a relatively dry site adjacent to a palustrine wetland area (DB3). Site HWY was closest to the upper freshwater source for Monie Creek and had a variety of freshwater plant species. Subtidal locations (MB1, MB2) within Monie Bay proper were sampled with a gravity corer.

Pore water ammonium and phosphorus concentrations represent a balance between processes that contribute nutrients to pore water (i.e., organic matter decomposition, dissolution of Fe-P complexes) and processes that remove nutrients from pore water (advection, assimilation by plants, microbial transformations). As for most other systems, Monie Creek pore water concentrations of NH_4^+ and PO_4 were greatly elevated with respect to those in surface waters. Values were similar to those observed in other brackish and salt marshes (Jordan and Correll, 1985; Lord and Church, 1983).

Pore water data from the sites HWY and DB2, collected in August 1990, are compared in Figure 4. At the HWY site, pore water Cl^- values were among the lowest for this study, corresponding to a salinity of approximately 2 ppt. The higher July salinity at this site was apparently reduced by runoff from August storms. Winter and spring runoff would generate even lower salinities. Sulfate concentrations in August were quite low, and undetectable at and below 4-6 cm. Despite these relatively low sulfate concentrations, significant rates of sulfate reduction are evidenced by relatively high concentrations of acid-volatile sulfide (generally FeS; Cornwell and Morse, 1987) and chromium-reducible sulfur (FeS + FeS_2 + elemental S) at site HWY. Hydrogen sulfide was not detected in the pore waters at this site, but a faint sulfide smell was present in the marsh.

Nutrient concentrations at the HWY site were much lower than for any other sites in this study. Both NH_4^+ and PO_4 concentrations were very low in August, with undetectable levels of NH_4^+ at 8-10 cm and undetectable concentrations of PO_4 at and below 4-6 cm. July pore water nutrient concentrations were also quite low at this site (PO_4 = 0.7-5.0 µmol L^{-1}; NH_4^+ = 21-61 µmol L^{-1}). These low nutrient concentrations strongly suggest that nutrients remineralized within these sediments may be rapidly assimilated by plants. The rate of sedimentary nutrient remineralization may thus be an important control on primary production.

In DB2, the back marsh site, porewater chloride and sulfate profiles were consistent with higher salinity and higher rates of sulfate reduction. Sulfate reduction was also indicated by relatively high levels of solid phase reduced sulfur species. The nutrient profiles show low concentrations of NH_4^+ and PO_4 at the sediment-water interface, steadily increasing to high concentrations at 8-10 cm. A strong gradient of pore water nutrient concentrations upward from the 8-to-10-cm depth to the 4-to-6-cm depth suggests upward flux and consumption of nutrients in the top 5 cm of sediment. Hydrogen sulfide concentration in the pore water ranged from 0 mmol L^{-1} at 0-2 cm to 0.7 mmol L^{-1} at 8-10 cm.

We examined the solid phase chemistry of all sites in both surface (0-2 cm) and deeper (8-10cm) sediment horizons (Figure 5). Spatial heterogeneity at these sites can be quite large, and we arbitrarily selected the data for the upper Monie Creek marsh sites from late July and the data for the Bay marsh and Monie Bay sites from August so that adjacent sites had temporal coherence.

Ash-free dry weight concentration, a measure of organic matter content, was between 22 and 26 percent of total sediment mass in the surficial section of the Monie Creek marsh cores. The Monie Bay subtidal sediment samples were distinctly lower in organic matter, perhaps a result of increased dilution of organic inputs by inorganic particulates from other sources such as the Wicomico River, lower organic matter input from primary producers, and increasing distance from the organic-rich brackish marshes.

Phosphorus concentrations in marsh sediment were relatively low, averaging 0.76 ± 0.17 mg g^{-1} in surface sediments and 0.66 ± 0.04 mg g^{-1} in deep sediments. These values are somewhat lower than those found in tidal freshwater sediment by Chambers and Odum (1990), similar to those in the mainstem of the Chesapeake Bay (Boynton and Kemp, 1985; Cornwell, unpublished data), and lower than those found in marsh sediments from the Choptank River subestuary (Cornwell and Stevenson, unpublished data). We differentiated between inorganic and organic P forms in this study because P cycling is highly dependent of the form of P in the sediments. Organic P is an important component of total P in these sediments, averaging about 70 percent of total P in the marsh sediments, well within the range (40-80 percent) found for Choptank River marsh sediments. The persistence of inorganic P in sulfidic sediments suggests that Fe-P complexes may not have a large effect on P diagenesis deep within the sediment (Krom and Berner, 1981). In this system, the supply of sediment P to pore waters may be more related to the oxidation of P-containing organic matter than to inorganic redox processes (i.e., Cornwell, 1987). Core MB2 had very low P concentrations, perhaps a result of dilution by P-depleted inorganic particles from the Wicomico River.

Extractable iron values in this study are a measure of the sum of the oxide Fe concentration (Leventhal and Taylor, 1990) and AVS-associated Fe (Cornwell and Morse, 1987). This extraction does not recover any Fe associated with pyrite. In surface sediments, Fe concentrations were quite variable, ranging from 3 to 15 mg g^{-1}. Deeper within the sediments, extractable Fe concentrations were lower and less variable, most likely because of the more complete conversion of Fe oxide minerals to iron sulfides. As in most marine sediments, AVS in Monie Bay marsh and bay sediments was a low to modest proportion of chromium reducible S (Morse and Cornwell, 1987; Cutter and Velinsky, 1988).

Summary

Water column nutrient concentrations in the Monie Bay system are low compared with those in other Chesapeake Bay marshes. The supply of nitrate and phosphate is dominated by agricultural runoff, timed to seasonal and event-scale freshwater inputs. The source of ammonium to the water column appears to be the sediments, via ammonification.

Consumption of nutrients, through plant uptake (N and P) and denitrification (N) leads to undetectable levels of nitrate and phosphate by summer. Both nutrients exhibit limiting concentrations over the course of the growing season.

Sediment biogeochemistry is closely tied to the hydrodynamics of the system: higher energy portions of the Bay exhibit lower organic matter concentrations, more continuously flooded sediments contain higher concentrations of reduced sulfur compounds, and more regularly flushed bank marshes have higher extractable iron content.

This Research Reserve site exhibits many biogeochemical features typical of Chesapeake Bay marshes, yet it differs in other significant ways, most notably as a result of its relatively undisturbed watershed. It thus provides excellent opportunities for further study of marsh processes.

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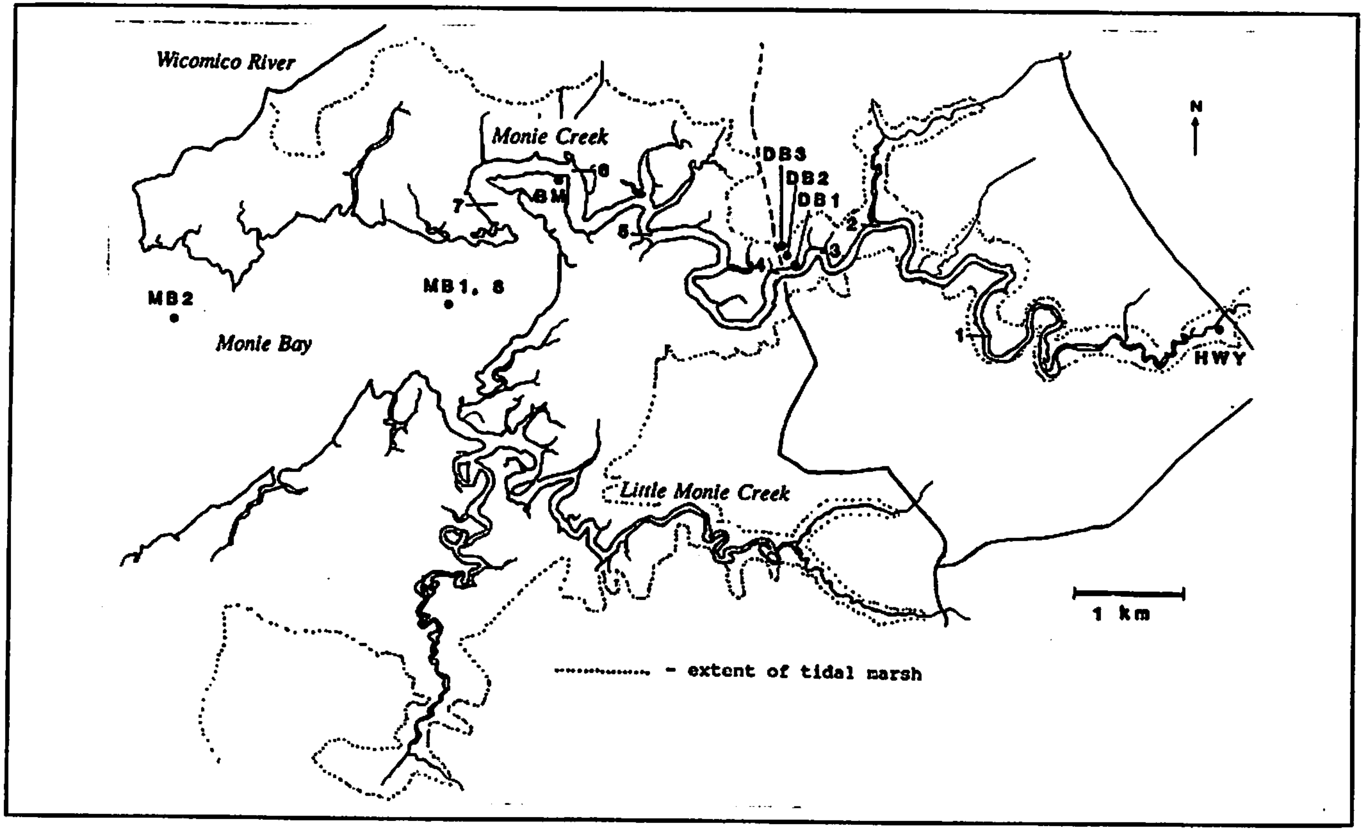


Figure 1. Map of Monie Bay component of the Chesapeake Bay National Estuarine Research Reserve in Maryland. Sites 1-8 are water chemistry sampling sites; sites HWY, DB1, DB2, DB3, MB1 and MB2 are sediment sampling sites.

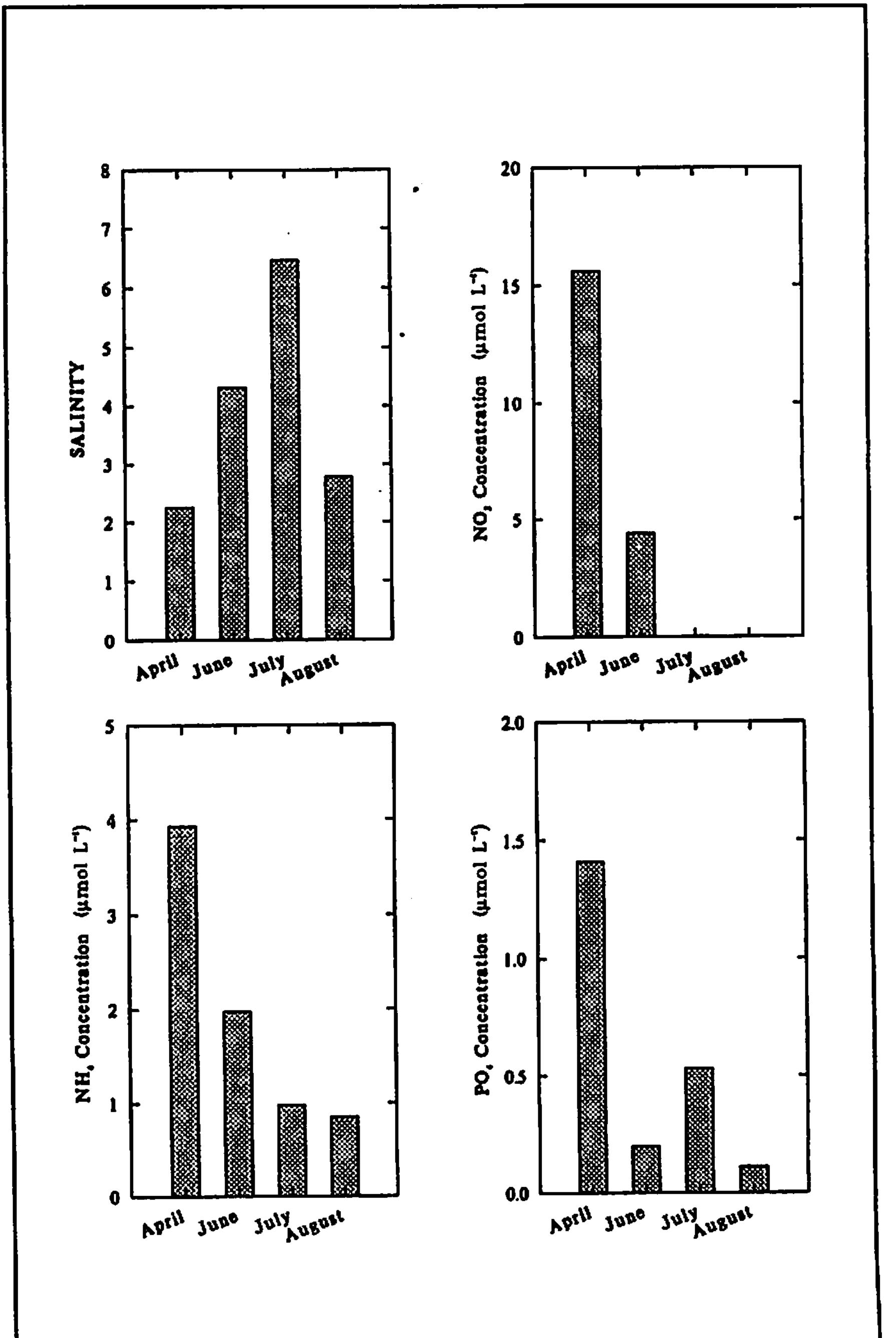


Figure 2. Water quality measurements at Site 4 in Monie Creek, 1990. Salinity was calculated from Cl^- concentrations.

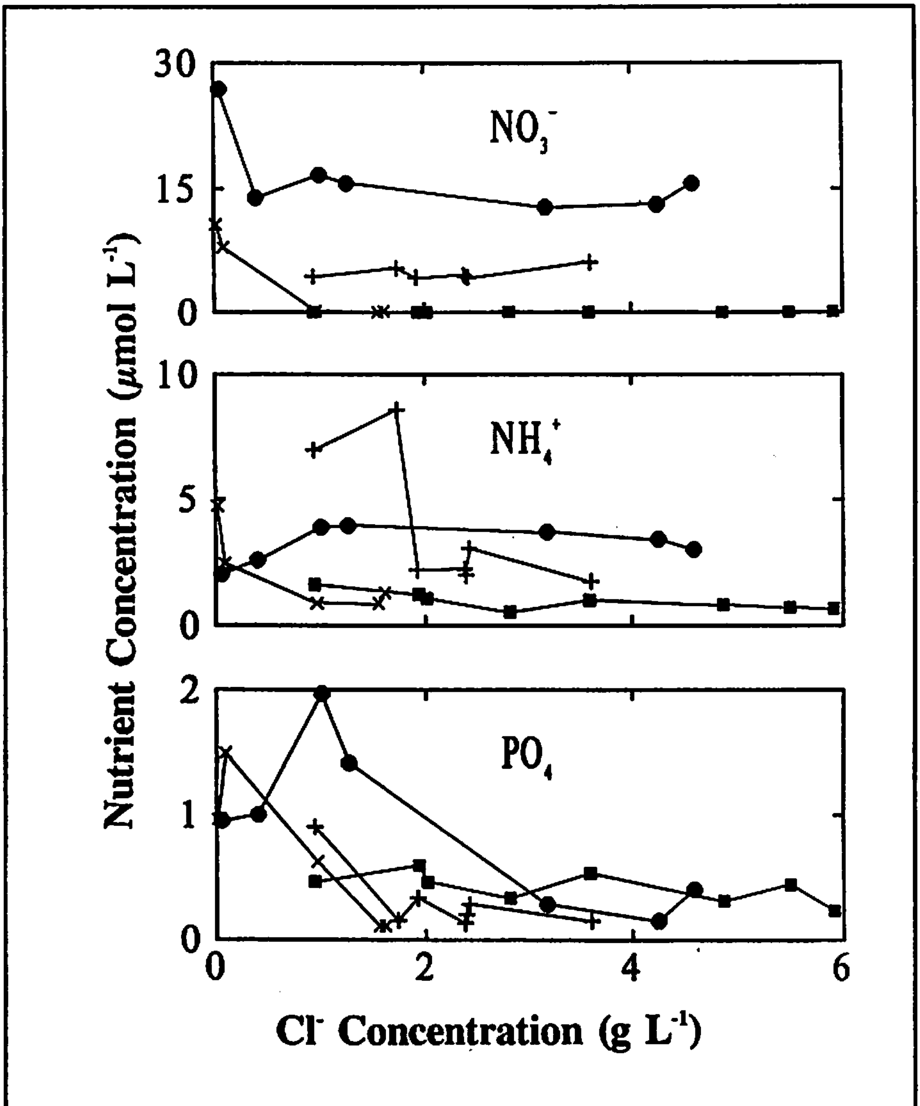


Figure 3. Water column nutrient concentrations vs. chloride concentration for four sampling periods in 1990 in Monie Creek. Sample times included April (●), June (+), July (■) and August (x). Chloride concentrations are used as a measure of conservative mixing; deviations from a linear nutrient to chloride ratio result from processes that remove or add nutrients to the creek.

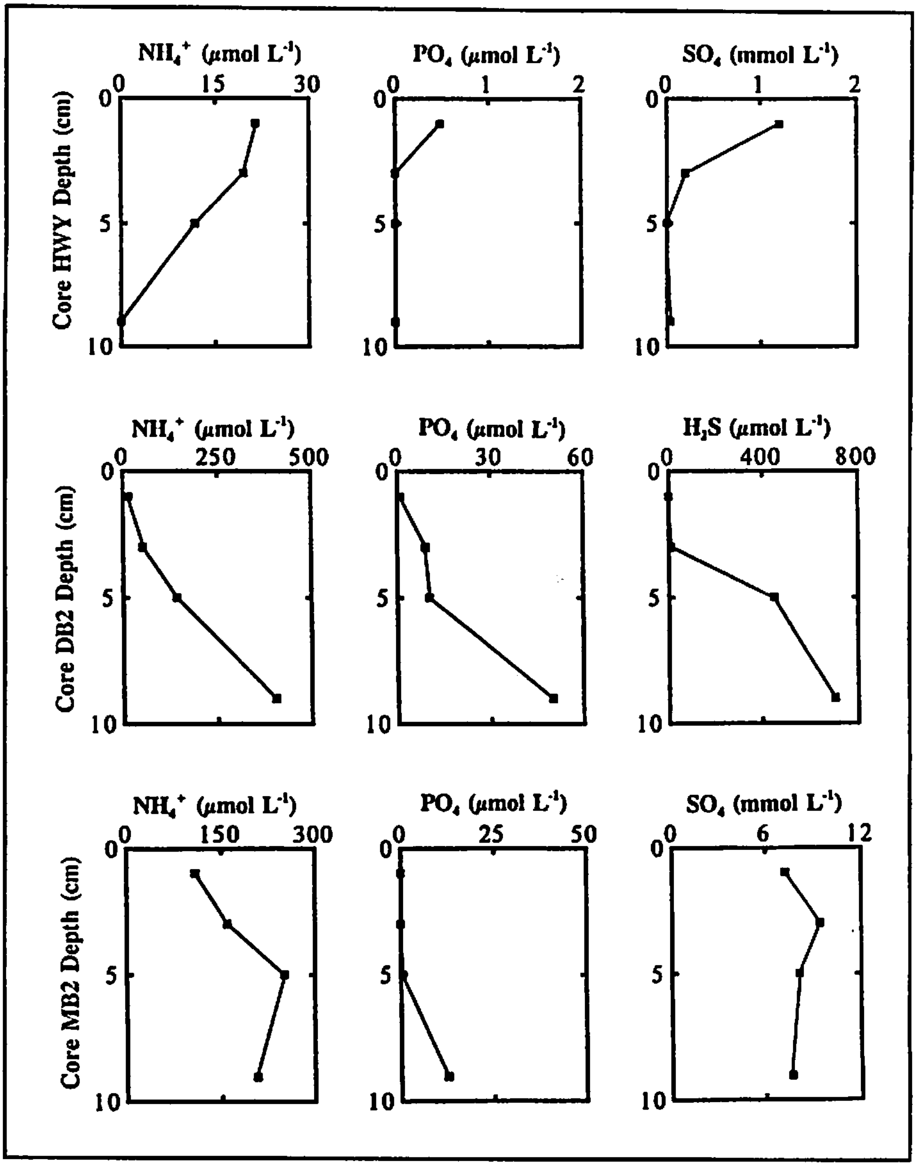


Figure 4. Pore water nutrient and sulfur data from sites HWY, DB2 and MB2. Site HWY is the least saline site; site DB2 is a poorly drained back marsh site; and MB2 is a subtidal site near the Wicomico River.

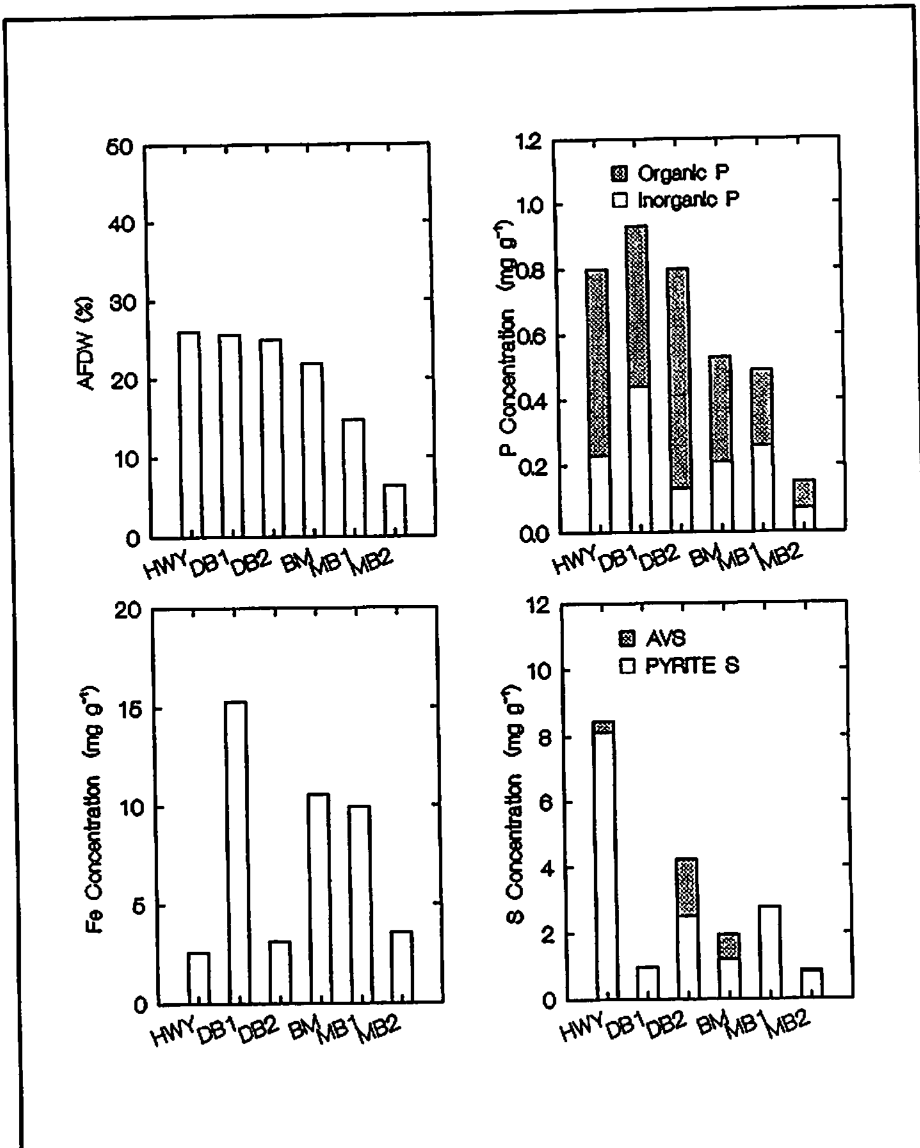
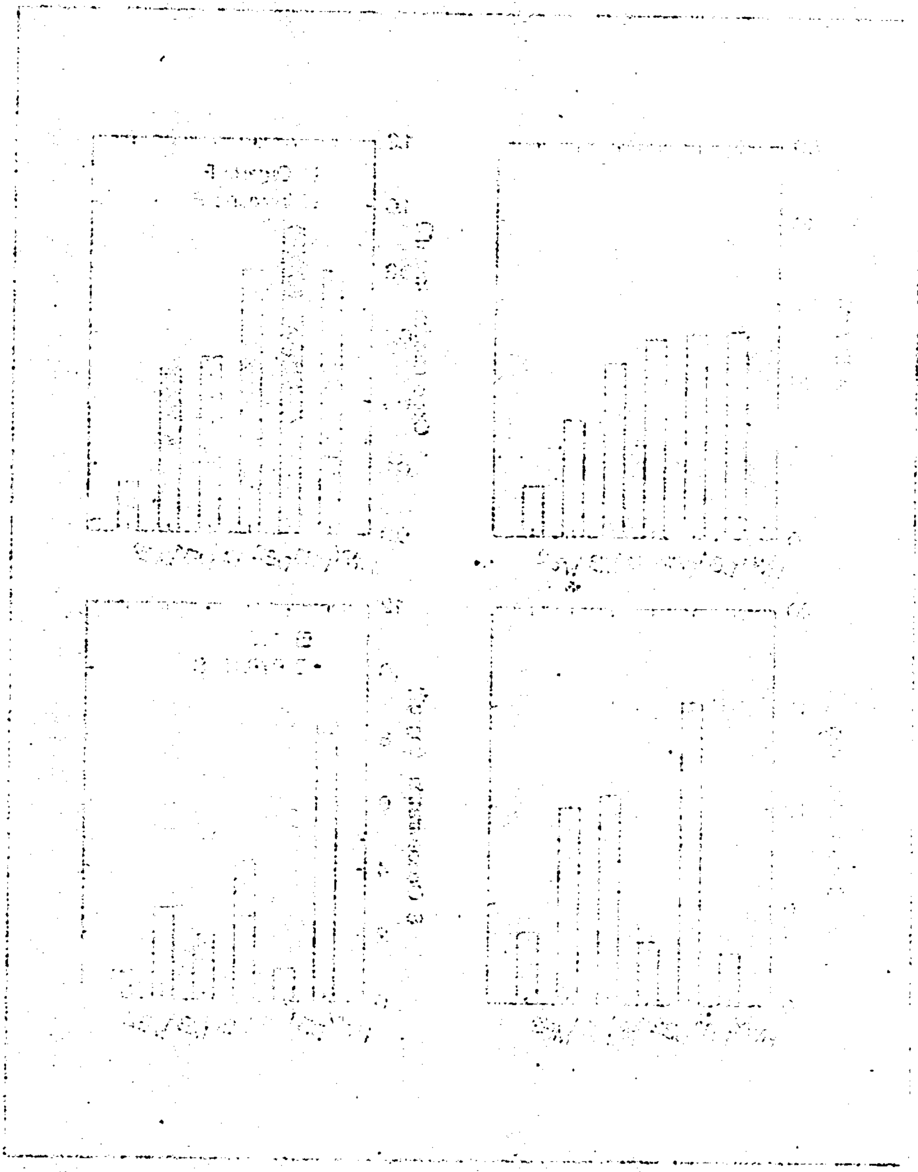


Figure 5. Surficial sediment chemistry from Monie Bay marsh (HWY, DB1, DB2, BM) and subtidal (MB1, MB2) sediments. Ash-free dry weight (AFDW) is a measure of organic matter content. The iron is HCl-extractable iron. Sulfur species are AVS (generally FeS) and pyrite (generally FeS_2 with an undetermined amount of elemental S).



Estuarine Management

NUTRIENT MANAGEMENT FOR THE CHESAPEAKE BAY: A REVIEW

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Abstract

Signatories from Maryland, Pennsylvania, Virginia and Washington, D.C., in conjunction with federal regulatory agencies, agreed to the 1987 Chesapeake Bay Agreement, which calls for a 40-percent reduction of nitrogen and phosphorus entering the mainstem of the Chesapeake Bay by the year 2000. The strategy includes point- and non-point-source nutrient loads from the 64,000-square-mile watershed of the Chesapeake Bay. To meet this goal, a Basinwide Nutrient Reduction Strategy was developed. The purpose of this paper is to present the framework from which estimates of nutrient loadings throughout the bay are developed and how the results from computer models will be used to direct basinwide nutrient reduction.

Information generated from computer model simulations is being used to understand the causes and results of nutrient enrichment in the Chesapeake Bay and the proper actions necessary to improve the bay's water quality. There are a number of questions that need to be resolved regarding planned nutrient management for the bay. One concern is whether the same nutrient reduction goals should be applied to the entire bay watershed, a process that involves interstate regulatory coordination. Geographic comparisons contrasting the consequences of tributary-specific goals will be investigated to address this issue. Another concern is whether nutrient reductions implemented below the fall line are significantly more effective than those from upland watersheds. A more detailed description of point- and non-point-source characterization of the bay is discussed along with future management implications.

Introduction

The Chesapeake Bay, created from the drowned river valley of the Pleistocene-incised Susquehanna River valley (Ludwick, 1972), is the largest of some 850 estuaries in the contiguous United States. The bay extends from Havre de Grace, Md., south 195 miles to its discharge to the Atlantic Ocean near Norfolk, Va. There are an estimated 4,000 miles of shoreline sculpture with numerous inlets and tributaries. The coastal and estuarine ecosystem of the bay functions as an effective nutrient trap from river waters that drain more than 64,000 square miles of watershed that encompass the bay basin. Nutrients from as far away as West Virginia and New York are carried by the rivers and deposited in the tributaries and upper bay waters. These nutrients include nitrogen and phosphorus that are essential for primary production that supports the wide variety of living resources in the Chesapeake Bay. However, recent expansions in population growth and associated land-use changes have dramatically increased nutrient loadings to the bay. This accelerated eutrophication is reported to have caused significant declines of the bay's water quality and living resources during the past several decades.

The 1987 Chesapeake Bay Agreement committed the signatory jurisdictions (Virginia, Pennsylvania, Maryland and the District of Columbia) to develop and implement a strategy to improve water quality conditions in the bay. It called for a 40-percent reduction of nitrogen and phosphorus entering the mainstem of the Chesapeake Bay by 2000. The Nutrient Reduction Strategy developed in 1988 presents the point- and non-point-source controls that will be used to meet each jurisdiction's share of the reduction goal. An important component of the Chesapeake Bay Program is the continued application of numerical models for use in addressing specific management issues.

A steady-state coupled hydrodynamic/water quality model assisted in establishing the target of a 40-percent reduction of nitrogen and phosphorus. The present generation of Chesapeake Bay models is vastly superior to the earlier version and will be instrumental in the 1991-92 reevaluation of the established 40-percent reduction goal. In fact, the management utility of computer models will continue until our ultimate goal is reached. This report describes the current Chesapeake Bay modeling effort and presents its utility and potential capabilities with respect to the Basinwide Nutrient Reduction Strategy.

Numerical Modeling

The Chesapeake Bay Time-Variable Water Quality Model (3D Model) represents the tool through which proposed management actions can be tested prior to implementation of actual control programs. This allows for more cost-effective selection of appropriate nutrient reduction strategies. The 3D Model is being used to determine the relationship between nutrient loads and the control of eutrophication and anoxia in the bay. As a result, emphasis is placed on water quality conditions, particularly dissolved oxygen, in the mainstem of the bay with ancillary information about related water quality variables that influence the bay's living resources. These parameters include light attenuation and dissolved nutrients. The 3D Model comprises four separate but linked models (Figure 1). They are: a Watershed Model (WSM), which delivers point- and non-point-source nutrient loads from the 64,000-square-mile watershed of the Chesapeake Bay (both above and below the fall line); a Hydrodynamic Model, which simulates movement of water via tides and currents; a Sediment Model, which simulates nutrient fluxes at the water/sediment interface, as well as transformations of nutrient forms in the sediments of the bay; and a Water Quality Model, which simulates the relationships between nutrients and primary production, as well as chemical processes in the water column affecting water quality. Point-source loads below the fall line are handled in this component. Atmospheric deposition was determined by combining wet and dry loadings of nitrogen and phosphorus to surface waters of the bay, its tributaries and river reaches. The WSM handles atmospheric loadings to the reaches above the fall line, while all other atmospheric loadings were coupled to the Water Quality Model. A more through description of the models is described by Butt (1992), Donigion et al. (1991) and Johnson et al. (1991).

The Chesapeake Bay and its extensive watershed comprise a dynamic system, experiencing continual change from both internal and external sources. The 3D Model will assist in understanding the important nutrient processes affecting bay water quality. It has the capability to estimate the time required for the water quality of the bay to respond to nutrient controls throughout the bay region. In addition, it will provide projections of the expected water quality response to proposed control actions (e.g., point- and non-point-source controls) under present and future conditions. A number of scenarios will be developed that simulate comparisons under varying combinations of point- and non-point-source loads and provide potential management alternatives. A summary of annual nutrient loads is presented in Table 1.

Nutrient Loadings

The 1987 agreement called for an equitable achievement of the 40-percent nutrient reduction. The 3D Model is being used to determine equitable targeted loadings, identifying the maximum allowable nitrogen and phosphorus loads from each tributary to meet the 40-percent or adjusted reduction goal. Once the targeted loadings have been agreed upon, the states use the best available information to determine the mix of point- and non-point-source controls to meet the identified tributary loadings. In order to accomplish these tasks, it is necessary to characterize temporal and spatial nutrient loadings associated with the bay.

Nutrients enter the Chesapeake Bay from point sources (e.g., municipal and industrial wastewater discharge), non-point sources (e.g., cropland, animal waste, urban and suburban runoff), atmospheric deposition (airborne contaminants), and the Atlantic Ocean. River basins, such as the Susquehanna, Potomac and James rivers, contribute the majority of nutrient loads to the mainstem of the bay (Table 1). Model results indicate that atmospheric loadings account for about 9 percent of the total nitrogen and 5 percent of the total phosphorus loads entering the bay. While total nitrogen is exported from the bay to the Atlantic Ocean, there is a net import of total phosphorus to the bay from the ocean; this import is almost equal to atmospheric deposition.

The original Baywide Nutrient Reduction Strategy defined "controllable loads" as the nutrient loads that were not natural background loads. This included only point-source (PS) and non-point-source (NPS) loads from those states party to the Chesapeake Bay Agreement (EPA, 1992). Both total nitrogen (TN) and total phosphorus (TP) loads by basin are displayed in Figure 2. The majority of total nitrogen loadings occur in the upper portion of the Chesapeake Bay (Figure 2a). Non-point sources from the Susquehanna River are responsible for more than 36 percent of the total controllable nitrogen to the bay. Twenty-one percent of the TN load coming from PS and NPS above and below the fall line are from the Potomac River. A substantial amount of TN is also delivered to the bay below the fall line from both urban and crop runoff in conjunction with point-source loadings. Virginia tributaries and inland coastal wetland systems contribute less than 17 percent of the total nitrogen. Atmospheric deposition of TN amounts to about 9 percent.

Loadings of TP occur in approximately equal proportions from the Susquehanna, Potomac and James rivers (24, 23 and 21 percent respectively, Figure 2b). Non-point sources above the fall line dominate TP loads from the Susquehanna and Potomac rivers. The second largest contributions of TP occur from the James River and from along the banks of the upper bay. The James River is dominated by NPS loading above the fall line and PS below the fall line. The upper portion of the bay receives most of its loadings from below the fall line from point and non-point sources.

Future Management Implications

Progress towards PS control and nitrogen and phosphorus reduction in Virginia is summarized in Figure 3. The figure indicates the 1985 baseline PS loading estimates and the year 2000 target developed for the strategy. Both projected and actual loading estimates are shown for each phase. There was an increasing trend for PS nitrogen loads from the base year through Phase I (Figure 3a). This was predicted because of population growth and the corresponding increased flows from publicly owned treatment works (POTWs). However, as the figure shows, PS nitrogen loads have returned to 1985 levels and are lower than strategy projections. Phase II nitrogen loads decreases are attributed to nitrogen control efforts at several major industrial facilities.

Figure 3a illustrates that the 40-percent reduction target for PS phosphorus loads was achieved during Phase II of the strategy. The phosphate detergent ban that went into effect in January 1988 resulted in a 33-percent reduction during Phase I. A further decrease occurred during Phase II, with the activation of phosphorus removal systems at several POTWs. However, the decrease in annual loadings was countered by a progressive increase in the volume of flow from Virginia's POTWs. Further reductions of phosphorus loads are expected to occur through continued implementation of the Policy for Nutrient Enriched Waters. This policy, adopted in March 1988, requires many facilities permitted under the Virginia Pollution Discharge Elimination System to meet a 2.0 mg/l phosphorus effluent limit. The policy is expected to maintain phosphorus loadings below the target through the year 2000.

Conclusion

The Chesapeake Bay Program's highest priority is to restore the bay's living resources. This can be accomplished through water quality improvements achieved primarily through nutrient reductions as outlined above. These reductions, it is hoped, will ultimately provide for increased dissolved oxygen and improved water clarity, allowing submerged aquatic vegetation propagation. However, there are several areas to the program that could be expanded. Currently, the 1987 agreement only includes three states and the District of Columbia. Combined, they represent 83 percent of the entire bay drainage basin. The remaining 17 percent of drainage area is encompassed by West Virginia, New York and Delaware. Therefore, the Bay Program could be expanded to include these states. There is also the issue of incorporating atmospheric deposition as a controllable pollutant. Although it contributes only 9 percent and 5 percent of TN and TP, respectively, atmospheric nutrient reductions are possible through the efforts of the Clean Air Act and other planned regional or local regulatory actions.

Nutrient loadings from PS, NPS and atmospheric deposition may not be the only factors contributing to summer anoxia in deeper waters of the bay. The 3D Model indicates that phosphorus is being imported from the ocean in amounts equal to atmospheric deposition. However, until now, we have been considering controllable nutrients and their impact on the bay's living resources. What about the influence living resources have on the bay's water quality? Studies need to be conducted that investigate if there is any correlation between the rapid decline of submerged aquatic vegetation in the early 1970s and noticeable increase in anoxic and hypoxic events in the bay. Recent studies have theorized that the bay may have lost its natural filter (Newell, 1988) due to the overharvesting of oysters. It is becoming increasingly more evident that managers need to work across disciplines if we are going to solve the numerous resource problems of the bay. It is not beyond the scope of our technology to use living resource management as an effective tool in nutrient management for the bay. This could result in substantial cost savings from expensive PS and NPS nutrient control measures. Ecosystem models could be coupled with the current water quality models to further investigate these options.

Acknowledgments

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Table 1. Annual nutrient loads to the Chesapeake Bay by basin.

Basin	Total Nitrogen ($lb \times 10^3/yr$) PS+NPS AFL*	NPS BFL	PS BFL	Total N loads	Total %	Total Phosphorus ($lb \times 10^3/yr$) PS+NPS AFL	NPS BFL	PS BFL	Total P loads	Total %
Susquehanna	138,654	0	0	138,654	40.22	6,590	0	0	6,590	25.42
Choptank	0	0	267	267	0.08	0		104	104	0.40
Patuxent	2,010	2,343	603	4,956	1.44	203	200	110	513	1.98
Western Shore, Md.	0	6,598	21,792	28,390	8.23	0	530	1,414	1,944	7.50
Eastern Shore, Md., Pa.	0	26,741	636	27,377	7.94	0	1,887	198	2,085	8.04
Potomac	46,146	10,471	22,951	79,568	23.08	5,094	764	362	6,220	23.99
Rappahannnock	4,254	5,474	390	10,118	2.93	435	433	136	1,004	3.87
York	2,164	2,927	1,290	6,381	1.85	304	218	418	940	3.63
Appomattox	1,856	0	0	1,856	0.54	279	0	0	279	1.08
James	13,338	9,025	20,461	42,824	12.42	2,424	495	2,951	5,870	22.64
Eastern Shore, Va.	0	3,080	1,303	4,383	1.27	0	83	297	380	1.47
Total	208,422	66,659	69,693	344,774	100	15,329	4,610	5,990	25,929	100
Percent	60.45	19.33	20.21	100	59.12	17.78	23.10	100		

* Point-source (PS) and non-point-source (NPS) nutrient loads delivered to the fall line. ABL, above fall line; BFL, below fall line.

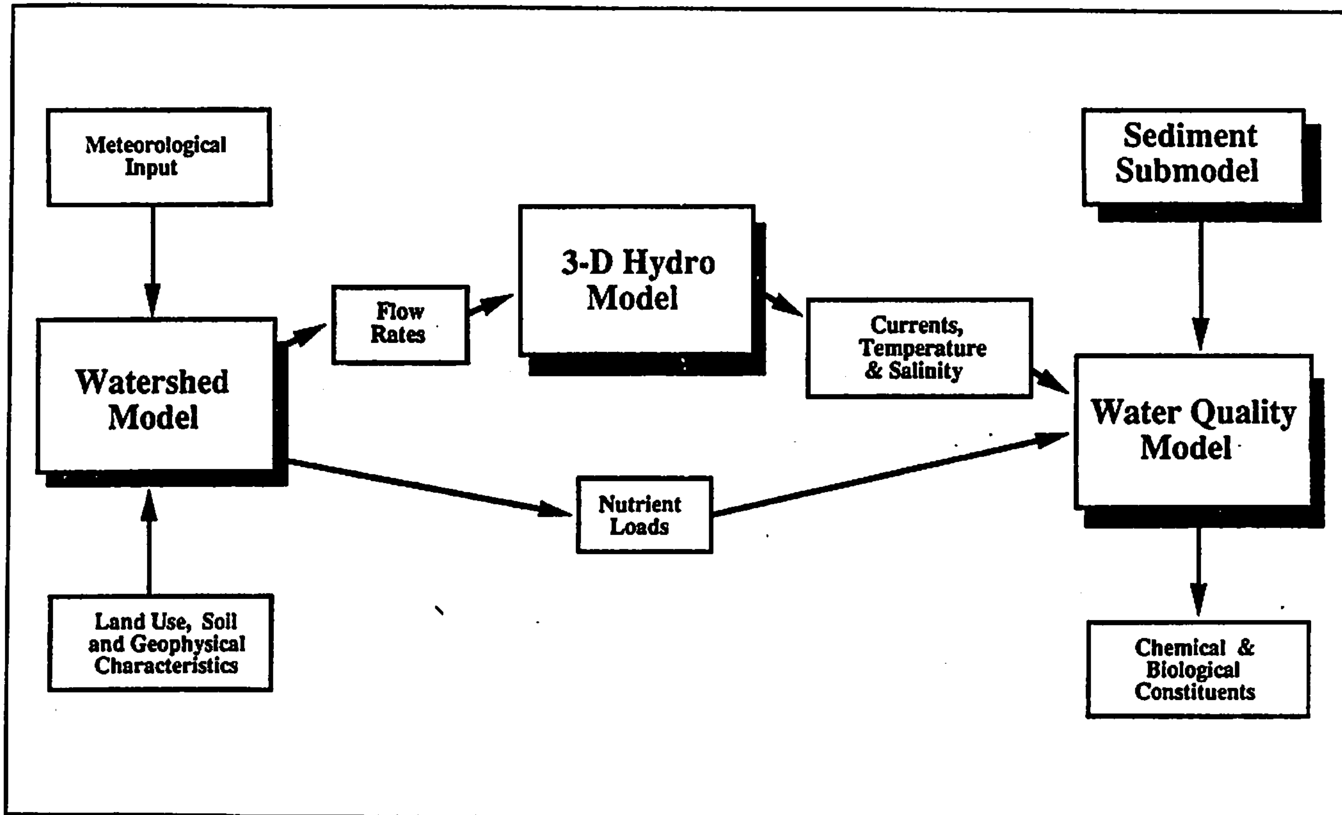

Figure 1. Chesapeake Bay models.

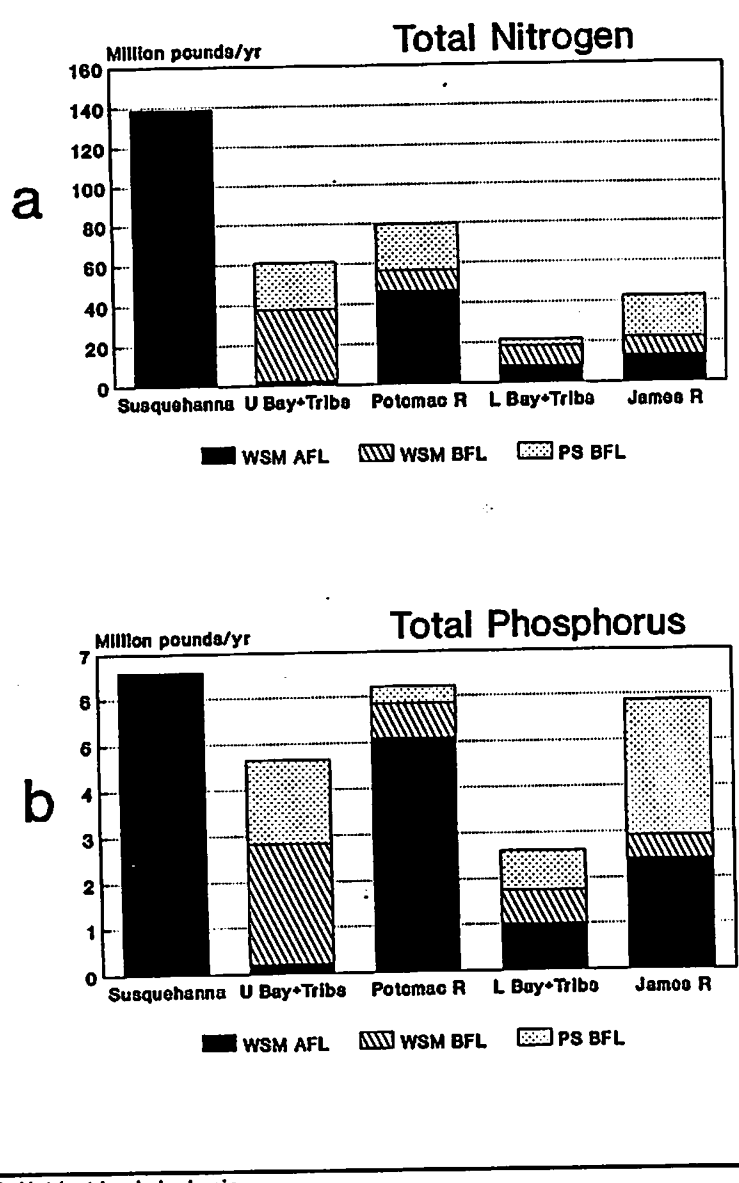

Figure 2. Nutrient loads by basin.

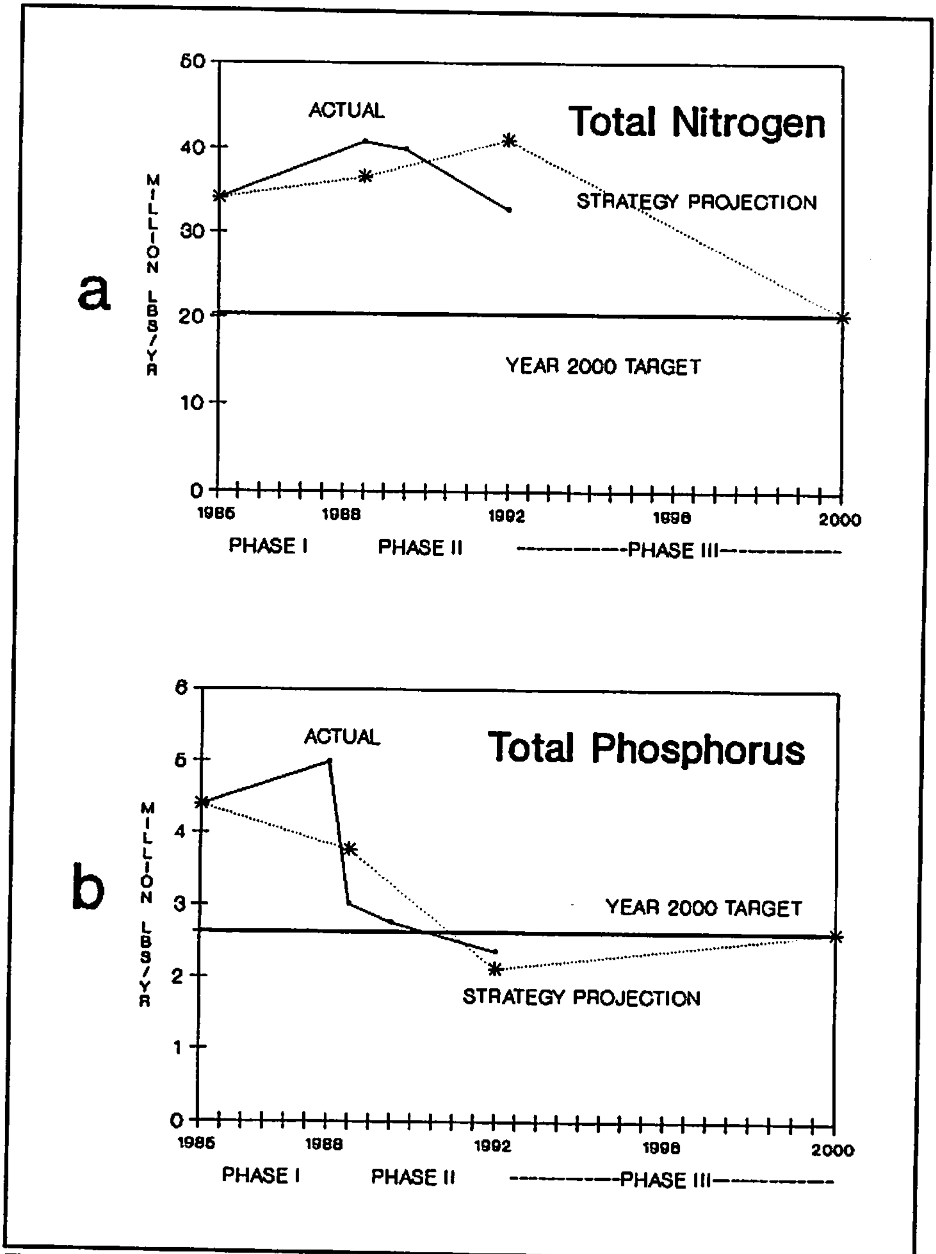

Figure 3. Virginia point-source reductions.

COOPERATIVE ENVIRONMENTAL MANAGEMENT: AN EXAMPLE FROM THE NATIONAL ESTUARY PROGRAM SANTA MONICA BAY RESTORATION PROJECT

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Introduction

The environmental movement is entering a new age. For two decades, traditional command-and-control regulations told firms what pollution control technology to use and how much pollution they could emit (in effect, unidirectional communication and isolated problem-solving). Nevertheless, significant improvements in the quality of air, water, land and natural resources were made. Now, in an era of new environmental challenges and heightened economic sensitivities, awareness is emerging that a more "democratic" and inclusive process is needed to solve our complex and costly environmental problems. Regulators and planners have found that allowing for (and encouraging) input from regulated and interested parties into the decisionmaking process promotes public-private partnerships and more innovative and effective solutions. This practice has come to be known as Cooperative Environmental Management. While command-and-control management still has a place in today's environmental protection, cooperative management offers an equally powerful and efficient tool for developing solutions.

The diversity of interests and complexity of jurisdictions in coastal resources management makes decisionmaking difficult and time-consuming. Complex and controversial issues threaten the viability and ultimate success of environmental planners who must obtain widespread support for their plans and actions. Fortunately, we are witnessing a new era of environmental protection. New partnerships, forged partly by the demands of regulation but mainly by public pressure and awareness, are addressing our most complex problems.

Cooperative Environmental Management is a relatively new buzzword in environmental management. The phrase describes a framework and process for consensus-building and has come to connote a positive spirit that often develops when diverse interests give and take in order to make progress. In many respects, the National Estuary Program (NEP) has come to embody this cooperative management style, primarily due to the way in which programs are organized. NEP management conferences encourage diverse interests to participate, bringing together representatives from the regulatory community, industry and environmental groups. Good examples of cooperative environmental management can be found throughout the NEP. This paper focuses on the experiences of the Santa Monica Bay Restoration Project, those pertaining to the following issues: non-point-source pollution control, sewage treatment, and endangered species habitat enhancement.

The Santa Monica Bay Restoration Project (SMBRP) is a National Estuary Project created by Section 320 of the Clean Water Act and managed by the U.S. Environmental Protection Agency (EPA) and the state of California. The SMBRP is a unique coalition of government, environmentalists, scientists, industry and the public.

Its basic charge is to develop a comprehensive management plan to restore and protect the bay.

The project has several success stories that exemplify the trend toward cooperative environmental management.

Regulation through Local Level Negotiation:
A Successful Approach to Control Non-Point-Source Pollution

In November 1990, an article appeared in the *Los Angeles Times* lauding Environmental Defense Fund Executive Director Fred Krupp for negotiating a deal with McDonald's to end the fast-food chain's use of polystyrene foam packaging (*L.A. Times*, Nov. 12, 1990). Krupp is quoted as saying "... We may be entering a new era of environmental problem-solving by negotiation."

The SMBRP applied a similar strategy when it brought together a group of its management committee members representing stormdrain managers, environmentalists and regulatory agencies to develop a program to control urban runoff into Santa Monica Bay.

The SMBRP needed to develop a set of requirements and a compliance schedule for implementation of urban runoff and stormwater management. It was apparent from the outset that a negotiation strategy was needed. The Los Angeles County Department of Public Works—the owner/operator of more than 2,000 miles of stormdrains—was not interested in entering into a National Pollutant Discharge Elimination System (NPDES) permit with the Regional Water Quality Control Board (RWQCB) earlier than the time required under anticipated federal Water Quality Act regulations.

On the other hand, the city of Los Angeles, the owner/operator of approximately 1,100 miles of stormdrains, *was* interested in pursuing an early permit as provided for in the WQA. In recent legal settlements with EPA and the state of California stemming from sewage treatment violations, the city agreed to not only correct its sewage problems, but also to begin cleanup of stormdrain pollution. Management changes brought about as a result of the legal settlements thus created the impetus for the city to act aggressively on stormwater pollution control.

Discussions between city and county public works officials (who together serve a population of more then eight million), along with an assessment by an SMBRP committee of the merits of pursuing an early permit, resulted in consensus. The county, as the principal permittee, agreed to pursue an early NPDES permit not only for the Santa Monica Bay watershed, but for the whole of Los Angeles County. All 86 cities in the county eventually would be co-permittees, with the city of Los Angeles and other Santa Monica Bay watershed cities as first-phase co-permittees. Important factors that convinced county officials to undertake negotiations for an early permit included:

Agreement to use a National Association of Flood and Stormwater Management Agencies' recommendation as the starting point for permit development;

Strong encouragement and commitment to participate in the negotiations by high level management at the regulatory agencies; and

Consensus that a locally developed program would not only be less expensive than the federal model, but also more effective.

Negotiation and the cooperative management approach resulted in a workable stormwater program tailored to the distinct structure and conditions of Los Angeles County. The negotiation process proved to be very useful for several reasons:

Negotiation allowed for customizing/refining solutions;

Negotiation promoted "ownership" of the solutions; and

Negotiations encouraged creativity and innovation.

The management committee of the SMBRP served as an integral mechanism for informal discussions and conflict resolution between the involved parties. Although contested by one environmental group, the NEP process as carried out by the SMBRP resulted in support and cooperation from other key Los Angeles environmental groups and early proactive steps by governmental agencies. The early permit is a significant accomplishment by regulatory and implementation agencies to address the threat to water quality posed by non-point-source pollution.

Issue Resolution: Sewage Treatment for Ocean Disposal

One of the most difficult issues facing the SMBRP was the level of treatment required for all sewage discharges to the bay. Under the Clean Water Act (CWA), full secondary treatment is required of all sewage discharges to ocean waters. The Los Angeles County Sanitation Districts (LACSD) applied for a variance from full secondary treatment under Section 301(h) of the CWA in 1979. Despite a final decision by EPA to deny the waiver request in December 1990, LACSD continued to argue against implementing full secondary treatment. LACSD argued that the discharges were covering up contaminated sediments from historical illegal dumping of toxic substances (DDT, PCBs, etc.) in the 1970s.

The sewage treatment issue was complicated by a lawsuit filed by NOAA et al. (National Oceanic and Atmospheric Administration and state trustees) against the parties responsible for the illegal dumping. The county also faced possible litigation for the toxic discharges.

Recognizing the importance of this issue for the project, the SMBRP management committee sought to pass a resolution in favor of full secondary treatment. Because of the opposing views represented, a negotiations team was established to develop consensus. After several months of intense negotiations, the county and the environmental groups agreed to a resolution that was subsequently adopted by the SMBRP.

The project played a critical role in resolving the issue by providing a balanced forum and a sense of shared responsibility. The negotiation team strategy worked because it encouraged personal interaction and commitment outside the formal setting of the project, while maintaining a sense of responsibility to the project. The sharing of power and information involved in the negotiations encouraged the self-esteem of individual team members, thereby multiplying the total power of the group. Thus, when the team succeeded in developing a mutually agreeable resolution, it generated enthusiasm and ownership among all project members.

The negotiations were not easy. Many times during the process it seemed as if they would fail. However, the cooperative spirit which was maintained facilitated consensus. Moreover, the sense during the whole process was that if the project could not agree on this issue, it could never develop a viable management plan for the future. This sense of responsibility created accountability among project members to make the passage of a resolution a reality. This was a prime example of how cooperative environmental management can bring about beneficial solutions.

Multi-Jurisdictional Negotiation: Enhancing Habitat for an Endangered Species

The California Least Tern (*Sterna antillarum browni*) is a state and federally listed endangered species. Although the species was historically abundant, loss and degradation of coastal habitats for nesting (sandy beaches) and foraging (estuaries) were responsible for the species' rapid decline through the 1960s and 1970s. More than a decade of monitoring key breeding colonies indicated that the tern was persisting, but remained extremely vulnerable to human disturbance, depredation from natural and feral predators, and pollution.

Despite the tern's vulnerability and threatened existence, a nesting colony at Venice Beach had been highly successful. The success at Venice was due primarily to intense management of the site, including pre-season site preparation, fenced breeding enclosures, monitoring and predator control.

The Least Tern is attracted to the Venice Beach/Marina del Rey area because of its wide sandy beaches and marina channels that offer important foraging and nesting habitats. The problem was that the Venice site was becoming overcrowded. Birds returning to breed at Venice were having to look elsewhere for nesting sites. As there were no other protected sites in the bay area, the SMBRP (through its expert consultants) set out to establish another nesting colony in the area.

What at first seemed like a relatively simple and easy task turned out to be a complex and time-consuming project. Many public agencies had to be involved. Permits for establishing the new site were also required. A number of organizations had to be consulted, informed or lobbied for support. These included the U.S. Fish and Wildlife Service (USFWS), EPA, State Parks and Recreation Commission, State Fish and Game Department (DFG), State Coastal Commission (CCC), County Department of Beaches and Harbors and local property owners.

In January 1992, the Santa Monica Bay Restoration Project began an intense negotiating process in order to have the required permits approved (and a fence put up) in time for the terns' arrival in early April. As the SMBRP began to build support for the new tern site and seek the necessary permits, two major issues arose. The first was that the proposed site for the terns also happened to be a proposed site for a large public parking lot under the State Parks and Recreation Commission's General Plan. The second issue was that the County Department of Beaches and Harbors had plans to dredge the marina. That would have severely diminished the area's foraging productivity and would have harmed the beach as well, because the dredge material would have been piped across the beach and into the ocean near the proposed tern site. The county was unwilling to agree to a tern site, if such action could jeopardize future dredging of the marina.

The county needed assurance that the resource protection agencies would not try to stop future dredging projects because an endangered species used the area. The project was able to bring the parties together to provide those assurances. It was important to communicate the fact that when the terns are not here (October through March), dredging activity could take place.

The parking lot issue was resolved by negotiating with the State Parks and Recreation Commission. After convincing the commission that the parking lot and nesting site could co-exist, the commission agreed to reposition the proposed parking lot and downscale it.

Bringing the right people together for negotiation was critical to building support for the nesting colony. Previous discussions over the phone and in person had not been fully successful, because each time key participants were absent. Because there was a need for "buy in" from several organizations, participants came to value the diversity of interests which were represented. This encouraged trust and cooperation, which in turn generated enthusiasm and ownership of the project. By the end of the negotiation process, everyone wanted to be able to say that he or she had done something to protect and enhance an endangered species.

The negotiations for establishing the tern breeding site had another benefit. The cooperative process forced people to re-examine and discard stereotypes. For example, both the Beaches and Harbors organization and the Parks and Recreation Commission were viewed by some as being insensitive to the needs of wildlife, promoting the idea that beaches and marinas were for people only. However, this image was dispelled when these agencies demonstrated their cooperative spirit and enthusiasm for the project once the details were worked out.

Cooperative Environmental Management:
A Model Strategy for the Future

The adversarial attitudes that characterized the beginnings of the environmental movement are fading. Although traditional command-and-control environmental regulation resulted in significant improvements in the quality of our environment, it negatively affected relationships and innovation. The command-and-control approach resulted in distrust of government and widespread antagonism toward corporations, as well as a suspicion that anything supported by business was probably bad for the environment. Over time, regulators and environmental groups have come to find that applying a more collaborative or democratic approach to problem-solving leads to better solutions. While there has been some resistance to this approach, success stories mount. The National Estuary Program has had much success using this model.

Finally, where the Cooperative Environmental Management approach has been used, participants have at the least come to better understand and respect each other, and often innovative and effective solutions have been developed. The benefits of cooperative environmental management are many. Cooperative management encourages participation and the sharing of power and information, generates enthusiasm and ownership of the solutions, and encourages self esteem and commitment in team members.

ESTUARINE PRESERVATION AS A LAND-USE PLANNING CHALLENGE

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Introduction

A significant negative consequence of human development is the declining health of estuarine ecosystems. Degradation of these ecosystems threatens both the natural resources that depend on them for survival, and the economies of many nations which derive economic and recreational value from estuaries. While the literature reviewed for this paper references estuaries located throughout the world, the most extensive information provided herein refers to a local estuary, the Chesapeake Bay. International cases are cited in order to stress the global scope of the problem, and to suggest that some of the recommendations made might apply beyond the United States.

Excessive human-generated pollution deposited in estuaries is the leading cause for their decay. (Estuaries are also negatively effected by other activities, such as the reduction of freshwater inflow; however, a discussion about the full range of human activities that impact estuaries is beyond the scope of this paper.) The primary source of such pollutants is development on surrounding lands. Managing the development and use of land bordering estuaries is therefore a vital means of limiting estuarine deterioration.

Present efforts to minimize pollution entering estuaries focus on containing wastes emitted by nearby industries (e.g., capping pipeline emissions). This example illustrates that management efforts are untimely, because initiating efforts late in the process of land development necessarily limits them to measures that do not threaten existing industries and infrastructure. This writer maintains that effective protection of estuaries can only be accomplished if appropriate efforts are undertaken at the earliest possible stage of development—when decisions are made about permissible uses of lands.

Further, the paper suggests that the land-use planning process is an appropriate paradigm for local decisionmakers to maximize consideration for estuaries in land-use decisions. By incorporating estuarine protection studies and measures within the land-use planning process, development will accordingly be based on the capacity of a watershed to support human activities. This linkage is critical to maintaining the water quality of and deriving beneficial uses from estuaries.

The Importance of Estuaries

Estuaries are by far the most productive ecosystems—aquatic or terrestrial—on earth. They act as spawning, nursing, and feeding grounds for countless fish, shellfish and wildlife, including a large number of endangered

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species. They are, in essence, the fertile breeding ground for much of life on this planet.

This is not intended to suggest that preserving estuarine species is merely an environmental concern. Indeed, while the food chain that estuaries support begins with protozoa and plankton, it culminates with fish-eating mammals (including humans). Two-thirds of all fish caught globally hatched in estuaries. In the United States, this biological harvest has an annual value to the economy of over $19 billion (EPA, February 1990). Yet, these critical and lucrative harvests have greatly diminished as a result of increasing degradation to their breeding grounds. In Ghana and elsewhere in West and Central Africa, for example, irresponsible waste disposal practices have destroyed entire fisheries industries (Curtis, 1987).

Threats to Estuaries

It is increasingly clear that estuaries are being destroyed by the pollutants that are deposited into them. Whether an estuary is a fjord in the mountains of British Columbia, a drowned river valley like the Chesapeake Bay, or a result of seismic movement, as with San Francisco Bay, a characteristic that is typical of any estuary is that it is fed by inland streams and rivers. Estuaries are therefore the ultimate destination for pollutants carried by other bodies of water, and appropriately are referred to as "the sinks at the end of the system where water cannot be washed any further downstream" (Jensen, 1987). This process implies that even if human settlement does not occur directly on the shores of an estuary, the effluent from human development occurring anywhere within the watershed that feeds the estuary directly impacts its health.

Scientists are only beginning to grasp the significance of anthropogenic effects on these ecosystems. There are two primary types of input to which estuaries are highly vulnerable—excessive natural materials and alien biocides. To facilitate coastline settlement, humans channel rivers, fill wetlands and undertake numerous other construction-related activities. The resulting sedimentation accumulates excessive levels of nutrients in water bodies, spurring the growth of microorganisms that hoard the oxygen needed by other marine organisms for survival.

Moreover, humans introduce additional materials to waterways once settlements become populated. These include not only nutrients from human waste but also human-engineered chemicals (i.e., fertilizers and pesticides). These foreign substances reach surface water bodies both through direct discharge from pipelines (point sources) and indirectly, through urban and agricultural runoff carried by stormwater (non-point sources).

While point-source polluting activities are typically regulated by governments (i.e., by placing caps on allowable emissions), greater emphasis must be placed on controlling non-point-source pollutants (NPS). Indeed, the Environmental Protection agency reports that NPS accounts for 65 percent of the pollution entering streams and rivers and 75 percent of that entering lakes (SCSGC, 1991). Hence, non-point-source pollution is the leading cause for the degradation of estuaries, and should therefore be the focus of efforts to protect them.

The Land-Use Planning Process

The remainder of this paper focuses on the inadequacy of land-use planning, a heretofore anonymous "villain" in the facilitation of urban and agricultural runoff. This analysis indicates deficiencies of three stages in the traditional planning process, resulting in poor land-use policy decisions:

Identifying goals and objectives;
Collecting and analyzing data; and
Proposing alternate plans.

By addressing estuarine problems at all three stages, this writer advocates using the planning process to promote land uses that minimize runoff. Clearly, preventing non-point-source pollution from entering waterways should be considered a land-use planning challenge. Planners, by definition, are "integrating practitioners." Since the following discussion stresses the need for multidisciplinary interaction in order to succeed in preserving estuarine ecosystems, planners are well suited to fulfill this role.

Differentiating Between Long-Range and Short-Term Objectives

Short-term pollution prevention objectives are immediate responses to indicators of environmental stress. Pipeline pollution controls, for example, will attempt to reduce excessive nutrient input and toxic loading. Long-range objectives, on the other hand, are guided by a goal of developing an integrated strategy for the environmental management of estuarine ecosystems. This strategy must integrate land and water use patterns with the ability of a watershed to, foremost, support its own natural processes, and secondly to support economic development (Malone and Bell, 1991). To do so, long-range objectives must be based on an ever-increasing understanding of these ecosystems and of the human role in their preservation or destruction.

The difference between short-term and long-range objectives highlights the need to identify the appropriate level of organization and government for particular programs and policy decisions. Since changes in water quality are first perceived at the local level, reactive measures to combat crises should be taken at this stage. However, since pollutants from everywhere in a watershed are ultimately carried to downslope estuaries, degradation in the long-run results from the aggregate contributions of all the localities within the watershed. Thus, a regional perspective is required when developing long-range objectives for protecting an estuary. The need for regional action is recognized in the 1987 Clean Water Act Sec. 319(b)(4): "A state shall, to the maximum extent practicable, develop and implement a management program under this subsection on a watershed-by-watershed basis within the state." Yet, even this seemingly progressive legal regime is inadequate in two ways.

First, watersheds often cross jurisdictional boundaries, demanding cooperation between governments. The Baltic Sea, the Persian Gulf, and the Chesapeake Bay are a few examples of coastal seas that are impacted by land uses within multiple jurisdictions (Morris and Bell, 1988). The states whose land composes the Chesapeake Bay drainage basin recently recognized this need for regional cooperation (albeit after the Bay had suffered severe degradation). The governors of the states surrounding the Bay—Virginia, Maryland, Pennsylvania and the mayor of Washington, D.C., signed an agreement in 1987 to promote major efforts to improve water quality in this estuary. However, the majority of the states that share watersheds across the United States, and Middle-East countries bordering the Arabian Gulf, do not recognize this perspective on regional responsibility. As a result, one government may feel that undertaking efforts to mitigate estuarine degradation is futile, due to the unchecked pollutant levels contributed by neighboring jurisdictions.

The second fallacy regarding the policy level of contemporary efforts is that municipalities are too heavily entrusted to do the right thing. In Virginia, for example, local governments are responsible for implementing the state's Urban Nonpoint Source Management Plan. While the Virginia Erosion and Sedimentation Control Law and the Stormwater Management Program mandate that municipalities develop programs that comply with minimal criteria for controlling runoff, more extensive protection efforts are only encouraged. Following are examples of municipal activities that are merely suggested (and hence discretionary) by the Virginia Department of Conservation and Recreation (1989):

Encouraging local development of Best Management Practices (BMPs);
Enacting tree preservation ordinances or other measures to protect and maintain urban vegetation. (To emphasize the absence of voluntary local commitment, it is noteworthy that virtually all of the Washington Metropolitan Area counties' executives recently proposed to reduce or postpone tree planting/preservation programs in their 1993 budgets (Cohen, 1992));

Controlling the pace and pattern of development by time-phased extension of sewerage and other municipal services, in order to channel development into suitable areas and to discourage it in areas where it is likely to have adverse effects on water quality.

Government decentralization is appropriate in promoting authority to respond to short-term problems locally. However, municipalities are driven by local agendas, and therefore cannot be relied upon to independently initiate efforts that will preserve downstream estuarine ecosystems in the long run. While municipalities may adopt some land-use control measures, insufficient incentive exists for them to take aggressive action. Indeed, such actions often threaten to undermine competing municipal interests. For example, minimum lot size zoning contributes significantly to a local government's tax base. Yet, one result of such zoning is urban sprawl, which requires more roads and other impervious surfaces that increase runoff. Sprawl also encroaches upon water-retaining forested areas at its ever-expanding periphery. The fate of the indigenous vegetation includes both removal and degradation—from exposure to pollutants too alien or too numerous to be absorbed. The unnecessary elimination of acres of trees is counterproductive (if not sinister), because it destroys the earth's most efficient pollution filter.

Evidently, the perspective of the decisionmaker greatly effects the perception of incentives. Typically, localities favor activities with concentrated local benefits and widely dispersed costs, while tending to avoid activities where costs are incurred locally and benefits are dispersed (VCES, 1985). Hence, in the initial stage of the planning process, a clear distinction must be drawn between short-term problems and long-range challenges. Only by clarifying these objectives will the appropriate levels for program initiation become apparent.

Data Collection and Interpretation

The success of decisions regarding the use of estuarine ecosystems is limited by our understanding of the components and processes of the systems. Such knowledge is necessary to estimate the capacity of estuaries to absorb the byproducts of adjacent land uses. Yet, for several reasons, the baseline data upon which impacts of land uses on estuaries are traditionally analyzed is flawed.

First, the discipline-specific research approach provides a narrow understanding of the ecosystem and of human impact on it. Research on specific aspects of physical or biological processes is valuable and necessary preliminary information. However, future baseline studies and research on estuarine processes should focus on interdisciplinary relationships, which will account for chemical, physical, biological and geological components.

Moreover, professionals in disciplines heretofore isolated from science-based decisionmaking should participate in interpreting data derived through scientific studies. Professionals from fields such as economics, landscape ecology and humanities can contribute useful information on ecological and social phenomena, developing a more comprehensive base for policy decisions. A drainage basin should be considered as an entire ecosystem, composed not only of its geography, but of its people, economics, history, politics and culture (Morris and Bell, 1988).

Finally, research conducted by groups whose primary interest is program implementation may not fairly address issues that have become politicized (USFS, 1990). Regulatory agencies and special interest groups have their own environmental or management agendas. Alternatively, academic institutions might be sufficiently independent to conduct unbiased research. Where no such autonomy exists, decisionmakers might solicit multiple studies representing a broad spectrum of interests.

Ideally, objective, interdisciplinary research information must be provided to a multidisciplinary group of professionals, who will then communicate to policy-makers how such analyses can be used in a community. Only this kind of approach will ensure that research and information exchange is not restricted by biased notions of what is "relevant" to policy formulation (Malone and Bell, 1991).

Alternate Plans

The third planning stage that can be used to encourage land-use decisions that protect estuaries is the stage at which alternate plans are proposed. Integral to this phase is an openness both to innovative contributions from professionals in a wide spectrum of fields and to the introduction of relevant case studies from other parts of the country or the world. Often in planning, however, this openness is thwarted by a perspective based only on discipline-specific or local experience. Such openness is additionally obstructed by the disproportionate emphasis granted the preferred alternative; however, a discussion of the improprieties involved in planning decisions is beyond the scope of this paper. To highlight this point, two examples of innovative alternate solutions are discussed.

In the area of interdisciplinary cooperation, the following example cites a proposed program to use highway rights-of-way for achieving the dual objectives of transportation and water quality improvement. Highway rights-of-way extend beyond highway shoulders to include setbacks for noise abatement and other purposes. In total, right-of-way areas encompass a considerable amount of public land and are assembled at great public cost. Many of these linear rights-of-way are appropriate for the installation of stormwater management structures such as infiltration trenches. Such a dual use will both maximize the public benefit from this land resource and preclude the need to further condemn private land, which is an expensive procedure. Parties interested in and studying this concept include the Federal Highway Administration, the U.S. Environmental Protection Agency, and at the state level—Virginia's Department of Transportation and Division of Soil and Water Conservation (VDCR, 1989).

The potential benefits derived from international comparisons are apparent in a study conducted by the Coastal Seas Governance Program. To generate alternatives that might be used in preserving the Chesapeake Bay, researchers studied numerous other large estuaries around the world. Governments around the Setonai-Kai estuary in Japan, for example, limit yellowtail fish farming, an action deemed urgent because the excessive excretion of nitrogen by the fish impairs water quality. The problem was remedied by providing state-subsidized insurance to those who farm at or below a pre-determined optimal density (Morris and Bell, 1988). One conclusion drawn from this example is that there are workable management alternatives to enforcing strict regulations—the carrot in lieu of the stick.

The comparative study by the Coastal Seas Governance Program found that most nations do not rely on laws and regulations like the United States does. The need to enforce strict regulations not only ends up consuming court dockets, but often is ineffective in the first place since the laws themselves are misguided. Most regulations do not impose solutions at the problem's source—controlling land uses, but rather deal with the symptoms of environmental stress (i.e. pollution). Consequently, enormous resources are dedicated to enforcing efforts that in many cases are only marginally effective.

Conclusion

This paper has outlined three stages in the land-use planning process that can be used to advance the preservation of estuarine ecosystems. Short-term objectives should be set based on sporadic local demands, and long-range objectives based on jurisdictional accountability for regional problems. Research intended to further develop our understanding of estuaries should be undertaken by neutral interdisciplinary scientists and interpreted by multidisciplinary teams of professionals. And finally, input from both analogous cases worldwide and multiple disciplines should be encouraged when generating alternate scenarios to be analyzed.

Traditional attempts to deal with estuarine contamination have been instituted at steps late in the land-use development process, because this has been convenient for society. While existing development is often a limiting factor, this should not stop us from forging ahead with innovative protective measures and even rethinking redevelopment patterns.

Available knowledge about estuarine processes demands that we look at estuaries as complete systems. Only in this way can we begin to intervene in their destruction at a stage that is early enough to bring it to a halt. We must take our understanding of the anthropogenic impacts on these ecosystems and apply it at the point where this contact is initiated—during the land-use planning process. Only by coming full circle in dealing with these systems can we hope to successfully interrupt the destructive cycle and prevent further degradation.

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Coastal Hazards

COASTAL NATURAL HAZARDS POLICY IN OREGON: A CRITIQUE AND ACTION PLAN

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Abstract

The Oregon coast is affected by a variety of natural hazards—chronic erosion, landslides, flooding and potentially catastrophic earthquakes and tsunamis. Hazard mitigation at the state level is accomplished through state-mandated, locally-implemented land use planning and development policy, and state regulatory programs for shore protection. Hazards policy implementation is generally ineffective, particularly with respect to the cumulative effects of hard shore protection structures. Shortsighted land development policies are driving the demand for hard shore protection. Furthermore, present polices do not address the potential impacts of accelerated sea level rise expected next century or the very real threat of a major subduction zone earthquake and related hazards. To deal with these implementation shortcomings and unaddressed hazards, Oregon Sea Grant and state coastal managers have organized a Coastal Natural Hazards Policy Working Group. The PWG represents a broad range of interests, and is using an all-hazards approach to build consensus and develop recommendations for improved hazards mitigation policy.

Introduction

The Oregon coast experiences a wide variety of common natural hazards. Winter storms cause flooding and beach erosion. Large waves set up nearshore rip currents that hollow out embayments in the beach and cut into dunes and sea cliffs. Wave undercutting causes bluff-top slumping and landslides. We have learned that major episodes of coastal erosion are often caused by raised sea levels and changed storm patterns associated with periodic El Niños and that these events will continue to occur. Very recent geologic research suggests that large magnitude, potentially destructive earthquakes occur along the Cascadia Subduction Zone off Oregon and that we are entering the time window for the next event.

Coastal growth and development pressures in Oregon have increased significantly in the 1980s. Growth trends today point upward all along the coast and several areas are experiencing unprecedented rates of increase. A good deal of this growth is occurring in hazardous areas, such as low-lying beachfront and river mouth areas, high oceanfront bluffs, and steep hillside land.

Oregon's beach protection and land use policies dealing with coastal natural hazards were enacted in the late 1960s and early 1970s. A recently-completed Sea Grant evaluation of these policies found a variety of conflicts, gaps, overlaps and implementation problems that merit further examination. Furthermore, much of the new technical information acquired in recent years has hazards policy implications that could not be anticipated just 10 years ago.

The combination of these factors—new scientific and technical information, growing development pressures in hazardous areas, and weaknesses in present hazard mitigation policies and their implementation—point to the need for a comprehensive review and overhaul of beach protection and hazard mitigation policies. The need for such a review was also one of the conclusions of the participants in the conference *Coastal Natural Hazards: Science Engineering, and Public Policy*, conducted Oct. 1-3, 1991, in Newport, Ore. (Good, in press).

This paper reports on Oregon's efforts to improve its management of coastal natural hazards. The major classes of hazards and their actual or potential impact on developed areas of the Oregon coast are introduced. It explains the existing coastal policy framework for mitigating these hazards and presents highlights of our recent evaluation of policy implementation effectiveness. Finally, it describes a collaborative Sea Grant/Oregon Coastal Management Program "policy dialogue and negotiation" project just getting underway and what our expectations are for this process.

Natural Hazards Affecting the Oregon Coast

Natural hazards that affect the Oregon coast may be classified as chronic or catastrophic. Chronic hazards along the coast occur with a relative degree of predictability and affect only limited areas at any given time. The damage they cause is usually gradual and cumulative. These hazards include the familiar problems of beach and upland erosion, sea cliff recession, slumping and small landslides, and coastal flooding. They are caused by large winter storms that have waves with significant wave heights up to 20-30 feet; associated storm surge and wave setup along the beach and shoreland; strong nearshore currents including rips; high winds, rain, runoff, and associated lowland flooding; and elevated sea levels, caused by seasonal effects and periodic El Niños (Komar, 1992; Quinn et al., 1987). Long-term sea level rise is also a problem in some areas of the Pacific Northwest, though the effect in the short term is minor due to long-term coastal emergence in most areas. The response to these chronic hazards is often structural protection, with seawalls and revetments common solutions (Kraus and McDougal, in press).

Catastrophic hazards are those associated with earthquakes, three types of which may occur in the Pacific Northwest coastal region: crustal, intraplate and subduction zone (Madin, in press). Crustal earthquakes occur on local faults along the coast and may be as large as magnitude M6-M6.5 on the Richter scale. Intraplate earthquakes occur along the subducting Juan de Fuca plate, deep below the surface under the Coast Range and western Willamette Valley. While no such earthquakes have been recorded in Oregon, there have been intraplate quakes in the Puget Sound region as large as M7.1 (1949) and 6.5 (1965). Very large earthquakes are thought to occur along the Cascadia Subduction Zone (CSZ), the great offshore fault where the Juan de Fuca plate subducts under the North American plate. While there is no historical record of such events, there is abundant geological evidence for earthquakes in the M8 to M9 range. The last event was about 300 years ago and the average recurrence interval is thought to be 340-590 years. The scenario for a large CSZ earthquake is frightening: it includes strong, sustained groundshaking, ground subsidence and associated flooding over a wide area along the coast, soil liquefaction and associated structural failure, and very large tsunami beginning to arrive shortly after the earthquake. All of these coseismic hazards occurred in the 1960 Chilean subduction zone earthquake, with heavy loss of life and property. This earthquake is thought to be a good analog for the expected CSZ event. Other tsunami caused by distant earthquakes occurring along the Pacific rim are also a hazard to the coast—the 1964 Alaska earthquake, for example, caused damage within many coastal estuaries.

Coastal Natural Hazards Management in Oregon

Efforts to mitigate hazards along the Oregon coast involve all three governmental levels and are summarized in Table 1. Three of the functions listed—information and mapping, development planning and siting, and shore protection—are discussed below. The state and local agencies involved, and the authorities for development and shore protection are part of Oregon's networked coastal management program.

Hazards Research, Information, and Mapping. The principal hazards research, mapping and technical assistance organization in Oregon is the Department of Geology and Mineral Industries. Much of the funding for this work is through the U.S. Geological Survey, the Federal Emergency Management Agency, and other agencies. Much of the research that has contributed to our understanding of coastal processes and their influence on shorelines has been Sea Grant and other federally-funded work at Oregon State University and Portland State University. The state coastal agency, the Department of Land Conservation and Development, prescribes hazards inventory standards for local governments. Local governments prepared hazard inventories in the late 1970s or early 1980s, but most of the information used for the inventories was general and of limited use at the detailed site development level.

Planning and Siting of Development. Oregon's Statewide Land Use Planning Program includes hazard-related planning goals local governments used to develop local comprehensive plans (LCPs). Three goals apply directly to hazards management. Goal 7, Natural Hazards, mandates that development subject to natural hazards not be located in known areas of natural hazards without appropriate safeguards. The term "appropriate safeguards" has never been defined. Goal 17, the Coastal Shorelands Goal, requires that LCPs consider geologic and hydrologic hazards along the ocean shorelands. When problems of erosion or flooding arise, preference must be given to land use management practices and non-structural erosion controls. Goal 18, Beaches and Dunes, prohibits development on hazardous dune and interdune lands, and prohibits breaching of foredunes except in certain unusual circumstances. Development on more stable dunelands requires findings that such development is adequately protected from erosion and other hazards.

Cities and counties were required to address Statewide Planning Goals in their local comprehensive plans (LCPs), which had to be reviewed and approved by the state. All coastal jurisdictions completed their initial round of planning in the early 1980s and have state-acknowledged LCPs and implementing ordinances. Specific LCP provisions for regulating development in hazard areas vary. All counties have required construction setbacks, either fixed or variable, some require geologic hazard reports from a registered geologist or engineer, and some use overlay ordinances and other provisions. However, there are few standardized provisions in the plans and some are more effective than others.

The federal government gets involved in land use management indirectly through provisions of the National Flood Insurance Program (NFIP) (42 *U.S.C.* 4001), administered by local governments through the Federal Emergency Management Agency. The Upton Jones provision of the law, passed in 1987, authorizes advance payment for relocation or demolition of any structure which is covered by a current NFIP policy and which is subject to imminent collapse due to erosion. However, this provision has not yet been applied in Oregon and it is not likely to be an important management tool. Most of the erosion-related property loss is for bluff-top areas where residents do not have federal flood insurance.

Shore Protection. The installation of shore protection structures (SPSs) along the oceanfront are regulated by two state laws: the Oregon Beach Law (ORS 390.605-390.770) and the Oregon Removal/Fill Law (ORS 196.800-196.990). These are administered as a joint permit program by the State Parks and Recreation Department (SPRD) and the Division of State Lands (DSL), respectively. The emphasis in both laws is the protection of the recreational and aesthetic qualities, and public access to and along the beach. Both agencies regulate the riprap revetments and seawalls installed along the shore to control erosion and bluff slumping, though their jurisdictions differ somewhat. Oregon's coastal planning Goal 18 for Beaches and Dunes also plays a role in regulating shore protection. The goal prohibits beachfront protective structures in areas that were not "developed" on January 1, 1977. Development is defined as houses, commercial and industrial buildings and vacant subdivision lots which are physically improved through construction of streets and provision of utilities to the lot, or areas where special exceptions have been approved. For SPSs, the goal also requires that visual impacts must be minimized, necessary access to the beach be maintained, and that negative impacts on adjacent property, and long-term or recurring costs be minimized. SPRD and DSL have incorporated these standards into their own regulations.

The U.S. Army Corps of Engineers regulates installation of SPSs under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (P.L. 95-217). The Portland District Corps issued a new Nationwide Permit for "bank stabilization" (NWP 13), with regional conditions for Oregon, effective February 14, 1992; it replaced a similar 1986 regional permit. NWP 13 effectively removes the Corps from day-to-day shore protection decision-making.

Are Coastal Natural Hazards Policies Being Implemented Effectively in Oregon?

Beginning in 1989, Oregon Sea Grant in collaboration with the Oregon Coastal Management Program, initiated an evaluation of the effectiveness of existing state and local policy in managing development and shore protection along the oceanfront. The objectives of the study were to determine if the goals and objectives of Oregon's shoreline management laws, programs, and regulations are being achieved; to examine the validity of the underlying scientific and management principles on which these laws, programs, and regulations are based; and to provide those who make and carry out ocean shoreline management policy with specific suggestions for improving policy and policy implementation. Below is brief outline of the study and its principal conclusions and recommendations. More detailed results may be found elsewhere (Good, in press).

The principal focus of the evaluation was on the state laws and policies and LCPs that comprise the Oregon Coastal Management Program. Policy objectives from each law or policy were identified and synthesized into a single set of land use and shore protection policy objectives. For each objective, possible measures or indicators of policy achievement were identified. A study area was selected for evaluation that represents a worst-case scenario for development along the coast—the 16-mile long Siletz littoral cell on the central coast. Data needs to evaluate achievement of policy objectives were identified, a geographic information system (GIS) was developed that incorporated this data on a tax lot by tax lot basis, and the data were collected and entered into the GIS. A set of queries related to the policy objectives were developed and performed. The result is an assessment of how well key policy objectives in Oregon's shore protection and land use laws were achieved in this largely developed area of the coast.

Policy Evaluation Results and Conclusions. The shoreline in the Siletz littoral cell is being gradually hardened with shore protection structures (SPSs), mostly large riprap revetments and low concrete seawalls (Figure 1). Of the 14 miles of beachfront shoreline, 6.8 miles (49 percent) have seawalls or revetments installed. Figure 1 also shows a clear relationship between SPS construction activity and the periodic El Niños that bring short-term elevated sea levels, major storms, and erosion. Because strong or very strong El Niños occur on average every 8.5 years (Quinn et al., 1987), these severe erosion episodes and the gradual armoring of developed coastlines are likely to continue under present management. Another important finding is that a major source of sand supply for this littoral cell—eroding sea cliffs—is gradually being "locked up" by SPS installed to prevent erosion (Figure 2). The SPSs installed along sea cliffs have already "locked up" 39 percent of the potentially-available sand supply produced by gradual erosion. Given the prospect of continued erosion episodes associated with El Niños and the specter of long-term accelerated sea level rise along this stretch of coast, a scenario for gradual narrowing and loss of an important recreational beach can be easily constructed. Thus, while individual SPSs have little effect on the beach, their cumulative effects may be significant.

Another conclusion is that the demand for SPSs is being driven mainly by shortsighted oceanfront development practices that are continuing despite a seemingly sound management framework. One clear example has to do with compliance with setback regulations. To take advantage of the view, oceanfront property owners want to locate as close as possible to foredune or sea cliff edge. Construction setbacks in local ordinances, based on bluff height and erosion rate, often place a house too far landward to take maximum advantage of the site's view, or in some cases, make the lot unbuildable. To overcome these limitations, property owners hire a geologist and/or engineer to evaluate the site. Almost uniformly, the consultants recommend smaller setbacks than the erosion rate would suggest so that the house can be built in a more desirable location. These site reports are routinely approved by local governments. For the study area littoral cell, the results of this practice are detailed in Table 2. Where required setbacks have been encroached upon, 40 percent of the unprotected properties subsequently required SPSs; where the plan setback was followed, no SPSs have been needed.

The study also concluded that there are significant gaps, overlaps and inconsistencies in state and local policy for hazards management. The clearest example of this is in the SPS regulatory program at the state level. The State Parks and Recreation Department (SPRD) manages the beach as a state recreation area, but only regulates structures west of a designated zone line that was surveyed in 1967. Because there have been substantial changes along the shore since that time, many property owners install seawalls or revetments without coming under SPRD jurisdiction. But they may fall under the jurisdiction of the other state regulator of SPSs, the Division of State Lands (DSL). DSL is not limited by this line; they regulate to the highest measured tide or the vegetation line. However, because their jurisdiction is based on the amount of material used in the structure, most concrete seawalls and some small revetments are not regulated by DSL. Thus, in some cases, SPSs are regulated only by local government, most of whom are even less well-equipped to evaluate alternatives, need and effects. Such gaps and overlaps in policy could be easily corrected.

Other policy shortcomings relate to the new scientific findings noted earlier, such as the potential for large earthquakes and long-term sea level rise. These also need to be addressed in efforts to reduce the potential impacts of natural hazards on the coast.

Policy Evaluation Recommendations. Results of the policy evaluation study and recent scientific findings suggest a need for a comprehensive review and overhaul of coastal natural hazards policy in Oregon. Specific recommendations from the study are listed below:

Establish a broad-based policy working group to identify hazard issues not being addressed and develop appropriate policy recommendations;

Establish an all-hazards mapping program: examine erosion-accretion stability of beaches and adjacent uplands; identify high risk areas for earthquakes; and evaluate tsunami runup associated with large subduction zone earthquakes;

Require littoral cell management plans for selected areas to better link beach and upland development management; employ a special area management planning process;

Establish a coast-wide oceanfront subdivision rule that requires lot depths consistent with hazards and other construction setback needs;

Establish a statewide, formula-based construction setback taking into account all relevant hazards at the site;

Establish statewide standards and peer review for geotechnical site reports;

Eliminate gaps and overlaps in state and local SPS regulatory programs;

Promote alternatives to hard SPSs, such as dune building and stabilization, upland structure relocation, and soft structures; require these or other alternatives where feasible;

Eliminate state and local public development incentives in hazard areas using an approach similar to the federal Coastal Barrier Resources Act;

Establish a continuing education program for the public, professionals, and local officials on coastal natural hazards and their effective management; and

Develop and implement non-regulatory approaches to reduce the coastal hazards.

Coastal Natural Hazards Policy Working Group

The combination of the factors discussed above—new scientific and technical information on hazards, growing development pressures in hazardous coastal areas, and weaknesses in present hazard mitigation policies and their implementation—pointed to the need for a comprehensive review and overhaul of beach protection and hazard mitigation policies. The need for such a review was also one of the conclusions of the participants in the conference *Coastal Natural Hazards: Science Engineering, and Public Policy*, conducted Oct. 1-3, 1991, in Newport, Ore.

In response to this need, and as an outgrowth of the coastal hazards conference, Oregon has established a Coastal Natural Hazards Policy Working Group (PWG). The PWG had its initial meeting in March 1992 and expects to continue its work with monthly workshops until completion in a year or more. The 20-member group represents a range of "stakeholders" with different perspectives and interests—oceanfront property owners, builders, consultants, local officials and planners, state and federal regulators and resource managers, environmentalists, educators, and others. It is supported by a team from Sea Grant and the Extension Service at Oregon State University, staff from the Oregon Coastal Management Program, and a Technical Advisory Committee. Using an interest-based problem-solving approach, the PWG will examine what is known about the different classes of hazards and how they do or might affect the coast, and develop and recommend improved strategies and policies for hazards reduction. The group will work in the context of present legislative goals—to protect life, property, and the scenic and recreational values of the ocean shore—but not be limited by them. The PWG will be seeking effective, efficient, and equitable solutions that are technically sound and acceptable to all stakeholders. Using consensus-building and other group processes, the PWG will define the issues and problems that need to be addressed; formulate and evaluate alternative solutions; and recommend preferred alternatives to solve identified problems.

Defining the Issues and Needs. One of the principal goals of the coastal hazard conference was to present the results of a decade or more of scientific and engineering research on coastal hazards and to discuss its implications for public policy and management. At the close of the meeting, more than 100 of the conference participants joined 10 focus groups to present their views and suggest priorities about research needs, ·policy implications of recent research, policy implementation issues, and possible solutions. One purpose for this exercise was to develop an initial list of ideas for the proposed PWG.

Using the technical, policy and focus group information generated at the conference, along with additional technical assistance, the PWG will define the issues and problems. Creativity and new thinking in definition of problems will be encouraged; in part, this will be stimulated by the diversity of interests represented within the PWG, and in part by the process facilitated by the OSU Extension Service.

Formulating and Evaluating Alternatives. At this stage of the process, the PWG will develop alternative solutions to identified policy problems, estimate the feasibility of alternative solutions, and estimate what might happen once proposed solutions are implemented. Alternatives identification will begin with an inventory of current policy efforts addressing similar problems in other regions. A wide variety of approaches, leverage points and combinations of approaches will be examined. Evaluating the feasibility of policy alternatives will at a minimum include assessments of fiscal and human resource requirements; the complexity of the processes necessary to implement and maintain the policy; and the magnitude of change required of established organizations. Questions of efficiency, effectiveness and fairness will also be dealt with. Finally, forecasts or estimates of the potential impacts of each policy alternative will be made. Quantitative estimates will be sought where possible, but expert opinion will also be used.

Recommending Preferred Alternatives. Based on the PWG's evaluation of policy alternatives, they will recommend preferred policy alternatives or combinations of approaches to solve identified problems. These will be forwarded to appropriate legislative or administrative bodies for consideration.

In conclusion, the Oregon coast is affected by a variety of natural hazards—chronic erosion, landslides, flooding and potentially catastrophic earthquakes and tsunamis. Hazard mitigation at the state level is accomplished through state-mandated, locally-implemented land use planning and development policy, and state regulatory programs for shore protection. Hazards policy implementation is generally ineffective, particularly with respect to the cumulative effects of hard shore protection structures. Shortsighted land development policies are driving the demand for hard shore protection. Furthermore, present polices do not address the potential impacts of accelerated sea level rise expected next century or the very real threat of a major subduction zone earthquake and related hazards. To deal with these implementation shortcomings and unaddressed hazards, Oregon Sea Grant and state coastal managers have organized a Coastal Natural Hazards Policy Working Group. The PWG represents a broad range of interests, and is using an all-hazards approach to build consensus and develop recommendations for improved hazards mitigation policy.

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Table 1. Governmental functions and agencies/authorities for coastal natural hazards management in Oregon.

	Federal Government	State Government	Local Government
Research, Technical Information and Mapping	U.S. Geological Survey: hazards Federal Emergency Management Agency (FEMA): flood, erosion Army Corps of Engineers (COE): erosion	Department of Geology and Mineral Industries: hazards information and mapping Department of Land Conservation and Development (DLCD): hazard inventory standards Universities/Sea Grant	Local Comprehensive Plan (LCP): hazards inventory
Planning and Siting of Development	FEMA: Natonal Flood Insurance Program (NFIP)	DLCD statewide planning standards: Goal 7: Natural Hazards Goal 17: Coastal Shorelands Goal 18: Beaches and Dunes	State-approved LCP with natural hazards, shorelands, beaches and dunes elements; local subdivision, zoning and flood damage prevention ordinances
Design and Building Criteria	FEMA coastal and flood construction standards	State Building Code Agency	Local building code administration: city/county
Shore Protection	COE Nationwide Permit No. 13: bank stabilization	Beach Law: regulates shore protection structure Removal/Fill Law: regulates revetments and fill	LCP and development ordinances (provisions vary)
Emergency Planning and Response	FEMA	Emergency Management Division: disaster response and planning	County emergency services

Table 2. Construction setback compliance and subsequent need for shore protection structures, Siletz Littoral Cell, 1977-1991.

	Lots Developed	SPS Needed Later
Setback Encroached[1]	58	23 (40%)
Setback Followed	6	0

[1] Average construction setback encroachment was 56 feet.

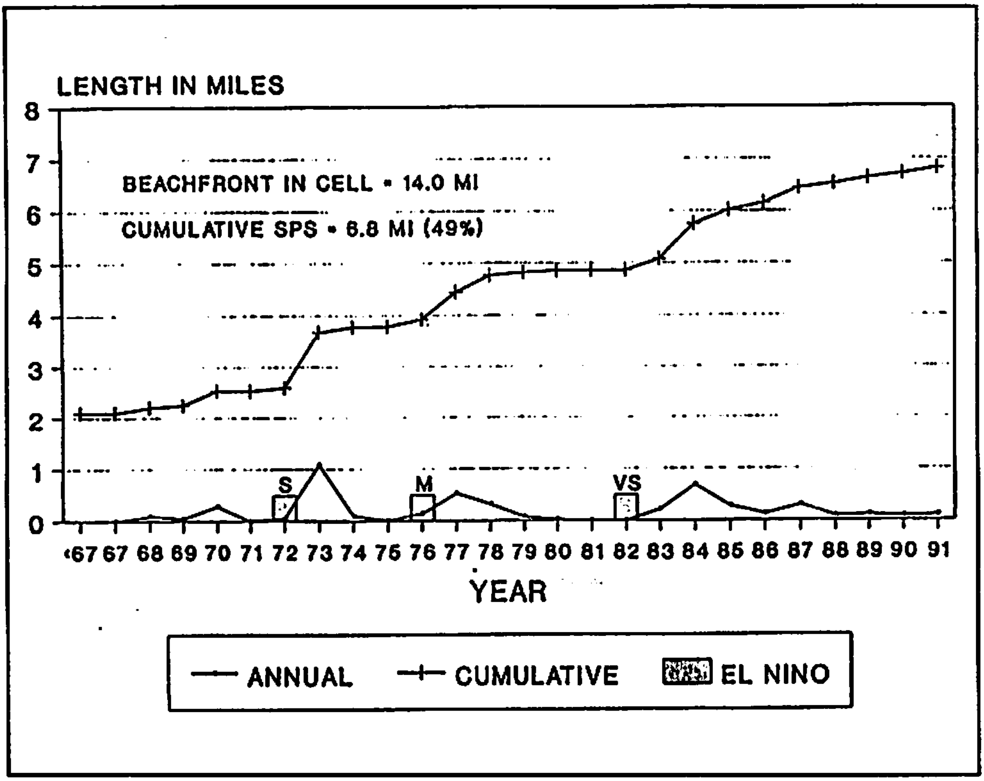

Figure 1. Cumulative length of shore protection, Siletz Littoral Cell.

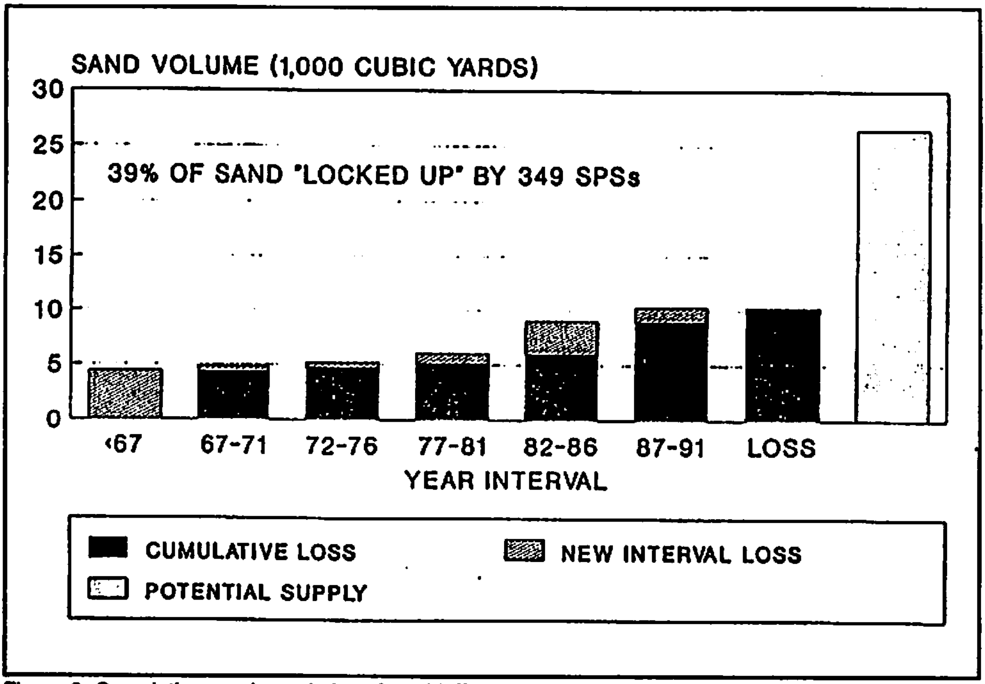

Figure 2. Cumulative sand supply loss from bluffs due to shore protection, Siletz Littoral Cell (low rate).

ACCELERATED SEA LEVEL RISE AND MARYLAND'S COAST: ADDRESSING THE COASTAL HAZARDS ISSUE

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INTRODUCTION

Coastal hazards are a significant concern in the state of Maryland due to the state's extensive shoreline development and abundant natural coastal resources. The coastal zone of Maryland is currently at risk from the following hazards: shore erosion, inundation, flooding, hurricanes, northeasters, storm surge, subsidence and sea level rise. Since the creation of the Coastal Zone Management Program in 1978, Maryland's state and local governments have made a unified effort to reduce the damage from coastal hazards. To address shore erosion concerns the state developed the Atlantic Coast Beach Erosion Control District Act, the Ocean Beach Nourishment Project, and the Shore Erosion Control Program (SECP). The SECP provides both structural and non-structural shore erosion control devices. To reduce flooding hazards the state has created the Comprehensive Flood Management Grant Program, the Waterways Permit Program and a Hurricane Evacuation Project. All coastal communities in Maryland are part of the National Flood Insurance Program. Maryland's Chesapeake Bay Critical Areas Program and the Federal Coastal Barriers Resource Act incidentally plan for most coastal hazards by managing land use along the coast. This analysis describes Maryland's present coastal hazards and management activities designed to mitigate them.

Accelerated sea level rise due to global warming caused by the greenhouse effect will intensify all of Maryland's coastal hazards. The state of Maryland has established programs and promotes education with the intent to mitigate most coastal hazards. Despite these programs, the state may not be prepared for higher sea levels induced by global warming. An expected increase in the state's coastal population will augment the problem. Also included is a discussion of some possible strategies to prepare for higher sea levels: strategic retreat option, the Public Trust Doctrine, public education and increased communication with scientists.

CHARACTERIZATION OF COASTAL HAZARDS

Shore Erosion

Shore erosion is a serious concern along Maryland's exposed Atlantic coastline. Historical shoreline mapping analysis reveals that Maryland's entire Atlantic barrier island coastline has been eroding at an average rate of 2 feet per year (Leatherman, 1987). Prior to the state's beach replenishment project in 1988, shore erosion at Ocean City had reduced the beach to a narrow width.

Critical erosion rates of 12 m/yr (39.36 ft/yr) are occurring at the northern section of Assateague Island. This high rate is due to a lack of sediment input from the littoral sediment system. The Ocean City inlet jetties may be responsible for this blockage. A sand bypass system has not been considered due to prohibitively high costs associated with such a project. It is estimated that by the year 2020 the northern part of Assateague island will be lost due to shore erosion. A major storm may breach the island at any time causing increased coastal hazard problems at the Ocean City airport, housing developments and marinas (Leatherman, 1987; Maurmeyer and Leatherman, 1989; Weaver and Hayes, 1989). The national and state park systems have not developed a long-term management strategy for this area.

Shore erosion has historically been a major problem in the Chesapeake Bay (the Bay). In the last 100 years, 25,000 acres of shoreline have been lost in Maryland due to shore erosion. Annually, 325 acres of land are lost in Maryland due to shore erosion (COE, 1990).

One area of particular concern is the Calvert Cliffs shoreline along the developed western rim of the Bay. Bluff erosion rates average 7.5 ft/yr in this area (Wilcock et al., 1992). Bluff erosion is occurring due to a combination of shore erosion and groundwater seepage along the cliff slope. Methods of controlling slumping of the bluff due to groundwater seepage are nonexistent at present.

COE (1990) estimates that 11 million cubic yards of shoreline material is deposited in the Bay yearly as a result of shore erosion. Shore erosion benefits downstream beaches by providing necessary material for the littoral transport system. But material eroded from shorelines that ends up as suspended sediment in the Bay causes a variety of problems. Suspended sediment decreases water clarity which impacts animal and plant life by blocking out sunlight. Suspended sediment may also settle on highly sensitive shellfish zones, smothering oyster beds (Kearney and Stevenson, 1991). Sediment eroded from the Bay shorelines may contain high amounts of nitrogen and phosphorous which contribute to a reduction of oxygen in bottom waters. Low oxygen causes stress and possibly death to aquatic species (Fischer and Doyle, 1987). Increased dredging may be required as sediment deposits in navigation channels.

Flooding, Hurricanes, Northeasters and Storm Surge

Maryland's coastal areas are at risk from flooding caused by hurricanes, northeasters and storm surge. Northeasters can occur from September to May and hurricanes from June to November. Storm surge, large wind induced waves, can reach heights of 20 ft and sweep far inland causing massive damage.

Along Maryland's Atlantic coastline, flooding is a serious concern due to extensive development and relatively low topographical elevation. For example, much of Worcester County, including Fenwick Island's 8.9 mile urban coastline, is primarily below 2 m (6.5 ft) mean sea level, less than the 100 year storm elevation. Atlantic coastal storms with strong winds increase flooding by pushing ocean waters towards the mainland, filling the coastal bays, reducing the hydraulic head effect that occurs during gravity drainage. Major storms have occurred periodically at the Atlantic coast. The most famous storm was the 1962 Easter Sunday northeaster storm that occurred during spring high tide. It caused catastrophic damage to all of Ocean City and the back bay mainland coast (Fehrer, 1990). The problem is compounded by increased community development in this area and a lull in major storm activity in the last 20 years.

The Bay's characteristic coastline of low elevation and large tracts of urban population remains highly vulnerable to flooding during large storms. The Eastern Shore of the Bay is the most vulnerable area to flooding because large sections lie below 3 m (10 ft) mean sea level. Storm surge and large wind-induced waves can reach heights of 6.5 m (20 ft) and sweep far inland causing massive damage. The Eastern Shore's large tracks of submerged aquatic vegetation, wetlands and associated animal life are also especially vulnerable to storm waves and temporary salinity changes caused by large storms.

The location of many large metropolitan areas, residential housing tracts and marine-related industries along the western bay shoreline makes it difficult to reduce flooding hazards in this area. A 1933 hurricane was responsible for the highest storm surge on record in the Bay: 9.6, 8.2 and 7.3 feet above mean sea level were recorded at tide gauges at Washington, D.C., Baltimore and mid-Bay, respectively. Extensive flooding as well as severe shore erosion due to large wind induced waves occurred (COE, 1990). In 1972, hurricane Agnes caused extensive flooding in the Bay's tributaries resulting in hundreds of millions of dollars worth of damage.

Inundation

Tide gauge data indicate that the sea level along Maryland's Atlantic and Chesapeake Bay shorelines has been rising at a rate of 3 to 4 mm/yr in the past century (Kearney and Stevenson, 1991). As waters rise along Maryland's coast, land adjacent to the coast becomes inundated. Inundation due to relative sea level rise claims more land in the overall erosion process. As land becomes inundated its economic value is depleted; coastal property is the most expensive property in the state (Giese and Aubrey, 1987).

Inundation is especially significant in tidally connected wetland and unprotected developed areas. Wetlands have two options to keep pace with inundation: trap enough organic and inorganic sediment, a process called accretion, or migrate landward as upland terrain becomes submerged (Kearney and Stevenson, 1985). The problem is especially serious at the wetlands of the Bay's Eastern Shore. Shore erosion rates greater than 8 ft/yr have been observed in this area. At the Blackwater National Wildlife Refuge in Dorchester County, wetland loss due to inundation has been recorded since 1938. Inundation is occurring here because marsh accretion rates average between 1.7-3.6 mm/yr, less than the 3.8 mm/yr recorded relative sea level rise in the Chesapeake Bay (Stevenson, et al., 1985).

The loss of tidal wetlands due to inundation will preclude a loss of natural shore erosion control, flood energy mitigation and near-shore stabilization. In the Bay many types of finfish, shellfish and aquatic fowl colonies are threatened from wetland loss. Ultimately, man will be affected; it is estimated that 78 percent of the commercial fish catch are estuarine dependent species (Bigford, 1991).

As sea level rises, wetlands naturally migrate landward to take advantage of the newly inundated upland terrain. If the land just above the wetland is developed, steeply sloped or bulkheaded, the wetland may be squeezed out of existence or observe a significant loss of total wetland area (Weaver and Hayes, 1989; Titus, 1991). Concern exists because 96 percent of the coast in Maryland is privately owned.

Subsidence

Subsidence of the coast induces inundation of the shoreline which causes an increase in most coastal hazards (i.e., active erosion and flooding). The subsidence rate in Maryland averages between 1.6 and 2.0 mm/yr (Kearney and Stevenson, 1991).

It is hypothesized that three factors are responsible for land subsidence in Maryland: compaction of the Atlantic coastal aquifer due to massive groundwater withdrawal; isostatic submergence of the shoreline caused by heavy river and shoreline sediment loading in the Chesapeake Bay (Kearney and Stevenson, 1991); and isostatic submergence of the Atlantic coastal plain due to a realignment of the Earth's crust following the disappearance of the Wisconsinin glaciers, 5,000 years before the present (Davis, 1987). The relative contribution of each of these effects on land subsidence in Maryland is undetermined. Significant groundwater withdrawal occurs due to urban, industrial and agricultural operations. The 800 million metric tons of sediment that have settled into the Bay over the last century is believed to be partly responsible for submergence of the shoreline (COE, 1990).

EXISTING MITIGATION PROGRAMS

Shore Erosion Mitigation Programs

Atlantic Coast Beach Erosion Control District Act. The state established the Atlantic Coast Beach Erosion Control District Act to reduce development on areas seaward of the existing natural primary dune along the Atlantic Coast. This Act forbids land clearing, construction activities, or the construction or placement of permanent structures like bulkheads or seawalls in the Beach Erosion Control District (BECD). The BECD is generally the beach area east of the crest of the existing natural dune. In Ocean City, the boundary is a mutually approved state-Ocean City building limit line.

Ocean City Beach Renourishment Project. By the mid 1980s chronic erosion had reduced the beach at Ocean City to a critical narrow width. Many high-rise buildings were vulnerable to active shore erosion and flooding during storms. To reduce these hazards, the state of Maryland prepared a beach renourishment project by the authority of the Ocean Beach Replenishment Act.

Because of the tremendous economic investment at Ocean City, the option of relocation was not judged to be appropriate. Beach renourishment was considered the best option to control coastal hazards at Ocean City because it ameliorates active erosion, protects the city from storm waves and surges, and maintains public and private property. Beach nourishment also significantly increases the amount of beach area for recreational uses (Klarin and Hershman, 1990a; Maurmeyer and Leatherman, 1989).

The Department of Natural Resources' Shore Erosion Control Program (SECP) is the legal authority responsible for the beach renourishment program. The SECP contracted the Army Corps of Engineers (COE) in 1988 to direct the $60 million, two-phase beach-nourishment project. During the first phase the COE placed 2.3 million cubic yards of sand to widen the beach between 100 and 165 feet. The second phase began in spring 1990 and is expected to be completed by the end of

1992. It entails the construction of a steel bulkhead along the length of the boardwalk and a 15-foot-high vegetated dune along the remainder of the beach. Maintenance projects in the form of surveys and renewed sand placement (where needed) are planned every two years (Maurmeyer and Leatherman, 1989; Leatherman, 1988).

Three recent Atlantic Ocean northeasters (October and November 1991 and January 1992) tested the effectiveness of the replenishment project. Although the newly constructed dunes reduced the flooding damages to shoreline development, significant dune areas were completely flattened. The storms also destroyed some newly constructed sand fencing and grasses. A preliminary assessment of shore erosion indicates that sand was displaced to the near-shore zone and along the beach. The COE is presently preparing an official assessment of the damage.

Shore Erosion Control Program (SECP). The SECP provides interest-free loans and technical assistance to coastal property owners and local governments who are experiencing shore erosion problems. Both structural and non-structural assistance may be provided depending on the feasibility and affect on the natural environment. Structural erosion control methods include the use of bulkheads and rip-rap revetments and are only provided to those shorelines with erosion rates greater than 2 ft/yr. The program gives priority to shorelines with houses or other development threatened by shore erosion.

Non-Structural Shore Erosion Program (NSSEP). The NSSEP provides 50 percent matching funds to property owners and local governments for the placement of non-structural erosion control measures, primarily grass or wetland planting, in non-critical eroding areas. The program applies to those properties with less than 3/4 of a mile of fetch and with existing tidal marsh vegetation within 500 feet of the shoreline.

Calvert Cliffs Slope Erosion Project. The state is attempting to determine the role of sea level rise, wave action and groundwater seepage in the ongoing shoreline loss in the Chesapeake Bay region. The state, in conjunction with the Johns Hopkins University, is studying the reasons for bank failure and resulting loss of shoreline in the Calvert Cliffs area. Groundwater porosity, seepage rates, wave action and wave levels will be monitored and analyzed at four sites to develop a slope stability model for bluff areas. This information can then be used to determine appropriate management measures to address the causes of bluff erosion at this and similar areas located along the Chesapeake Bay.

Flood Hazard Mitigation Programs

Hurricane Evacuation Program (HEP). The Water Resources Administration (WRA) and other state agencies participated in the development of the HEP, which was completed by the COE in 1991. The HEP assists local governments in preparing evacuation plans and provides techniques for public education. The HEP includes a hazards, vulnerability, behavioral and transportation analysis for all of Maryland's coastal counties. Coastal county inundation maps were created to identify areas subject to hurricane hazards for four different degrees of storm severity.

Comprehensive Flood Management Grant Program (CFMGP). The CFMGP administered by the WRA provides 100 percent funding for watershed studies that define flood magnitudes and frequencies, floodplain boundaries and mitigation strategies. Fourteen coastal watershed studies, including one tidal flooding study, have been undertaken since 1984.

The CFMGP also provides 50 percent matching funds for flood hazard reduction projects. Typical capital projects include land acquisition, removal of flood-damaged or flood-prone structures (particularly residential homes), construction of tidal flood gates, establishment of automated flood warning systems, and construction of levees and detention/flood control structures. Preference is given to projects which involve the removal of structures in flood hazard zones. The towns of North Beach and Chesapeake Beach in Calvert County have received funding for such projects.

National Flood Insurance Program (NFIP). The NFIP provides flood insurance to participating communities who adopt flood management ordinances restricting development in flood hazard areas. The WRA is designated as the state coordinating office for the NFIP. The WRA provides assistance to local permitting officials in the application of a flood ordinance. WRA also performs periodic evaluation visits to assure the NFIP that communities are adequately administering the regulations of the program. All of Maryland's coastal counties and towns are participating in the NFIP.

A Community Rating System was established in 1991 to encourage insured communities to provide services that go beyond the basic NFIP goals. Communities are rated by their programs' ability to reduce flood losses, facilitate accurate insurance ratings, and promote the awareness of flood insurance. Citizens of communities that are part of the system enjoy a discount on the cost of federal flood insurance. Most local governments in Maryland have established flood hazard management programs which exceed NFIP standards.

Waterways Permit Program (WPP). The WPP was created to reduce flooding and flood hazards on streams with a drainage area greater than 400 acres. The primary objective of the program is to avoid increased flooding and related hazards as a result of new floodplain activities. A secondary objective is to assure that projects do not adversely impact environmental quality of streams and wetlands. Any activity altering the course, current flow or cross-section of a non-tidal stream or its 100-year floodplain is required to obtain a permit from the Water Resources Administration. The maintenance of roads, bridges, culverts and other stream crossing structures are the primary types of activities that are given permits. Structures in floodplains are required to be physically elevated and are generally discouraged.

Other Mitigation Programs

The Chesapeake Bay Critical Area Act (CBCAA). In 1984 the state enacted the CBCAA to manage development around the Chesapeake Bay. Wise management of the Bay shoreline provides an opportunity to reduce coastal communities exposure to coastal hazards. The CBCAA establishes a program to manage land use in a 1,000-foot strip adjacent to the Chesapeake Bay and its tidal tributaries.

The CBCAA assists in controlling erosion around the Bay shoreline by establishing a 100-foot no-development buffer zone adjacent to the Chesapeake Bay and its tidal tributaries and encouraging the use of vegetative shoreline stabilization methods.

The Federal Coastal Barriers Resource Act (FCBRA). The FCBRA of 1982 was established to prohibit flood insurance and funding for new infrastructure that would support new development on undeveloped barrier islands. It established a Coastal Barrier Resource System (CBRS) along the Atlantic and Gulf coasts.

The Coastal Barrier Improvement Act of 1990 amends the FCBRA. It increases the amount of land in the CBRS including approximately 50 small areas and islands in the Chesapeake Bay.

ACCELERATED SEA LEVEL RISE

Global warming is expected to raise eustatic sea level by causing polar and alpine ice masses to melt and concurrently prompting thermal expansion of the upper layers of the ocean's waters (Hoffman et al., 1983). Accelerated eustatic sea level rise will affect all shorelines and exacerbate most coastal hazards (Shakespeare, 1991; Klarin and Hershman, 1990A; Klarin and Hershman, 1990B; Titus, et al., 1991; Titus, 1986; Gornitz, et al., 1991; Weaver and Hayes, 1989). For example, shorelines will retreat through increased erosion and inundation of barrier beaches, islands and bluff environments. Many areas in the coastal zone are rapidly developing, exposing an even larger population to coastal hazards, compounding the problem.

Global warming may also increase the severity and frequency of tropical storms. As erosion and storms increase, flooding of coastal areas will occur more often (Braatz and Aubrey, 1987). Increased erosion will also affect the recreation and tourism industry (Jansen, 1990).

If the sea level rises significantly in the future, saltwater intrusion will occur in freshwater bays, rivers and aquifers (Braatz and Aubrey, 1987). Saltwater intrusion will be most detrimental in the Chesapeake Bay where it will adversely affect coastal aquifers and cause changes in fish and plant populations. In coastal aquifers it will degrade potable municipal water supplies. In addition, saltwater intrusion will help spread the fatal mussel diseases Dermo and MSX in the Chesapeake Bay. Loss of oyster populations in the Chesapeake Bay due to these diseases has been observed for the past 40 years (Kennedy, 1991).

Addressing the Impact of Sea Level Rise

The state sees a need to determine the effects of a number of realistic sea level rise scenarios on its coasts so it can direct development and redevelopment away from areas vulnerable to inundation, determine setback standards as they relate to sea level rise and preserve tidal wetlands. Sea level rise scenarios will help the state evaluate, among other things, the adequacy of the Critical Areas Program (100-foot buffer) and if additional land use measures are needed along the Atlantic mainland coast.

The state of Maryland's Coastal Resources Division has contracted the University of Maryland's Laboratory for Coastal Research (LCR) to examine the effects of sea level rise on Maryland's mainland back bay shores. The study areas includes the landward shore of Isle of Wight Bay and part of Assawoman Bay. The

LCR will identify the amount of wetland and upland area lost, and the associated costs for four realistic scenarios of sealevel rise (0.36m, 0.54m, 0.89m and 1.33m total rise above present sea level) for three years, 2020, 2050, and 2100. The LCR will determine present and predicted erosion patterns caused by accelerated sea level rise and develop a range of practical erosion mitigation approaches that incorporate management of future development and preservation of natural coastal wetlands.

POSSIBLE MITIGATION METHODS TO PREPARE FOR HIGHER SEA LEVEL

If the rate of sea level rise increases due to global warming caused by the greenhouse effect, exacerbation of all coastal hazards will occur. One of the most effective methods to safeguard coastal populations and resources from coastal hazards is to implement a strategic retreat option. Many of the strategic retreat options either partially or entirely exist within the state, including setback standards, economic incentives, building design standards, development restrictions, buffer zones and lease restrictions. Concurrent with a strategic retreat option, the state should consider incorporating the Public Trust Doctrine into its Coastal Zone Management Program. The Public Trust Doctrine has the potential to discourage or prevent regulatory "claims" by private coastal landowners and would increase the flexibility of the Coastal Zone Management Program to address the full range of current and emerging public interests.

Safeguarding coastal populations and resources from coastal hazards is also possible through coastal engineering projects, public education, and research and communication within the scientific community. Public education programs are in need of revision and expansion to include newer techniques. Research and monitoring of scientific studies is warranted due to uncertainties with sea level rise, land subsidence, global warming and climate change parameters.

The Strategic Retreat Option

The strategic retreat option (withdrawing development as the sea approaches) is the preferred policy alternative of most Coastal Zone Management Programs and may prove to be the most effective method to reduce many coastal hazards in Maryland (Klarin and Hershman, 1990a). The strategic retreat option will require strengthening existing programs as well as creating new efforts to control coastal hazards. It could be implemented by a number of methods including setback standards, economic incentives, building design standards, development restrictions and lease restrictions.

Setback Standards. Setback standards are an attempt to limit development in high hazard zones while still adhering to a sea level rise policy. Setback standards would guarantee a reduced loss of property and human life during hazardous weather as well as provide an effective wetland migration zone as sea level rises. Setback standards can be based on historical erosion rates and/or zoning restrictions and are established with the intent of limiting development size and density. Setback standards based on periodic mapping are beneficial because they ensure changes to be implemented with time.

An indication of the exact location of all shorelines and their past and present shore erosion rate is needed in order to develop accurate setback standards. The state of Maryland has contracted the Maryland Geological Survey to computerize and update the historic shoreline and erosion rate maps developed in the 1970s. The maps will be updated using orthophoto quads based upon 1988-89 photography produced by the National Aerial Photography Project.

Economic Incentives to Reduce Development in High Hazard Zones. Economic incentives and disincentives can prove to be a powerful method to control development in high hazard zones. One of the most significant economic methods to reduce development in high hazard coastal zones would be to remove subsidized insurance and loans provided by the state and federal government. By eliminating subsidized insurance, coastal homeowners in high hazard zones would be economically responsible for losses due to coastal hazards. Suspending loans to developers or coastal homeowners would reduce development incentives along the coast.

Building Design Standards. New structural design standards that incorporate the possibility of coastal hazards including sea level rise should be required for new homes located in high hazard zones. The structural design of buildings, drainage and flood control systems as well as considering movability of structures can all be new requirements for development in coastal zones.

Building design standards may also address the occasional adverse environmental effects caused by coastal development. For example, in certain cases development increases salt water intrusion into an area. Design standards could be amended to require developers to determine their developments effect on ground water or other coastal resources. If a problem exists the developer would be require to amend the situation.

Development Restrictions. In certain limited areas, coastal hazards are significantly large. By restricting development in certain hazardous zones, coastal development is at a reduced risk during periods of unusual weather. Redevelopment restrictions could also apply to coastal homeowners whose structures are destroyed during inclement weather.

Lease Restrictions. Coastal property under long-term lease should be terminated. Existing property could be bought and leased under certain conditions. For example, if sea level rises enough to inundate a leased structure, the occupants would then be required to leave the premises. Property that is damaged by flooding or inundation could be retained by the state or federal government on the premise of creating open space zones.

The Public Trust Doctrine

In order to address coastal environmental problems and to expand management and protection of coastal waters the state should investigate the utility of incorporating the Public Trust Doctrine (PTD) into its Coastal Zone Management Program (CZMP). The PTD gives title to all tide waters and "navigable waters," the lands beneath these waters up to the "high mean water line," to the state as a trust for the citizens of the state. The PTD is a natural tool for protecting the "existing uses" of coastal resources, because it protects the public's right to access and use of public trust lands and waters (Kelly and Slade, 1991).

The benefits of the PTD are: "increased flexibility of the coastal program policies to address the full range of current and emerging public interests; buttressed enforceability of these policies against challenges based on unconstitutional "takings" claims; and required consistency of federal agency activities to act consistently with a state's PTD as incorporated into its approved CZMP" (Kelly and Slade, 1991).

Two steps are required to incorporate the PTD into the state's CZMP: conduct an in-depth, detailed and comprehensive examination of the status of the PTD in the state; and submit amendments to a state's CZMA that incorporates the PTD into its enforceable policies (Kelly and Slade, 1991).

Engineering Methods to Reduce Coastal Hazards

Fluidized Sand Bypassing and Beachface Dewatering. Many shorelines downdrift of jetties are experiencing sand starvation due to a blockage of the long shore sediment transport. The Ocean City inlet, for example, blocks the southern movement of long shore sediment transport causing sand accretion at the southern end of Fenwick Island (Ocean City) and sand starvation at the northern section of Assateague Island. Currently, Assateague Island is eroding at a rate greater then 10 ft/yr and its width has decreased significantly. As a consequence, the mainland area directly behind the northern section of Assateague Island experiences severe flooding and erosion during large storms.

Fluidized sand bypassing and beachface dewatering, new technologies in the field of coastal engineering, may be able to mitigate this and related problems. Fluidized sand bypassing is a process where sand and water are equally mixed and then pumped to a suitable or desired location. When equal amounts of sand and water are mixed the result is a sand-slurry that will flow down a slight grade and is pumpable for significant distances (Parks, 1991). This fluidized sand bypassing technique could be applied to solve the sand starvation caused by the Ocean City inlet jetties. Sand can be removed from sources below the inlet and pumped onto the shore at northern Assateague Island.

Beachface dewatering is a process where water is pumped out of a beach to allow a wave runup to "soak in," allowing part of its load of suspended sand to remain on the beach. After multiple wave runups the result is sand accretion and beach widening. Although both methods depend on buried pipes, a new "self-burial" technique that reduces costs has been developed and tested (Parks, 1991). The beachface dewatering technique could be applied to any sandy shoreline experiencing severe erosion.

Shore Erosion Devices. Hard structural shore erosion devices should be restricted especially in critical environmental areas like beaches, dunes and wetlands. Soft structural erosion control programs, like grass and wetland plantings, should be established. Resedimentation, restoration and impoundment programs should be given funding and more priority.

Beach Renourishment Programs. Beach renourishment programs have been given priority in certain areas because they aid in the mitigation of shore erosion yet maintain public and private property. Most renourishment programs have been undertaken in areas where a high economic risk exists due to shore erosion, flooding and other coastal hazards. Additional research is needed to determine if beach renourishment is cost effective and if natural resources are harmed in the process of sand placement along the coast.

Public Education

Government policies concerning the mitigation of coastal hazards will need the strong support of state citizens to be successful. Currently, many citizens of Maryland are unaware of the issues, problems, and potential impacts of coastal hazards. A public education program must communicate precise and objective information about coastal hazards and its ramifications as well as appropriate steps that can be taken to mitigate the problems of coastal hazards. Effective educational programs that are long-term, interdisciplinary, well coordinated, proactive, research-based and multi-faceted for both formal and informal settings are necessary (Spranger, 1990).

Public education should instill a broad understanding of the issues as well as provide technical data on individual subjects where needed. Schools need the latest scientific findings to educate students about the issues of coastal hazards. Adults can be taught of the dangers of coastal hazards through informal public debate or higher education programs. Adult education should stress individual responsibility as well as methods to become involved in managing the coastal areas.

Many coastal hazards mitigation programs within the state offer information to the public about their services. The material available is usually in the form of pamphlets or posters, but technical information on a personal level is also available. The Coastal Zone Management Program needs to expanded its visibility to all citizens of the state. The public needs to be informed that they can provide input that can be used to guide the management of coastal areas. Public forums (i.e., Committee to Preserve Assateague Island) and committees (i.e., Coastal Resources Advisory Committee) meet on a regular basis and provide a forum for interested parties to express their desires concerning coastal management. Many programs exist and are designed to inform and involve citizens about many issues affecting the Chesapeake Bay and the Atlantic Coast, such as CoastWeeks, Bay Feast, the National Estuarine Research Reserve, Chesapeake Bay Communication Plan and local government workshops. These programs should be expanded and additional funds and technical training must be implemented to increase their effectiveness.

Many options are available to increase public education within the state. Educational films, promotional ads and mass mailings of one page fact sheets concerning coastal hazards issues is an effective method to educate the public and to increase the visibility of the Coastal Zone Management Program. The development of additional educational activities would increase the effectiveness of the state's coastal hazard programs.

Scientific Uncertainty

Reduce Uncertainty with Sea Level Rise Rates. An effective coastal hazards strategy requires accurate rates of sea level rise. Because data on regional sea level rise are not always available or accurate, creating policies concerning sea level rise without general baseline data is unjustifiable (Klarin and Hershman, 1990). The state should prepare an accurate database of sea level records from Maryland's tide gauge stations. The data should be examined periodically to determine trends in sea level rise.

In spite of scientific uncertainty regarding accelerated sea level rise due to the greenhouse effect, planners must be aware of the present rate of sea level rise if changes in sea level are occurring. Tide gauge data analysis can provide an excellent examination of the present and past sea level trends, as well as indicating any changes in the movement of the land. An analysis of past sea level trends, coupled with temperature data can provide accurate sea level rise predictions.

Reduce Uncertainty with Subsidence Rates. Tide gauge data contain movements of the land surface as well as actual water changes. Scientists believe Maryland's coast is subsiding at a rate of 1-1.5 mm/year. The causes, mechanisms and processes of land subsidence should be examined. The state should determine the exact amount of subsidence caused by the three separate processes discussed above.

Reduce Uncertainty with Climatic Change Parameters. Information concerning climate change and its effect on oceanographic, meteorological and hydrographic processes are still unknown or only speculative. Creating policies on conjectured data is not warranted (Klarin and Hershman, 1990). The state must remain in contact with the scientific community and published literature in order to be aware of any new information concerning changes in the prognosis of climatic change parameters and how they would effect the state.

CONCLUSION

Although many coastal hazards continue along Maryland's coastal zone and there currently exists a variety of mitigation programs, additional efforts will be necessary as sea level continues to rise. Some strategies that were recommended in this analysis are possible through increased efforts in existing programs. Feasibility studies should be funded to determine appropriate responses to present and future problems. The fluidized sand bypassing and the beachface dewatering techniques would mitigate many of the existing shore erosion problems. Incorporating the Public Trust Doctrine into the state's Coastal Zone Management Program may expand its ability to increase its management of human and natural resources in the coastal zone. Public education is extremely important because policies governing the coast are implemented at the local level where most citizens are involved. Public officials need to be aware that policies concerning the coastal zone are necessary and are based on scientific effort and research. By preparing a strategy in advance the state would reduce costs, and protect lives and natural resources in the coastal zone.

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Ocean Resource Management: Large Marine Ecosystems

THE MOVEMENT TOWARD HOLISTIC OCEAN MANAGEMENT: ORGANIZATION BASED ON THE ECOLOGICAL APPROACH

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Abstract

Coastal resource management has evolved over the years to address a variety of interrelated issues and uses. However, the development of coastal management policies has not always occurred in a coordinated fashion. Two trends are readily apparent. First, all too frequently, government responses to coastal zone problems have emerged in relative isolation from one another, such that policies covering seemingly discrete issues (e.g., commercial fishing, pollution control, or navigation) often come into conflict. Second, governments have commonly approached coastal policy solely within the context of their own boundaries or jurisdictional zones. Since ecological systems in oceans and estuaries do not often correspond to political boundaries, this approach has met with only limited success.

Scientists, planners and resource managers in a variety of settings are now beginning to move away from the traditional fractured approach to coastal resource management and instead are embracing more systematic management regimes. In this paper, ecosystem-based coastal management is examined using three examples of holistic approaches. On the local level, Salem Sound 2000 is a partnership that brings together citizens from the communities bordering an embayment on the north shore of Massachusetts in an effort to improve water quality and the overall health of their coastal environment. The Gulf of Maine Program embraces similar objectives but on a larger scale, uniting three states and two Canadian provinces in a long-term cooperative effort to provide stewardship over their common waters. Finally, the Large Marine Ecosystem (LME) concept offers a paradigm through which vast regions of the world's oceans might be organized for resource management based on ecologically relevant criteria.

The author concludes that functional and spatial comprehensiveness are of primary importance in organizing coastal and ocean management regimes, and that grassroots political organization is a necessary component of facilitating management organization based on ecosystems (rather than on jurisdictional boundaries).

The theme "Organizing for the Coast" can be interpreted in two distinct ways, both of which are appropriate components of any effort to improve coastal resource management. On the ground level, organizing refers to grassroots political action to unite groups and individuals around coastal causes or problems. Organization from this standpoint implies a process of building coalitions and developing a consensus as to how one or more particular concerns should be addressed by public policies. Marshaling support also implies that education may be necessary to inform potentially interested parties about a coastal or ocean issue, to explain why the issue merits attention, and to advocate (if possible) an approach to dealing with the issue.

At an institutional or administrative level, on the other hand, organization refers to the social structures used to perform various tasks, and specifically, the structure of governance used by agencies, municipalities, states or nations to carry out coastal management. Political organization might at first appear to be a dry bureaucratic phenomenon of little real consequence, but scholars and governmental officials have long recognized that the organization of agencies, commissions and other executive bodies can have a profound impact on policy outcomes (Ross, 1981). Any organizational approach for management efforts draws attention to certain issues at the expense of others, thereby reflecting the perceptions of policy-makers about the relative importance of selected topics. Thus, the results of government's response to coastal management problems is closely related to the organizational approach employed by policy-makers.

The confluence of these two interpretations of organizing suggests that as we prepare to meet the mounting challenges facing coastal management, we must focus our attention on mustering support among ocean and coastal constituencies as well as on re-examining the institutional devices used to address coastal problems. This paper explores both paths using three examples of ecosystem-based approaches to resource management. On the local level, Salem Sound 2000 is a partnership that brings together citizens from the communities bordering an embayment on the north shore of Massachusetts in an effort to improve water quality and the overall health of their coastal environment. The Gulf of Maine Program embraces similar objectives but on a larger scale, uniting three states and two Canadian provinces in a long-term cooperative effort to provide stewardship over their common waters. Finally, the Large Marine Ecosystem (LME) concept offers a paradigm through which vast regions of the world's oceans might be organized for resource management purposes based on ecologically relevant criteria.

Traditional Approaches to Organizing for the Coast

Coastal resource management has evolved to address a variety of interrelated issues and uses. However, the development of coastal management policies has not always occurred in a coordinated fashion. Two trends are readily apparent. First, all too frequently, government responses to coastal zone problems have emerged in relative isolation from one another, such that policies covering seemingly discrete issues (e.g., commercial fishing, pollution control, or navigation) often come into conflict (Juda and Burroughs, 1990). Second, governments have commonly approached coastal policy solely within the context of their own boundaries or jurisdictional zones. Since ecological systems in oceans and estuaries do not often correspond to political boundaries, this approach has met with only limited success.[1]

The drawbacks of traditional issue-by-issue and jurisdiction-by-jurisdiction management have been observed for years.[2] Nevertheless, there have been few substantive departures from the traditional piecemeal approach to ocean and coastal

[1]Underdal (1980) refers to this pattern as a loss of spatial comprehensiveness.

[2]A seminal critique of piecemeal approaches to marine policy appears in the Stratton Commission report, which led to the creation of NOAA (Report of the Commission on Marine Science, Engineering, and Resources, 1969). A more recent assessment of the limitations of the current regime for coastal management is presented by Archer and Knecht (1987).

governance. And perhaps more critically, growing coastal populations and expanded human utilization of the oceans have intensified the ecological stresses on the coastal and marine environments to unprecedented levels. Given the propensity for human impacts on coastal ecosystems to extend well beyond the reach of individual political jurisdictions, towns, states and even nations find it difficult to preserve environmental quality and sustainable resource development for their coastal zones without having their efforts thwarted by neighboring regions. The problem, put simply, is that governance of human uses of the oceans and coasts has failed to reconcile sociopolitical management regions with natural ecological systems.

Holistic Ocean Management

In light of the failures of traditional fractured management approaches, scientists, planners and resource managers in a variety of settings are slowly beginning to advocate more systematic and holistic resource management strategies. This enlightened approach is embodied in the concept of ocean management, which, as distinct from fisheries, minerals, water quality, coastal zone or any other specialized marine resource management, evokes a notion of comprehensiveness, thereby accounting for (if not including) the aggregate of all management of individual marine uses.

Despite this seemingly all-encompassing perspective, ocean management does not necessarily imply managing the entire global marine environment, or even a single ocean, all at once. Instead, it implies a systematic attempt at managing ocean and coastal uses on a scale that is sufficiently broad to account for the interrelationships and interdependencies among human uses and the natural environment. In other words, under a holistic or integrated ocean management regime, all significant consequences of policy decisions are recognized from the outset as premises in the making of those decisions (Underdal, 1980).

The need for some form of holistic ocean management is captured by three interrelated factors. First, marine resources are finite. Living resources such as fish, marine mammals, sea turtles and coral are renewable in the sense that populations can regenerate and even expand in the face of limited harvesting pressures or other human intervention. However, an absence of adequate management can lead to overfishing, habitat degradation and loss, and other direct and indirect assaults, which in turn can deplete living marine resources, threatening marine biological diversity and pushing populations and species to the brink of commercial, if not biological, extinction (Thorne-Miller and Catena, 1991; Juda, 1987). Non-living marine resources, such as hydrocarbons or sand and gravel, are renewable only on geologic time scales, so their exploitation is limited by their scarcity and by the availability of terrestrial substitutes. The assimilative capacity of seawater for accommodating pollutants is also limited, although precise thresholds can be difficult to pinpoint (Krom, 1986). Finally, marine space is limited, so that merchant mariners, commercial fishers, pleasure boaters and other users must vie for unrestricted use of the physical environment in which to pursue their respective interests.

A second reason for holistic ocean management is illustrated by the concept of opportunity cost. In the economic arena, the use of limited resources for one purpose precludes their use for other purposes.[3] Examples from the marine environment are numerous: for instance, construction of offshore oil rigs can inhibit navigation, dredging and filling in estuaries can eliminate nursery habitat for fisheries, and coastal discharges of pollutants can impinge upon recreational opportunities. In many cases mutually exclusive marine activities can be tailored to accommodate one another, but this requires some type of systematic management.

The third factor warranting holistic ocean management is known as "externalities." Again borrowing from economics, externalities are the side-effects of an action that influence the well-being of non-consenting parties, either positively or negatively (Gwartney and Stroup, 1990). For example, marine mammals, sea turtles and birds occasionally become entangled in fishing gear, resulting in an unintended (and negative) side-effect of commercial fishing. But if fishing industries improve gear design to attract target species more efficiently, the direct benefits to fisheries (greater harvests of marketable fish with less by-catch) can also result in positive externalities (less incidental entanglements) for mammals, turtles and birds, as well as environmentalists. An important role of management, therefore, is to minimize (or internalize) negative externalities.[4]

The three concepts just discussed—finite resources, opportunity costs and externalities—are closely linked. The finiteness of marine resources underscores the role of opportunity costs and use conflicts in distributing benefits when evaluating the utility of various non-exclusive policy options. Put simply, the limited nature of ocean resources means that tradeoffs and conflicts between users and uses are inevitable. Thus, some form of comprehensive management must be employed to manipulate human uses of the oceans in order to promote one or more particular outcomes from an array of possible choices. The interrelated nature of human activities in the coastal and marine environments demands that any decisions involving one activity be made with due regard for implications for other activities. Likewise, most human activities involving the oceans also result in impacts (short-term or otherwise) to ecological systems, which in turn may affect other human uses of the coastal and marine environments. Each of these complex linkages between and among human actions and physical, chemical and biological processes in the oceans reinforces the importance of a broad perspective in accounting for the impacts of one ocean management decision on other marine issues. A systematic, holistic approach is crucial if the goal is to minimize the adverse effects of each ocean use on all other ocean uses, and therefore to maximize the total benefits to be derived from the marine environment.

Establishing holistic ecosystem-based regimes for ocean and coastal management poses formidable political, institutional and socioeconomic challenges.

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[3]For discussions of opportunity costs in natural resource management, see Gwartney and Stroup (1990), pp. 419-421; Goodman and Dolan (1985), pp. 207-217; and Juda and Burroughs (1990) pp. 23 and 33.

[4]Underdal (1980), pp. 163-166. The challenge of internalizing externalities may be the greatest motivating force behind calls for a holistic regime for ocean governance. See Pearson (1975), pp. 18-63.

Nevertheless, efforts to implement systems based on this type of organizational approach are now underway locally, regionally and internationally.

Salem Sound 2000

Salem Sound 2000 is a cooperative project aimed at bringing together the interest, expertise and resources of six neighboring communities located on the north shore of Massachusetts to facilitate the management of their shared coastal environment. The project is a self-proclaimed "Bioregion Management Initiative," an effort to manage Salem Sound as one marine ecosystem (or bioregion) rather than as a number of separate jurisdictional entities. It was established in the fall of 1990 with a grant from the Salem Partnership, a non-profit collaboration of local businesses and industries, with an initial goal of prompting local governmental officials, representatives of local business and industry, local scientists and concerned citizens to discuss the status of Salem Sound and to begin focusing on regional management (McGrath, 1990).

Salem Sound extends from Gales Point in Manchester-by-the-Sea to Marblehead Neck and includes Marblehead, Salem, Beverly and Manchester Harbors as well as the tidal rivers that extend from Danvers and Peabody. The Salem Sound 2000 project grew from a realization that as the local population continues to grow, and as residents seek new ways to develop their communities economically, ever-increasing demands are placed on Salem Sound's limited resources. Thus, largely on the initiative of a single resident of Salem, an effort began to create a new forum for the public and private sectors to set a collective agenda for the use and conservation of Salem Sound's natural resources. This grassroots venture into coastal environmental policy quickly gained the interest of local, state and federal officials, as well as financial backing from groups such as New England Power, South Essex Sewage District, Eastman Gelatine, New England Biolabs and the Massachusetts Environmental Trust.

The initial task of building support for the concept of ecosystem-based coastal management for Salem Sound culminated in a public symposium held at the Peabody Museum of Salem in July 1991. The symposium examined the need for a regional management plan for Salem Sound, as well as the role of local citizens, businesses, and industry in developing such a plan. The meeting also included "visioning sessions" for participants to share their goals for the future of Salem Sound, thereby initiating a planning process for subsequent management actions.

Since the symposium, a Salem Sound 2000 Working Group of representatives from each of the six municipalities, plus area citizens, businesses, and industries, has met on a regular basis. The working group has focused thus far on establishing an organizational structure for Salem Sound 2000, developing formal goals and objectives, and beginning to select short-term and long-term projects. Having organized a new means of promoting improved coastal management, the communities participating in Salem Sound 2000 are embarking on a renewed effort to manage their common resources cooperatively.

The Gulf of Maine Program

The Gulf of Maine Program is a regional effort to unite three states and two provinces in a long-term cooperative venture to protect the ecological integrity of their common waters. It includes the development of a comprehensive environmental monitoring program, a 10-year action plan for coordinated gulf management, and a significant education component to raise public awareness of the value of the gulf's resources as well as the threats to those resources. Like Salem Sound 2000, the Gulf of Maine Program is premised on the recognition that maintaining and improving coastal environmental quality requires communities to look beyond political jurisdictions and to manage coastal uses with regard to their effects on an entire ecosystem. The program also recognizes the importance of broadly based public support for shifting away from traditional management strategies and moving toward a more holistic approach.

The Gulf of Maine program was launched in December 1989 with the signature of a joint "Agreement on Conservation of the Marine Environment of the Gulf of Maine" by the governors of Massachusetts, New Hampshire and Maine and the premiers of New Brunswick and Nova Scotia, Canada. The agreement defines the Gulf of Maine region broadly to include Georges Bank and the Bay of Fundy and acknowledges that the natural resources of this system are interconnected and form part of an overall ecosystem that transcends political boundaries.[5]

Structurally, the program is governed by the Gulf of Maine Council on the Marine Environment, a body comprising two high-level representatives from each of the states and provinces. The council meets periodically to coordinate regional management efforts, but implementation of management initiatives is facilitated by a Gulf of Maine Working Group of staff members from state, provincial and federal resource agencies. The core of the program's agenda for management is contained in its action plan, which lists goals and objectives agreed upon by the states and provinces (after an extensive review by diverse constituencies), as well as specific strategies or actions to achieve the objectives for each goal. Topics for action in the next decade include cooperative efforts in monitoring and research, pollution control, habitat protection, public education and participation, and the protection of public health.

The mission statement enumerated in the action plan is unambiguous: "To maintain and enhance marine environmental quality in the Gulf of Maine and to allow for sustainable resource use by existing and future generations" (Gulf of Maine Working Group, 1991). Thus, by planning for the long-term interests of their citizens, Nova Scotia, New Brunswick, Maine, New Hampshire and Massachusetts have succeeded in organizing a coordinated ecosystem-oriented approach to coastal ocean management (Gulf of Maine Council on Marine Environment, 1991).

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[5]Many ecologists argue that the Gulf of Maine is a subsystem of a larger continental shelf ecosystem. See Sissenwine (1986), pp. 55-85.

The Large Marine Ecosystem Concept

On an even broader geographical scale, the Large Marine Ecosystem (LME) concept is an ecologically oriented approach to partitioning the ocean margins into identifiable regions based on physical and biological "boundaries." LMEs are discrete ocean regions, typically measuring 200,000 km^2 or larger, which are characterized by unique hydrographic regimes, submarine topography, and trophically linked populations (Sherman, 1986). The principal advantage of the LME approach is that it places marine organisms, non-living ocean resources, aquatic habitats and associated human activities within the context of their roles in marine ecosystems, rather than viewing each in relative isolation. Thus, the LME approach offers policy-makers a broad ecosystem-based perspective—not unlike that embraced by Salem Sound 2000 and the Gulf of Maine Program—for organizing management of coastal and marine activities.

Development of the LME concept has focused primarily on its application to management of offshore living marine resources (Sherman, 1991). However, the utility of LMEs as management units extends to a far wider range of marine issues than just fisheries, as envisaged by the concept of "ocean management" discussed earlier. Due to its broad consideration of both the biotic and abiotic components of marine ecosystems, viewing such systems as wholes rather than treating individual components as entirely separate events or processes, the LME approach can be a useful organizational tool for monitoring and managing nearly all marine phenomena. Similarly, given the linkages between coastal habitat degradation and declines in both water quality and stocks of living marine resources (Chambers, in press), the scope of LMEs should be interpreted by scientists and policy-makers to include estuaries, embayments, wetlands, and other portions of the coastal zone that influence regional marine ecology.

The LME approach is still conceptual in nature, insofar as a formal LME management regime has not yet been created for a marine ecosystem. Moreover, implementation of the LME approach will not come easily, since the political, institutional and socioeconomic barriers to ecosystem-based management are far greater for large ecosystems than they are for smaller systems like the Gulf of Maine or Salem Sound. Thus, for LMEs even more than smaller coastal ocean regions, education and coalition-building are essential ingredients for convincing fishermen, boaters, beachgoers and other constituencies that an ecosystem-based management regime offers significant advantages over less comprehensive alternatives. Active political support from such groups is absolutely critical if the movement toward holistic ocean management is to succeed at the level of LMEs.

Conclusion

Organizing efforts to improve ocean and coastal management requires both ground-level coalition-building among interested parties and the examination of new institutional mechanisms capable of incorporating the interrelationships between marine activities and processes. Traditionally, coastal management has proceeded without necessarily coordinating policies between coastal issues or between neighboring jurisdictions. But due to three interrelated factors—finite coastal resources, opportunity costs and externalities—piecemeal management has met with only limited success.

The movement toward holistic ocean management is a direct response to the limitations of its alternatives. Without accounting for the transboundary nature of both coastal processes and the impacts of various human activities, it is impossible to manage coastal resources in a way that promotes their optimal benefits to society. Salem Sound 2000, the Gulf of Maine Program, and the Large Marine Ecosystem concept all share a holistic approach that envisions managing human activities within the context of surrounding ecosystems that do not neatly correspond to political boundaries. Other coastal regions can benefit from applying this approach, although widespread education and community involvement will be critical if new management systems are to take hold and measurably improve the outcomes of coastal policies. In other words, shifting to ecosystem-based management regimes requires grassroots political organization to promote management organization based on the ecological approach.

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Monitoring and Assessment

ENVIRONMENTAL GUIDELINES FOR SITING AND MONITORING NET-PEN AQUACULTURE FACILITIES IN THE NORTHERN GULF OF MEXICO

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Abstract

There are a number of potential environmental concerns associated with net-pen culture in coastal waters. This report summarizes the data on these effects, places the data in the context of the northern Gulf of Mexico environment and suggests proposed siting guidelines to minimize adverse environmental effects. A copy of draft Mississippi regulations for net-pen culture is included.

There are five major areas of potential environmental concern: water quality alterations and their consequences, sedimentation and benthic effects, chemical usage, disease transmission, and escaped fish (exotic species, genetic impacts). There are also site-specific concerns regarding protected species, habitats of special concern, or important marine/coastal resources. These guidelines are intended to aid permitting agencies in reviewing open-water aquaculture permit applications and to assist the industry in selecting appropriate culture sites.

Introduction

The apparent profitability of commercial net-pen aquaculture in higher latitudes has created a growing interest in the establishment of such facilities in Gulf of Mexico waters. The rapid growth of commercial net-pen aquaculture in other regions has also brought attention to the potential environmental effects of such activities. Regulatory agencies in other areas have studied these effects and developed siting, operations and monitoring guidelines to detect and limit the potential negative environmental effects of net-pen aquaculture (Weston, 1986a, 1991; Washington Department of Ecology, 1990). Because most of the potential environmental effects of net-pen culture are independent of species cultured (Weston, 1991), existing information can be used to assess impacts and suggest a rational framework for evaluating net-pen aquaculture in the northern Gulf of Mexico. Such information also identifies site-selection criteria for successful operations.

Potential Environmental Effects

Water Quality. Current velocities inside net-pens can be reduced to 35 to 80 percent of outside velocity (Weston, 1986a). Stocking density, mesh size, pen volume, fouling and other variables can dramatically decrease water flow. Because reduced water flows affect dissolved oxygen and waste transport, this has important implications for farm size, orientation and location.

There have been no measurements of the effects of net-pens on water circulation. Weston (1986a) estimated net-pens will reduce current velocities to 95 percent of free stream values for a distance about equal to one structure diameter upstream, two structure diameters to either side and 20 structure diameters downstream. These reductions of current velocity in the vicinity of the aquaculture structures will cause increased sediment deposition. Decreased clearance between net-pens and the sea bed has been related to increased sedimentation (Washington Department of Fisheries, 1990; Weston, 1986a).

Waste loadings from net-pen culture are poorly understood and are extremely variable depending on feed regimen, fish size, temperature and other variables. Based on net-pen salmon culture, useful approximations of combined dissolved and solid waste loads, as g/kg fish/day are: ammonia, 0.3; nitrate, 0.1; organic nitrogen, 0.04; total nitrogen, 0.6; phosphate, 0.1; total phosphorus, 0.1; BOD, 3.0 (Weston, 1986a). Most of the nitrogenous waste will be released in dissolved form (Weston, 1991). Most of the BOD is associated with particulate material.

Unutilized feed and the metabolic products of food breakdown are the dissolved waste inputs (Weston, 1986a, 1991; Weston and Gowan, 1988). Ammonia is the principal nitrogenous waste, present primarily as dissolved nitrate and nitrite (Gowan and Bradbury, 1987). Localized increases in nutrient concentrations have been reported near net-pens (Nishimura, 1982 [cited in Weston, 1986a]). Because dilution is generally very rapid (on a scale of meters and hours), nutrient increases are spatially and temporally very limited, and net-pen aquaculture will not create conditions favorable for blooms of toxic phytoplankton.

The dissolved oxygen content of water near net-pen operations is reduced by respiration of fish (and fouling organisms) and by the biochemical oxygen demand of the waste feed, feces and urine. Field investigations around net-pens in warm waters have reported decreases in dissolved oxygen, up to 0.2 to 2.5 mg O_2/l less than ambient in one extreme case (Weston, 1986a). Oxygen consumption rates may reach 40 kg O_2/1000 kg fish/d for larger fish in warm (30 °C) water (Colt and Tchobanoglous, 1981). Because of the low solubility of oxygen in seawater at high temperatures, dissolved oxygen consumption may effectively limit the size of net-pen operations in the coastal waters of the northern Gulf of Mexico.

Benthic Effects. Excess feed, fecal material and debris from structures are the main solid wastes associated with offshore aquaculture. Estimates of waste feed (dry pellets) for experienced net-pen operations are about five percent (Maine Department of Marine Resources, 1991; Weston, 1986a). About one-third of ingested feed ingested is also assumed to be lost as feces (Fox, 1988; Gowen and Bradbury, 1987; Weston, 1986a). Assuming these losses and a feed conversion ratio of 2:1, the production of 1 kg of fish will result in an estimated production of 0.7 kg (dry weight) of solid waste.

Dispersion of waste particles increases with increasing depth and current velocity and with decreasing sinking speeds (Weston and Gowan, 1988; Fox, 1988). Sedimentation rates beneath net-pens have been found to be 2 to 10 times greater than in reference areas (Pease, 1977; Weston and Gowan, 1988). Because depth, current velocity and fish production level all affect rates of sediment deposition (Gowen and Bradbury, 1987; Washington Department of Fisheries, 1990; Weston, 1986a, 1986b, 1991), minimum depth and current requirements have been established in every area where net-pens operate (e.g. Caine [no date]; Doggett, 1990; New Brunswick Department of Aquaculture and Fisheries [no date]; Washington Department of Fisheries, 1990; and references in Weston, 1986a, 1986b).

Based on models of sediment deposition (Fox, 1988; Gowen et al., 1988; Weston and Gowan, 1988), much of the fecal matter, waste feed and debris will settle in the immediate vicinity of the net-pens under hydrological conditions typical of the northern Gulf of Mexico. The area receiving solid wastes from fish culture net-pens is relatively small, within 30 m of the culture facility (Weston, 1986b), while significant changes in sediment chemistry have generally been within 15 m (Pamatmat et al., 1973; Weston, 1986b, 1991).

The re-mineralization of carbon and nitrogen from uneaten feed and from feces consumes substantial amounts of oxygen and produces major changes in sediment geochemistry, including the production of toxic hydrogen sulfide (Weston, 1986a, 1991). In general, only about 20 percent of the carbon supplied to the farmed fish in feed is removed with the harvest; the 80 percent remaining is lost (Hall et al., 1990). The biochemical oxygen demand (BOD) of fish wastes on bottom waters may consume 1.5 to 3 times as much oxygen as respiration (Liao and Mayo, 1974). Because stratification and hypoxia of bottom waters is a frequent occurrence during the summer months in the northern Gulf of Mexico (Leming and Stuntz, 1984) this added BOD demand may have severe environmental effects.

Azoic zones are found below most fish farms (Gowan and Bradbury, 1987; Gowan et al., 1988; Weston, 1986a) and a benthic communities change along a gradient of increasing organic enrichment towards the net-pen. The spatial extent of changes in benthic communities is typically small, less than 30 m (Weston, 1991). Recovery of affected benthic communities may take months or years (Gowan et al., 1988; Weston, 1991) but sediment chemistry appears to recover to normal levels relatively rapidly (Pamatmat et al., 1973; Dixon, 1986 [cited in Washington Department of Fisheries, 1990]). Where water quality is maintained, fish and mobile macrofauna are frequently attracted to aquaculture sites (Weston, 1986a), even to those where azoic zones have been created.

Chemical Usage. Chemicals used for fouling control and treatment of diseases pose a threat to the marine environment only when their potential for environmental damage is not fully known or the substances are misused. Antifoulants approved for use in marine waters are acceptable. Of the three feed additive antibiotics and one topical treatment licensed by the Food and Drug Administration for food fish culture in the United States, none has been approved for use in either redfish or hybrid striped bass culture. Oxytetracycline (OTC), an antibiotic, and formalin will probably gain approval for use in striped bass/hybrid culture. Neither poses a significant environmental threat.

Formalin is applied as a bath to fish held in tanks for treatment (Federal Register, 1986), so there will be no environmental effect as long as the treatment waste is disposed of in an approved manner. Concern has been expressed about OTC release into the marine environment. Despite extensive use of OTC in treatment of fish diseases, there has been no demonstration of significant environmental effects (Weston, 1986a, 1991). There is no indication that application of OTC or other FDA-approved antibiotics, following established FDA and industry guidelines, would have significant environmental or human health effects. Weston (1986a, 1991) and Washington Department of Fisheries (1990) provide thorough reviews of the research supporting this conclusion.

Interactions with Resident Species. The escape of cultured fish from offshore net-pen operations is inevitable, giving rise to concerns about detrimental impacts on local fish populations (Maine Department of Marine Resources, 1991; Washington Department of Ecology, 1989; Washington Department of Fisheries, 1990). Because net-pen culture in northern Gulf waters will be limited to species already present and whose populations are augmented by hatchery stock (e.g., redfish, striped bass or hybrid striped bass), no genetic threat from escaped fish is evident, nor is there a threat of introducing non-native species and associated pathogens. Purposeful introductions of non-native marine species are controlled under state aquaculture regulations.

Concern has been expressed that cultured fish could act as reservoirs of disease, infecting wild fish populations. Despite the proliferation of cage culture worldwide, such an occurrence has never been documented (Washington Department of Fisheries, 1990; Weston, 1991).

Existing regulations provide adequate protection to the 33 species of cetaceans and five sea turtle species reported from the Gulf of Mexico (Minerals Management Service, 1991). Two turtle species nest on northern Gulf beaches. Because lights on offshore structures may affect nesting, hatchling behavior and survival, best management practices suggest conservative minimum separation distances to minimize interactions, even if there is no evidence to support or allay these concerns.

Piscivorous bird species that may be attracted to net-pens are abundant in the northern Gulf (Minerals Management Service, 1991). Bird predation on cultured fish stocks, especially juveniles, is of concern to aquaculturists while the effects of predator control measures on protected bird species are of concern to regulatory agencies. Control of bird predation must follow established federal guidelines for such activities and proposed control plans should be coordinated with the responsible state and federal agencies. Best management practices suggest conservative minimum separation distances to minimize interactions and use of non-lethal predator control measures.

Summary of Environmental Effects

The major potential impacts of offshore aquaculture and actions to quantify, regulate and minimize these impacts have been identified in a variety of state and national studies. There are three important conclusions. First, matching production levels with minimum depth and current speed is essential. Second, adequate separation distances is essential to ensure protection of sensitive resources. Third, environmental effects of net-pen culture are relatively limited in area and are reversible. The main environmental effects are:

Current velocity is reduced both within and outside net-pens. This limits inflows of oxygenated water and outflow of waste-bearing water and promotes sedimentation. Selecting sites with sufficient currents is essential.

Solid wastes from net-pen aquaculture will settle to the bottom immediately beneath and a short distance (tens of meters) away from the site. Selecting sites deep enough and with sufficient currents to disperse these wastes will minimize the impact.

The effect of aquaculture operations on water movement and water quality are not detectable within tens of meters of the culture site.

Effects on sediment chemistry and the benthic community immediately beneath and within a few meters of the site can be catastrophic. Areal extent of these effects is limited to a short distance (tens of meters) away from the site. Biological recovery occurs on the scale of months to years, and sediment chemistry returns to ambient in weeks to months after operations cease.

Fish culture in warm water can place heavy demands on available dissolved oxygen levels. Selecting sites deep enough and with adequate current speeds to allow for adequate dispersion of wastes, setting appropriate limits on total fish production, and following low-waste feeding practices will minimize adverse impacts. Stratified and hypoxic water bodies should be avoided.

There is no good evidence that net-pens have an adverse impact on fish and other nektonic species, transmit diseases to wild fish, stimulate blooms of toxic algae, contaminate resident fauna with antibiotics, or contribute to the development of antibiotic-resistant microbial populations threatening to human health.

Impacts on important marine habitats, protected species, fisheries resources and public lands can be severe. Impacts of net-pen aquaculture on protected birds and on marine turtle nesting success, hatchling movement and hatchling survival are not known. Setting appropriate separation distances and selecting sites away from such areas will minimize impacts.

Control of avian predators must conform to federal guidelines, and control plans should be developed and coordinated with the responsible agencies.

Siting Guidelines

Operation Size. Because the rate of accumulation of feed, feces and organic debris under net-pens are related to farm size, regulatory programs to detect and control potentially deleterious environmental effects should be linked to the size of the operation. The recommended degree of monitoring required increases with farm size. There are two established methods of classifying net-pen operations by size: by production level (Weston, 1986a) and by annual feed consumption (British Columbia Ministry of Environment, 1988).

Depth and Current Speed. Site current and depth characteristics are matched with production level or feed usage rates to determine the extent of environmental impact. However, because of the relatively shallow depths, low current speeds and seasonal stratification/hypoxia in northern Gulf coastal waters, it may be more appropriate to evaluate permits on a site-specific basis. This will require a survey of pre-operations site conditions and estimates of potential waste loads, DO and BOD demands, sedimentation and nutrient inputs based on net-pen design, array, loading and feed use.

Regardless of size, minimum recommended water depth beneath the net-pens should be established to ensure adequate dispersion of wastes, using approaches developed for other regions (e.g., Doggett, 1990; Washington Department of Fisheries, 1990). Net-pens should not be located in areas subject to vertical stratification of the water, where bottom waters are prone to reduced dissolved oxygen conditions. Because decomposition of organic material in stratified water is the primary cause of oxygen depletion (Boesch, 1983), solid waste inputs will compound near bottom dissolved oxygen problems.

Spacing. Because of the hydrodynamic effects of the net-pens on currents, spacing between net-pens should be at least two structure diameters and rows should be at least 20 structure diameters apart. Based on experiences in other states (e.g., Maine Department of Marine Resources, 1991; New Brunswick Department of Aquaculture and Fisheries [no date]; Washington Department of Fisheries, 1990) distances between farms should be no closer than 600 m (2,000 ft.).

Habitats of Special Significance. Selecting sites away from important fishing grounds, sensitive or important habitats and public lands such as parks, wilderness areas, beaches and similar areas minimizes the impact of net-pen aquaculture. Because the environmental effects of net-pen aquaculture are spatially very limited, only minimum separation distances would be required to avoid impacts on seagrass beds, oyster reefs, artificial reefs, spawning areas and other fishery resources. Minimum separation distances should consider both existing bird concentration points and their anticipated foraging behavior. The resources to be protected and separation distances will have to be determined case by case by responsible federal and state agencies. Permits must identify that separation distances may be increased to reduce any potential impacts on these habitats.

Navigation channels, fairways, open water disposal areas and other sites permitted for specified uses are not suitable for siting aquaculture operations. Separation distances should be reviewed and established case by case by the appropriate state and federal agencies.

While these guidelines do not specifically address aesthetics issues, these considerations will be taken into account in reviewing permits. Specifically, the presence of wilderness areas, marine sanctuaries, recreational areas and national seashores in the northern Gulf of Mexico will affect the siting, operations and monitoring requirements for aquaculture operations. No attempt has been made in this report to address other important concerns such as conflicts with other users, social impacts and related issues.

Draft Mississippi Net-Pen Aquaculture Guidelines (March 23, 1992)

Aquaculture Guidelines—General

The following general guidelines shall apply to all types of aquaculture activities in the marine waters of the state of Mississippi.

All aquaculture operations shall provide the Bureau of Marine Resources with an Environmental Assessment which describes the site characteristics and the potential impacts associated with the project;

Discharges into the surrounding waters of any waste materials associated with the production of cultured organisms, excluding excrement, shall be prohibited;

All aquaculture operations should avoid locating in close proximity to habitats of special significance. Habitats of special significance include special habitats for endangered and threatened species, public oyster reefs, seagrass beds, bird nesting areas, and sea turtle nesting grounds. Net-pen aquaculture operations shall not be located within one mile of the above referenced habitats. Molluscan shellfish aquaculture operations shall not be located within 1,500 feet of the above referenced habitats;

Care shall be taken to avoid locating aquaculture operations in close proximity to federal navigation channels and dredged material disposal areas. Aquaculture operations North of the baseline shall not be sited within two nautical miles of the centerline of a federal navigation channel. Aquaculture operations South of the baseline shall not be sited within one mile of a federal navigation channel nor shall they be sited within, a U.S. Coast Guard safety fairway, an anchorage area, or within the boundary of a dredged material disposal area unless specifically authorized by the U. S. Army Corps of Engineers;

Only non-lethal methods of predator control shall be allowed. A predator control plan for each aquaculture operation must be submitted to the Bureau of Marine Resources prior to the issuance of a permit;

Aquaculture operations shall not be located within 1,500 feet of any pipeline or submerged cable;

All aquaculture operations must be properly marked in accordance with U.S. Coast Guard regulations;

All aquaculture operations are encouraged to minimize impacts to the natural scenic qualities of the coastal wetlands.

Specific Guidelines—Fin Fish Aquaculture

Net-pen systems shall be located in waters of sufficient depth. A minimum clearance of 10 feet below the bottom of the net-pen system shall be maintained at all times. The distance shall be measured at MLW. If monitoring indicates a serious problem with water quality or other environmental conditions at the site, the operation must be adjusted to reduce impacts. Adjustments shall include but not necessarily be limited to modifying the feeding rate or feeding schedule, reducing the amount of fish in the net-pen system, or increasing the clearance under the nets to allow for increased water circulation;

Net pen aquaculture operations shall not be located within two miles of the shoreline of the offshore islands. The offshore islands include Petit Bois, Horn, East Ship, West Ship and Cat Islands.

Aquaculture Monitoring Program

Pre-Operational Environmental Survey

All aquaculture operations shall perform a Pre-Operational Environmental Survey (POES) three months prior to operation and submit the data and findings in a compiled report to the BMR. The POES is intended to characterize bottom conditions at the site prior to the commencement of the aquaculture operation. The POES shall include the following parameters:

Bathymetric Data. A bathymetric survey using a continuous recording depth recorder shall be performed at the aquaculture site. The site should be divided into transects 500 feet apart throughout the site. The transects shall be oriented in both north/south and east/west directions.

Biological Data. Bottom grab samples for benthic analysis shall be collected at intervals of 250 feet along the transects established for the bathymetric survey. A minimum of twenty sampling sites shall be established and a minimum of three replicate samples shall be collected at each sampling station for a large production level aquaculture operation. A maximum of twenty sampling sites shall be established and a minimum of three replicate samples shall be collected at each sampling station for a small production level aquaculture operation. Samples shall be sieved through a 1.0 mm sieve and preserved for future analysis.

Bottom Characteristics. Bottom core samples for sediment and chemical analysis shall be collected at intervals of 250 feet along the transects established for the bathymetric survey. A minimum of twenty sampling sites shall be established and a minimum of three replicate samples shall be collected at each sampling station for a large production level aquaculture operation. A maximum of twenty sampling sites shall be established and a minimum of three replicate samples shall be collected at each sampling station for a small production level aquaculture operation. Samples shall be analyzed for grain size, Total Nitrogen and Chemical Oxygen Demand.

Operational Monitoring Program

A Marine Environmental Monitoring Program (MEMP) shall be implemented once the aquaculture operation is initiated and the data and findings shall be submitted in a compiled report to the BMR. The MEMP is intended to monitor potential changes in water and sediment quality resulting from the aquaculture operation. Secondly, it provides data with which to review the current environmental requirements for possible future modifications. As additional data are obtained on the environmental effects of aquaculture operations, the annual monitoring protocol may be substantially revised. It is also possible that monitoring at some culture sites may be curtailed or eliminated entirely if little or no measurable effect on environmental quality is found. The determination to curtail or eliminate monitoring at any site will be made after the BMR reviews the survey results.

The MEMP consists of four principal elements: 1) hydrographic survey, 2) sediment chemistry, 3) water quality, and 4) benthic survey. The frequency and duration of the monitoring will depend on the type and size of the aquaculture operation. A summary of the parameters to be monitored and the frequency is shown in Exhibit 1 of this document. The sampling regime, including the depths of the water samples, types of grab samplers employed, and the data analysis procedures, will be determined according to the size and type of aquaculture operation.

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Table 1. Marine aquaculture environmental monitoring program. DO, dissolved oxygen; COD, chemical oxygen demand, TN, total nitrogen.

CULTURE SYSTEM SIZE	MONITORING PARAMETERS DURING MARINE CULTURE							
	WATER COLUMN					BOTTOM		
		Turbidity						
Net-Pen Culture	*Current Direction; speed*	*Secchi disk*	*Aerial photos*	*DO*	*Salinity*	*COD*	*TN*	*Benthic Sample*
Small Production Level[2]	continuous	daily	semi-annually	daily	daily	annually[1]	annually[1]	anually[1]
Large Production Level[3]	continuous	daily	quarterly	daily	daily	quarterly[4]	quarterly[4]	quarterly[4]

[1]Maximum of 20 sampling sites with three replicates at each site.
[2]135 tons or less of feed per net-pen system per year.
[3]Greater than 135 tones of feed per net-pen system per year.
[4]Minimum of 20 sampling sites with three replicates at each site.

Figure 1. Marine aquaculture environmental monitoring program. DO, dissolved oxygen; COD, chemical oxygen demand, TN, total nitrogen.

DEVELOPING TECHNICAL GUIDANCE FOR CONTROL OF NON-POINT-SOURCE POLLUTION IN COASTAL WATERS[1]

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Introduction

The Coastal Zone Act Reauthorization Amendments (CZARA) were passed by Congress on Nov. 5, 1990. A major provision of CZARA, Section 6217, calls upon coastal and Great Lakes states to develop enforceable programs to control non-point-source pollution affecting coastal waters. The new coastal non-point-source control programs are to be jointly approved by the National Oceanographic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) and implemented through existing state Coastal Zone Management Act (CZMA) programs and Clean Water Act (CWA) Section 319 non-point-source programs. Section 6217(g) of CZARA requires that EPA, in consultation with NOAA, the U.S. Fish and Wildlife Service and other federal agencies, develop technical guidance specifying methods for controlling sources of NPS pollution in coastal waters. These methods are to form the basis of state programs approved under Section 6217.

The requirements of Section 6217(g) are enormous. EPA is required to develop guidance identifying the best economically achievable methods to prevent and treat non-point-source pollution from several different land-use categories in the coastal zone, all within 18 months. These methods to control non-point-source pollution in the coastal zone are called "management measures" under the statute and include a minimum of six elements:

A description of a range of methods, measures or practices, including structural and nonstructural controls and operation and maintenance procedures, that constitute each measure;

A description of the categories and subcategories of activities and locations for which each measure may be suitable;

Identification of the individual pollutants or categories or classes of pollutants that may be controlled by the measures and the water quality effects of the measures;

[1]The views presented in this paper represent the opinions of the authors and should not be considered as official EPA or NOAA policy.

Quantitative estimates of the pollution-reduction effects and costs of the measures;

A description of the factors that should be taken into account in adapting the measures to specific sites or locations; and

Any necessary monitoring techniques to accompany the measures to assess over time the success of the measures in reducing pollutant loads and improving water quality.

These management measures are to be economically achievable, a term that is not defined in the statute. The measures are to be analogous to the best available technology developed in the early 1970s to control point-source discharges. Under best available technology, source control rather than receiving water quality is the objective. In other words, the emphasis is on preventing non-point-source pollution to the extent that potential polluters can afford.

Objectives

The objectives of this paper are to describe the problems and issues encountered in developing the management measures guidance required under Section 6217(g) of CZARA and to summarize how the problems and issues were addressed.

Issues and Problems

Several issues and problems arose in attempting to develop the guidance required by this statute. EPA, working with NOAA, had to set some initial bounds on the scope of the guidance.

Range of Measures. An initial task confronting EPA was determining the range of measures needed to respond to the requirements of Section 6217(g). In his testimony, Rep. Gary Studds (Studds, 1990) stated that EPA is expected to concentrate on the large non-point sources that are "widely recognized as major contributors of water pollution and on which there is broad consensus on the appropriate management measures that must be developed and implemented." In order to begin the process of selecting the necessary measures, therefore, EPA needed to determine which non-point sources were the major contributors to coastal water quality problems in the geographic areas of interest.

The geographic extent of coverage is clear: the management measures are to be implemented throughout the coastal zone. The coastal zone, however, is to be revised based upon recommendations made by NOAA and responses from the states. The boundaries of the state coastal zones are to be reconsidered because the original boundaries were not delineated for pollution control and so had little, if any, relationship to boundaries that would be established for pollution control purposes. For example, the entire state of Florida is currently in the coastal zone under the CZMA, but only a narrow strip of California is in the zone.

Regardless of geographic coverage, the issue remained as to which categories and subcategories of sources should be covered by the guidance; which are covered by existing programs such as EPA's NPDES program; and which should not be covered because of their insignificance as non-point sources in the coastal zone. Clearly, Congress directed EPA to address only those non-point sources that pose significant risks to water quality in the coastal zone. Unfortunately, definitive databases on the relative importance of various non-point sources in the coastal zone were not available.

The information available, however, indicates that non-point-source pollution is the greatest source of water quality problems in the nation's rivers and lakes and a significant source of problems in estuaries, the Great Lakes and coastal waters (U.S. EPA, 1992). Approximately three-quarters of the nation's estuarine waters were assessed in 1990 for Section 305(b) of the CWA, and 44 percent of the area assessed was impaired or threatened by point and non-point sources. The leading non-point sources contributing to these impacts were urban runoff (including construction) and agriculture. Hydromodification and silviculture were also locally significant problems. The leading pollutants impacting estuaries were nutrients, organic enrichment and pathogens. Information regarding major sources of problems in coastal waters was not reliable due to the small number of states reporting such data.

Despite the limitations of available data, EPA had to make decisions regarding those land uses and activities that would be addressed under the program. These decisions were largely based upon Section 305(b) data and other sources, such as NOAA's estimates of point- and non-point-source loads to estuaries and coastal waters (NOAA, 1989).

Given final resolution of geographic coverage and the sources within that area considered to be major contributors of non-point-source pollution in coastal waters, EPA still has to determine whether individuals and groups can afford to implement the proposed measures. Thus, economic achievability analysis will drive final decisions as to the range of management measures to be included in the "Management Measures Guidance."

Data. A second major issue encountered was locating and analyzing the data necessary to develop the guidance. Non-point-source pollution control technology was initially developed on a large scale under Section 208 of the CWA, but the technology was not widely implemented. Some states implemented Section 208 plans, developing considerable experience and knowledge, but most states could not afford to continue to fund 208 programs given other pressures and requirements. EPA developed guidance in response to Section 208 but the guidance was never updated. Thus, Section 208 did not become a major source of information regarding the effectiveness of non-point-source pollution control technology.

Other state and local non-point-source programs have provided limited information on the effectiveness of practices because of the general lack of additional funds for monitoring. Similarly, research dollars for non-point-source pollution control have always been limited, with the USDA appearing to take the lead in non-point-source research through its ongoing agricultural research program.

A few isolated programs in the 1980s generated some information on non-point-source pollution control effectiveness. For example, the Nationwide Urban Runoff Program developed a considerable database on urban sources and structural controls and spawned a generation of expertise in urban non-point-source control (U.S. EPA, 1983). The Model Implementation Program (North Carolina State

University, 1985) and Rural Clean Water Program (U.S. EPA, 1990) provided some data regarding the effectiveness of agricultural programs and controls. The Great Lakes Section 108 program has also been a source of much non-point-source information (Newell et al., 1986). The quantity of information generated through these efforts regarding the costs, effectiveness and applicability of non-point-source management measures, however, is less than what was needed to respond to the requirements of Section 6217(g). EPA had to look to the published literature; federal, state and local program literature; and even anecdotal information from recognized experts to assemble a database of cost and effectiveness information for this new program.

Selection of Best Available Technology. Using the data available, EPA then had to determine how to evaluate the information for the purpose of determining the best available technology for specific sources. This challenge was not simply one of combining apples and oranges but of combining information that had been collected and reported in different ways for a range of purposes. For example, literature useful for best available technology selection includes practice evaluation information reported in terms of percent load reduction vs. a control condition. The control conditions for studies often vary, making it difficult to combine these studies. Other literature may include only anecdotal information regarding the effectiveness of measures, while some state and federal programs issue guidance on measures with very little documentation to support the guidance.

Assuming that enough good data were available, the challenge still remained to select the best available technology for each category and subcategory of non-point sources. For example, to identify an urban stormwater control measure that applies to the entire coastal zone of the nation requires a considerable quantity of good data regarding the various options that could be used. The factors considered include effectiveness in controlling a broad range of pollutants, site-specific considerations to be made in implementing the measure across a broad range of geographic and climatic conditions, and the costs associated with implementing the measure across a wide range of technical and economic conditions. For some sources (e.g., agriculture) the literature is relatively rich (not necessarily rich enough, however), while for other sources (e.g., marinas) the literature is relatively poor for most areas. Needless to say, the basis from which EPA was to make decisions regarding best available technology was far from that which would be desirable.

Level of Specificity of Guidance. Another challenge in developing national guidance for a site-specific problem is achieving the proper level of specification while trying to stay within the constraints imposed by the statute and legislative history. For example, the statute calls for specificity regarding the measures and what will be gained from implementing them, yet the legislative history directs EPA to "offer state officials a number of options and to permit them considerable flexibility in selecting the management measures appropriate for their state" (Studds, 1990). Rep. Studds also made it clear that the level of specificity for best available technology in this guidance was not expected to be as great as that developed for the effluent guidelines under the CWA.

Studds' testimony also gave examples of measures that might be acceptable, including buffer strips, setbacks, erosion and sedimentation controls, critical habitat identification techniques, and siting and design criteria for marinas. Following this example, EPA could propose that conservation tillage be applied to all cropland in the coastal zone, yet it might be impractical to implement the measure on crops such as cotton. On the other hand, EPA could require the implementation of erosion control measures on all cropland, without specifying either a particular set of acceptable practices or a performance goal. This type of measure would provide the flexibility needed for national applicability but would be impossible to evaluate in terms of pollution control gained or cost to implement.

With respect to design specifications, EPA could propose the implementation of a specific measure, such as stormwater detention basins that handle 24-hour, 50-year storms, yet the practicality and cost of such a measure would vary considerably across the nation. Alternately, without such design specifications, EPA would have difficulty estimating the pollution control possible through implementation of the measure.

Other challenges confronted EPA and NOAA in the development of guidance for Section 6217, including the short time period within which the guidance was to be developed. The remainder of this paper, however, will focus on a discussion of the approach taken to resolve the above four issues: range of measures, data, selection of best available technology, and level of specificity for the guidance.

Approach

Work Groups. Confronted with the monstrous task of pulling together major guidance within the congressionally mandated 18-month time frame, EPA developed a work-group approach to bring in expertise and information not available at EPA. The statute called for EPA to coordinate with NOAA, the Fish and Wildlife Service, and other federal agencies with an interest or stake in the program, but EPA also needed to use expertise and information available at the state level. Work groups were established to provide additional state and federal expertise. Work group co-chairs included representatives from EPA, NOAA and the USDA Forest Service and Soil Conservation Service.

Range of Measures. Separate work groups were established to address: agriculture; forestry; urban sources; marinas and recreational boating; and hydromodification, dams and levees, shoreline erosion, wetlands, and biofiltration. EPA based its development of work groups on a decision that the five areas listed above were the areas of greatest concern in the coastal zone with respect to Section 6217. The available data clearly pointed to the significance of urban and developing areas, agriculture, and forestry, and the legislative history indicated that marinas also were of concern (Studds, 1990). Adequate information was available to justify the inclusion of the other sources as well. Work group members agreed with the selection of those five areas and suggested other areas to include (e.g., mining, oil and gas, atmospheric deposition, in-place contaminants). No new areas were added, however. An EPA group was also established to direct the economic achievability analyses.

Public comments on the proposed "Management Measures Guidance" (U.S. EPA, 1991) indicated that EPA's selection of sources to address was appropriate. A few additional areas were proposed by commenters (e.g., mining, storage tanks); some commenters felt that a few areas were addressed without adequate basis (e.g., marinas, grazing, forestry); and a number of commenters recommended that

EPA address groundwater concerns as well. Most commenters, however, either actively supported EPA's selection or were silent on the issue.

Data. EPA solicited data from work group members, conducted extensive searches of the literature, and requested data through the public comment process. Literature searches were conducted by EPA staff, EPA contractors, and EPA grantees and the following number of papers, manuals and guidance documents retrieved: agriculture, 810; forestry, 625; urban, 580; marinas and boating, 320; hydromodification, 430; and wetlands, 580. The findings from the literature, however, were for the most part not reflected fully in EPA's proposed guidance (U.S. EPA, 1991) because of the time constraints associated with producing that document.

All literature used in the development of the guidance will be included in the public docket. EPA developed databases to record bibliographical information for each citation and also used a database matrix for some of the agricultural data (Robillard, 1992).

Major findings regarding the quality and quantity of the information collected are: (1) agriculture has the most complete non-point-source literature, but is severely lacking in many cases; (2) forestry has little literature regarding actual effects of BMPs on water quality, yet state programs are rather consistent in the practices that are promoted and required for controlling non-point-source impacts from forestry; (3) urban literature is relatively strong in some cases (e.g., erosion and sediment control, storm water structural controls, and on-site disposal systems), yet very weak in others (e.g., non-structural control costs and effectiveness); (4) marina and recreational boating literature are very limited in most areas; (5) wetlands information is good in spots (e.g., sediment trapping efficiencies), but weak in others (e.g., nutrient removal); (6) dams and levees literature is weak regarding non-point-source controls; and (7) shoreline erosion and riparian zone protection literature are weak pertaining to non-point-source issues.

Additional findings reveal that the synthesis of non-point-source research information, even where relatively strong, is a difficult chore that is compounded by the apparent lack of an overall strategy governing research in the non-point-source area. The lack of communication has resulted in the development of disjointed research in non-point-source control technology. Questions addressed by one researcher are often addressed by other researchers in ways that do not promote incremental findings. Rather, it seems that the same types of studies are done in different regions, but with slightly different specific conditions or objectives. In other words, although there is potential for the development of national or regional trends through replication, there is generally not adequate control of confounding variables such that differences in effect can be attributed to geographic variables. Additional factors such as plot size, precipitation source, practice used, study duration, and monitoring protocol contribute in an unmeasured way to the variability in findings. It would be highly useful in agricultural studies, for example, to have the physical conditions reported in addition to the practices used. Where conservation tillage is applied it would be useful to have measurements of the parameters affected by conservation tillage (e.g., percent residue) reported to allow for better comparison of results from different studies.

Research on non-point-source pollution prevention approaches is generally lacking. The unfulfilled need for suitable techniques to measure the "no effect" expected from pollution prevention measures may contribute to the void in this research area. Much of the best available technology for non-point-source control is prevention, but the general lack of information in these areas (e.g, nutrient management, growth management, streamside protection zones, marina siting) makes it difficult to document their effectiveness in protecting water quality. However, several states incorporate pollution prevention practices in their forestry, agriculture, urban and marina programs. For example, Maryland incorporates a critical area concept and growth management practices to protect Chesapeake Bay shorelines (Chesapeake Bay Program, 1990).

Selection of Best Available Technology. In general, it was possible to identify the best available technology for non-point-source control in the five areas addressed in EPA's proposed guidance (U.S. EPA, 1991). In several cases (e.g., stormwater runoff control) a number of options were available to achieve the same pollution control goals. In a few areas (e.g., forestry) the technology employed was strikingly similar across the nation, but in other areas (e.g., cropland) the preferred methods varied considerably due to differences in site-specific conditions (e.g., crop, soil type, slopes, growing season). EPA derived options for best available technology for all source categories, but the required economic achievability analyses of these options were not completed for the proposed guidance. Preliminary analyses, however, indicated that the proposed measures could generally be expected to be economically achievable.

Level of Specificity. The level of specificity in crafting the measures for the proposed "Management Measures Guidance" was one of the most difficult tasks that confronted EPA. There was no example on which EPA could base its approach because "management measures" was a new term introduced by the statute.

Four approaches were considered to address the specificity of measures in the proposed guidance: propose specific practices, propose specific performance standards that practices or combinations of practices would be expected to achieve, propose specific programmatic requirements, or propose broad program requirements. The approach selected for each measure was based on the availability of useful information, the provision of flexibility, the variability of source characteristics and control effectiveness, and costs. Of these four approaches, EPA generally used the second and third in its proposed guidance (U.S. EPA, 1991), by establishing performance expectations for a number of measures (e.g., erosion control), and establishing procedural requirements in others (e.g., forestry harvest plan). A few of the proposed measures, however, took the form of specific practices (e.g., nutrient management and pesticide management).

A problem with the approach taken most frequently by EPA (i.e., the second approach above) is that essentially no research has ever been directed at the measures proposed by EPA research has traditionally addressed individual practices or simple combinations of practices. Proper application of the scientific method dictates that research be conducted in a manner that eliminates as many sources of unexplained variability as possible so that the effect can be detected amid the variability commonly found in environmental data. Additional practices can easily confound the interpretation of the effect caused by any single practice, and it can be difficult to sort out the effects of one practice vs. another when multiple practices are combined in a study.

Some research has been directed at systems of practices, but it was unlikely that the combinations of practices proposed by EPA as management measures had been studied under enough conditions to provide a definitive national database. EPA, therefore, was confronted with the need to use practice information to estimate the non-point-source control benefits of many of the measures proposed in its guidance. For those proposed measures that resemble practices (e.g., nutrient management) results from the published literature could be applied more directly, but other proposed measures (e.g., cropland erosion, stormwater runoff management) may consist of more than one practice in combinations that are not found in the literature.

The performance expectations in the proposed guidance were based upon a combination of data and best professional judgment. For example, much of the selection of forestry measures was based upon the existence of similar practices in state programs designed to address non-point-source problems. Some data exist regarding the effectiveness of specific forestry practices, but the existence of state programs that incorporate practices or systems similar to the measures strongly affected their selection. In addition, many of the measures are based upon common sense and are ones for which effectiveness can be gauged from visual observation since either sediment or habitat damage are the problems of primary concern.

The power in taking the second approach is the flexibility it provides states; states can employ a specific set of practices tailored to local conditions to meet the performance expectation. EPA is able to specify what is to be achieved at a minimum for all cases across the nation, while not intruding upon "the more intimate land-use authorities properly exercised at the local level" (Studds, 1990). This specificity regarding performance expectations, combined with the flexibility to choose the way in which expectations are met, provides an approach that can be used to meet the complex requirements in Section 6217(g) for the establishment of national management measures.

Summary and Conclusions

Selecting the best available technology for control of non-point sources throughout the nation's coastal zone is an extremely difficult task due to several factors. These factors include the natural variability in non-point-source problems across the nation, the site-specific nature and effectiveness of non-point-source control approaches, and the generally weak information base from which to make decisions regarding the best available technology.

EPA and its many federal and state cooperators found ways to address all problems encountered, and EPA issued proposed guidance that was consistent with the requirements of Section 6217(g). Some aspects of the proposed guidance were admittedly not addressed, but the primary reason for the omissions was the lack of time, not a lack of solutions to problems encountered. Having assembled a tremendous amount of data regarding the effectiveness of management measures, the EPA non-point-source program is in an excellent position to provide technical assistance on non-point-source control measures. In addition, the information collected can be used to assist other federal and state programs that address total maximum daily loads, watershed protection approaches, urban stormwater permits, and the prevention of pesticide contamination to surface and ground waters. Other agencies, such as the U.S. Department of Agriculture, may also benefit from the information gained under this cooperative effort.

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FACTOR ANALYSIS OF TIDE GAUGE DATA: A LOCAL EXAMPLE OF THE MASSACHUSETTS COAST

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Introduction

Sea level is the boundary between land and the oceans, with sea level change defined as vertical movements of this boundary. This analysis first examines the causes, mechanisms and possible consequences of sea level change. This is accomplished through a literature review. Second, a principal component analysis (factor analysis) of tide gauge data will be used to analyze the dominant spatial and temporal patterns of relative sea level change for the East Coast of the United States. The results of this analysis should allow us to reconstruct the eustatic rise in sea level from 1940-80. Finally, the results of selected sea level scenarios, plotted on a U.S.G.S. quadrangle of Eastham, Mass., will be examined to provide a local example of the possible economic losses resulting from potential future sea level rise.

Review of the Greenhouse Effect and its Relation to Sea Level

Concentrations of carbon dioxide (CO_2) and other trace gases (O_3, N_2O, CO, NH_3, SO_2, CFCs etc.), the components of greenhouse gases, have risen substantially in the atmosphere since the beginning of the industrial revolution (Hoffman et al., 1983). These rising concentrations result primarily from combustion of fossil fuels and deforestation. The greenhouse effect implies that as atmospheric concentrations of CO_2 and other trace gases rise, increased absorption of longwave energy will result in increased surface temperatures. One estimate is that if the atmospheric concentration of CO_2 doubles from its pre-industrial concentration of 290 ppm (e.g., 600 ppm) and if trace gases continue to increase at their present rate, then average global surface temperatures most probably will rise from 3-9° C in the next century (Charney et al., 1979).

Sea level will be directly influenced by an increase in earth's average surface temperature through a simultaneous affect of thermal expansion of the upper layers of the oceans and melting of large alpine and land based ice sheets (e.g., Greenland and Antarctica).

Higher sea levels will cause shorelines to retreat through increased erosion of barrier beaches, islands and bluff environments, as well as by increasing passive upland retreat (inundation), which can be detrimental in wetland areas. As sea level rises saltwater intrusion will occur in formerly freshwater bays, rivers and aquifers (Braatz and Aubrey, 1987). Saltwater intrusion in a coastal aquifer will reduce the quantity of fresh water available for municipal, agricultural and industrial uses (Jansen, 1990).

Higher surface temperatures from global warming may increase the severity and frequency of tropical storms. As sea level rises wave surges may also become more severe. As erosion and storms increase, flooding of coastal areas will occur more often, causing an increase in the destruction of coastal buildings and protective structures. Rising water tables will cause the soil to saturate faster, intensifying coastal flooding during storms (Canning, 1991).

Tidal wetland loss due to water logging of the soils from inundation, erosion and salt water intrusion will preclude losses of shellfish, finfish, crustaceans, and those species who depend on the wetlands for forage and cover. It is estimated that 78 percent of the commercial fish catch are estuarine dependent species (Millemann, 1989). Sport and commercial fisherman will next experience reduced harvests and a resulting loss of revenue. Other animal species who prey on wetland-dependent species will also decline.

Loss of sedimentary beaches may worsen the survival ability of certain threatened species, such as marine turtles and shorebirds. As erosion increases, the aesthetic nature of sedimentary beaches will decline, affecting the recreation and tourist industry (Jansen, 1990).

Coastal port operations may need to be modified because of changes in near-shore processes. Coastal industrial facilities may have to retrofit fresh water cooling intake systems to accommodate increased salinity (Jansen, 1990).

Scientific Background

Sea level is dynamic. Small changes in sea level (e.g., one meter) occur on a daily basis. Those changes are caused by changes in atmospheric, hydrographic and oceanographic phenomena (e.g., as a result of daily lunar tide changes, wind, waves, air pressure, river runoff). Large variation in sea level (i.e., hundreds of feet) occur on a long-term basis over thousands of years as a result of sea floor spreading or glacial melting. Large changes in the sea level are caused by mechanisms or events that cause a global or eustatic change in sea level.

Mechanisms Causing Long-Term Changes in Sea Level

Those events that cause a eustatic change in sea level include: cryospheric melting (glacio-eustacy), thermal expansion of the upper layers of the ocean (thermal eustacy), changes in the Earth's magnetic field (geoidal eustacy), and geometric changes of the ocean basin caused by sea floor spreading. The first two mechanisms will be discussed below:

Glacio-eustatic fluctuations in sea level result from the expansion (absorption of water in the form of ice or snow) or contraction (release of water) of large ice sheets or alpine glaciers (cryosphere) on the earth. Glacio-eustacy causes dramatic vertical changes in the sea level. For example, during the peak of the latest Wisconsin age ice advance, 15,000 years before present (YBP), sea level was between 60 and 150 meters lower then present (Revelle, 1983; National Research Council, 1987; Emery, 1980). In contrast, during the last interglacial (Eamian), 120,000 YBP, sea level was 6 meters higher then present levels (Revelle, 1983). Sea level variation over the past 160,000 years is shown in Figure 1.

Presently, the earth lies in an interglacial period. However, if the cryospheric areas were to experience increased melting, due to global warming, then large changes in sea level would be the result. At present 80 percent of the existing fresh water on the earth is locked up as ice or snow in Antarctica and Greenland.

One of the most pressing issues concerning the future cryospheric contribution to sea level rise is the possible disintegration of the West Antarctic Ice Sheet (WAIS). If the WAIS disintegrates then sea level would rise up to 6 meters (Jacobs, 1986). The WAIS is important because it is grounded on bedrock below sea level. Warming of oceans waters in the Antarctic Ocean may cause lubrication of the base of the ice sheet resulting in a rapid surge of ice towards the ocean. Further, melting of polar areas could cause a change in Earth's albedo (Untersteiner, 1984). This would result in positive increases in solar radiation storage at the surface of the earth with a net effect of warmer temperatures.

Thermal-eustatic changes in sea level result from changes in surface temperature. Cooler temperatures cause oceans to sterically contract (changes in the spatial atomic structure) which causes sea level to fall. Likewise, with warmer temperatures the oceans sterically expand causing a rise in sea level. However, the exact correlation between thermal eustacy and surface temperature is poorly understood. Gornitz et al., (1982) found a positive relationship between measured sea level and a curve representing global temperature trends, concluding that "part of the sea level rise may be attributable to thermal expansion" of the upper layers of the ocean.

Sea Surface Topography (Short-Term Changes in Sea Level)

Not only does sea level vary, but the ocean surface is not perfectly smooth. Like the surface of the Earth, it contains both depressions and expansions. Sea surface topography is the term used to describe this variation in vertical height of sea level. Sea surface topography is the departure of the mean sea level from the geoid (Kidson, C., 1986).

Atmospheric, oceanographic and hydrospheric phenomenon effect sea surface topography (i.e., atmospheric pressure, El Niño-Southern Oscillation, wind stress, temperature variations, currents, salinity, precipitation, river discharge, etc.). Sea floor topography also affects sea surface topography. These effects are most pronounced in shallow regions of the oceans where tide gauges are most commonly located.

Fortunately, tide gauges can filter out short term changes in sea level caused by variations in sea surface topography. This is accomplished by obtaining the mean of the tide gauge data for a short period of reference (day to month). When short term changes in sea level caused by variations in the sea surface topography are removed, tide gauge data can be used to determine the eustatic component of sea level rise or fall for a given period of time. Unfortunately, movement of the land is also documented on tide gauge data.

Movement of the Land

Tide gauge data also contain movements of the land as well as that of the sea. Movement of the land occurs due to isostatic effects caused by glacial and hydrostatic loading and unloading, volcanic eruptions, earthquakes, sediment compactions and interstitial fluid removal (i.e., groundwater withdrawal or petroleum and gas extraction). We can consider this to be the "noise" inherent in sea level data.

Glacio-isostacy, a form of neo-tectonism, is a term used to define either subsidence or emergence of the land following large scale glaciation. Many tide gauge stations in the northern hemisphere, due to the retreat of the most recent Wisconsin age glaciers (15,000 YBP), are influenced by glacio-isostacy. Thus, understanding the effect of glacio-isostacy is of vital importance for separation of the effects of sea level rise from those of land level adjustment in tide gauge data.

Glacio-isostatic subsidence and emergence occurs in many portions of the world. In the northeast coast of the United States isostatic emergence and submergence is taking place due to a relaxing of the glacial forebulge that formerly covered the whole area. Meanwhile the centrally glaciated region in Canada is rebounding. Aubrey and Emery (1989) believes that 44 East Coast tide gauge stations are influenced by this affect. Deletions of this "noise" leads to a eustatic rise in sea level of 1.0-1.5 mm/year.

Earthquake activity and volcanic eruptions also effect tide gauge measurements by moving the land that holds the instrument. New geodetic technologies such as Very Long Baseline Interferometry, the differential Global Positioning System and absolute gravity meters now allow discrimination between land motion and ocean change (Aubrey and Emery, 1989).

Factor Analysis of Tide Gauge Data

An examination of the past century's rise in sea level, through the use of tide gauge data, may indicate the trend in the future position of the sea level. Estimates of this centuries eustatic rise in sea level range from 5-30 cm (Braatz and Aubrey, 1987).

Because land movements and oceanographic changes occur with varying magnitudes around the Earth, examination of global tide gauge data would be inappropriate. Regional studies of tide gauge data where known movements of the land are understood and which can be subsequently subtracted from the raw tide gauge data may prove more useful in isolating the eustatic signal in sea level data.

Past analysis of the Eastern United States coastline has revealed highly variable spatial and temporal changes in sea level (Aubrey and Emery, 1983; Braatz and Aubrey, 1987). Increases were found in the rate of sea level rise from Pensacola, Fla. to Cape Hatteras, N.C., with decreases from Cape Hatteras to Boston, Mass. and increases in the rate from Boston to Eastport, Maine (Aubrey and Emery, 1983). These scientists believe that isostatic rebound caused by the last glaciation is the cause for the trend in the northern regions and that oceanographic and hydrographic effects are forcing the trends in the southern regions.

The purpose of this analysis is to verify the results of past examinations of sea level trends of the Eastern United States coastline using factor analysis of tide gauge data. If past interpretations of the eustatic, isostatic and oceanographic factors that produce temporal and spatial variability in relative sea level in the eastern United States coastline is correct, we can determine that this work is verifiable.

Methods of Factor Analysis

Data used in this analysis consist of yearly mean sea levels from 1940-1980 for 25 Eastern United States tide gauge stations provided by the National Oceanic and Atmospheric Administration (Hicks, 1983). The tide gauge data series was examined for large jumps and gaps due to inoperation or station movement. Gaps were filled in with the mean of that particular tide gauge series. Aubrey and Emery (1983) analyzed 26 stations from 1940-1979 (including stations from the West Coast) and Braatz and Aubrey (1987) examined 44 stations from 1920-1983, along the eastern North American coast (including stations in Canada).

Factor analysis was applied to the tide gauge data to most efficiently determine the dominant temporal and spatial structure of the data. Aubrey and Emery (1983) note that the advantages of factor analysis over linear regression include:

The technique is objective, and does not impose a pre-determined form to the data;

It provides an objective means of ranking uncorrelated modes of variability to eliminate weak signals or "noise" from the data;

It facilitates interpretation of spatial and temporal variability;

It produces modes of variability which are uncorrelated with one another;

It represents modes of change which are coherent in both space and time in the most efficient way possible.

Eigenvalues and eigenvectors are calculated from a correlation matrix of the standardized values. Standardizing the data sets each stations mean to zero and each stations variance to unity. This is done so as to minimize the dominance of any single sea level station.

Three important results can follow from this type of analysis. First, if the areas where the fastest relative rates of sea level rise are occurring can be determined, we can provide our results to those communities which will be affected. Stabilizing the coast is important for many communities. Second, the spatial and temporal structure of relative sea level rise will help clarify causes and time scales of variation in sea level (Aubrey and Emery, 1983). Finally, if results similar to those of prior analysis are determined to be correct we can conclude that the earlier work is verifiable.

Results of Factor Analysis

Factor analysis of tide gauge data supplies both temporal and spatial functions that explain diminishing amounts of the total variability of the data. Each factor pattern has a corresponding temporal score which explains the same amount of the variance (Braatz and Aubrey, 1987). Most of the total variance of the data in this analysis (87.98 percent) is explained by the first three eigenvalues (the first, second and third eigenvalues account for 73.42, 11.28 and 3.28 percent, respectively).

The first temporal score is interpreted as the strongest indicator of sea level change. The first temporal score graph from this analysis displays a good positive trend (^{b}1=.27446; Fig. 2). We can conclude then that relative sea level has been rising for the past forty years for all those stations that score high on the first factor pattern. Examining the factor pattern graph (Fig. 3) we can see that most stations have high positive values for the first factor pattern. The graph does show a trend of higher values for mid-Atlantic stations. This verifies that most stations have experienced increased rates of sea level rise for the forty year period. Braatz and Aubrey (1987) and Aubrey and Emery (1983) provide similar results (cf. Braatz and Aubrey, 1987, p. 33, Fig. 2 and p. 34, Fig. 3; cf. Aubrey and Emery, 1983, p. 27, Fig. 4, bottom graph and p. 28, Fig. 5, bottom graph). However, note that the rates of relative sea level rise was not the same for all stations. The second temporal eigenfunction may describe the difference in the rate of sea level rise among stations better than the first temporal eigenfunction.

The second temporal score of this analysis (Fig. 4) yields a small negative trend (^{b}1=-0.013705). Thus, the rate of sea level change has been falling for those stations that score high on the second factor pattern. The second factor patterns (Fig. 3) provides medium positive values for southern stations and low negative values for mid and northern stations. Mid and northern stations are experiencing an increased rate of sea level change compared to southern stations for the temporal sampling period.

Examining Aubrey and Emery's (1983) second normalized temporal eigenfunction we can see that their results are a complete inversion of the results from this analysis (cf. Aubrey and Emery, 1983, p. 28, Fig. 5, bottom). Re-checking the results of this analysis to see if an error had been made concerning this second temporal eigenfunction produced no differences in the results. There seems to be no answer for this bizarre anomaly, although the inversion does not change the results of this analysis. Braatz and Aubrey (1987) show a slight positive trend in their second normalized temporal eigenfunction (cf. Braatz and Aubrey, p. 34, Fig. 3). They examined stations from 1920-1980. A close examination of this graph shows that rates of relative sea level change increase rather quickly at the beginning of the 1930s. From 1930 to 1980 the rate decreases slightly with a lot of variance. This difference in the temporal sampling period explains why their second temporal eigenfunction is different from the results of this analysis.

The third normalized temporal eigenfunction (Fig. 5) shows a decreasing rate of relative sea level change over the 40-year period (^{b}1=-0.026038). Results from the third factor pattern (Fig. 3) show varying low positive and negative values. Boston, Mass. (BSM) and Portsmouth, N.H. have the highest factor pattern; therefore, these stations are experiencing decreasing rates of relative sea level change compared to all other stations. Braatz and Aubrey (1987) provide inverted results similar to those experienced in the second temporal normalized eigenfunction (cf. Braatz and Aubrey, p. 34, Fig. 3). It was determined that differences in the temporal sampling period is the reason for the discrepancy.

Relative sea level movement for the 40-year period was obtained by multiplying the beta-one coefficient of the linear regressions from each of the normalized temporal eigenfunctions with the spatial factor patterns (Fig. 6). The rate of relative sea level movement is highly variable along the coast. The rate of relative sea level movement increases as one proceeds northward from about 2 mm/yr at the Florida stations to a maximum of 2.683 mm/yr at the Portsmouth, Va. station. From Portsmouth to Newport, R.I. the rate of relative sea level movement decreases slightly. North of Newport the rate follows a generally decreasing trend. The results of this analysis agree well with those provided by Aubrey and Emery (cf. Aubrey and Emery, 1983, p. 26, Fig. 3). Braatz and Aubrey's (1987) graph (cf. Braatz and Aubrey, p. 35, Fig. 5) shows a slight deviation from the results of this analysis. Uneven temporal sampling periods may explain this difference. Perhaps the rate of relative sea level has changed for the area analyzed.

Calculation of the residual sea level was obtained by subtracting estimates of the isostatic adjustment from the relative sea level (Fig. 7). The isostatic adjustment values were obtained from Braatz and Aubrey (1987). The estimate values for the isostatic movement of the land are shown in the relative sea level movement graph (Fig. 6).

The results from this analysis are similar to those results provided by Braatz and Aubrey (1987) and Aubrey and Emery (1983). Differences between the figures are visible. For example, Braatz and Aubrey's (1987) graph (cf. Braatz and Aubrey, 1987, p. 35, Fig. 5) peaks at Charleston, S.C. while the results of this analysis peaks at Key West, Fla. The different temporal sampling periods may be the reason behind this difference. We may estimate that the rates of residual sea level movement have decreased at Charleston, S.C. Further analysis will be needed to predict the reasons behind this change. The equally weighted average of the residual sea level movement is 1.127 mm/yr. Braatz and Aubrey (1987) and Aubrey and Emery (1983) provide similar results of 1.2 mm/yr and 1-1.5 mm/yr, respectively.

Conclusion of Factor Analysis

Factor analysis of tide gauge data along the Eastern United States coastline reveals important variations in relative sea level. According to Braatz and Aubrey (1987) more than half of the variance of relative sea level can be explained by isostatic processes. Thus, one half of the relative sea level rise is attributable to eustatic events.

The results of this analysis differ very slightly from the two works discussed. The temporal structure (the first temporal score) of this analysis agrees well with the previous works. Differences in the temporal sampling period may be the reason for the slight discrepancy. Braatz and Aubrey (1987) believe that the rate of relative sea level rise has increased since 1934. They believe it may be due to a change in the rate of isostatic adjustment of increased thermal expansion of the upper layers of the ocean. It is possible that global warming due to the greenhouse effect is forcing this thermal expansion although further analysis will be needed to prove this assertion.

Area Analyzed (An Example of the Effect of Sea Level Rise)

Predicted rises in sea level were plotted on a land use map of Eastham, Mass. to provide a local example of the possible economic effects of sea level rise. Four different sea level rise scenarios were plotted on a land use map (1 ft., 4 ft., 11 ft. and 20 ft.). The 1-foot scenario is a continuation of the historical trend in sea level rise at Cape Cod. The 4- and 11-foot scenarios are EPA's mid range low and high, respectively, sea level estimation for the next century (Hoffman et al., 1983). The 20-foot scenario is the possible catastrophic effect for a collapse of the WAIS (Mercer, 1978). Area was calculated for each land use type affected by each sea level scenario using a planimeter. The land use map and parcel values were obtained from the Eastham tax assessor.

The total economic loss in terms of a loss of property or structure for each sea level rise scenario was obtained in a three step method. The first step was to obtain the average value of a parcel for each land use category. This was accomplished by dividing the total value per land use category by the number of parcels for each land use category. The result is the average value per property for each land use type. The next step was to obtain the average value per acre for each land use type. This was accomplished by dividing the average value per property by the average property size. The average property size was obtained through estimation. The result is the average value per acre for each land use type. This value was then multiplied by the number of acres affected by each sea level rise scenario for each land use type. The result was the total economic loss (in dollars) per sea level rise for each land use type.

Results of Area Analysis

The single-family land-use type is the highest affected land use type given any sea level rise scenario (Fig. 8). If the WAIS were to collapse then the combined single family homeowners in Eastham will lose over $110 million of property value. The potential developable land and commercial land use type would also be seriously affected by the sea level scenarios.

Conclusion of Area Analysis

Sea levels will ultimately rise and the losers will be private homes, transportation and commerce as well as natural coastal ecosystems. Giese (1987) estimates that from 1980 to 2025 Cape Cod, Mass. will lose between 3,000 to 10,000 acres of upland—land that is valued at $1 million per acre. Thus, by 2025 Massachusetts may lose between $3 and $10 billion. This analysis has shown that the potential economic loss for each land use category increases for each successively higher sea level scenario. These results should justify increased spending for coastal stabilization, planning and scientific predictions.

Conclusion

In this analysis we discussed the direct and indirect relationship between global sea levels, thermal expansion of the upper layers of the oceans and melting of large land based ice sheets and glaciers. Global warming caused by the greenhouse effect may increase eustatic sea level through large-scale thermal expansion and glacial melting. Because the ocean surface contains depressions and expansions and is directly affected by short-term oceanographic, meteorologic and climatologic processes, it was determined that an examination of tide gauge data may indicate the true rate of eustatic sea level movement.

A factor analysis of Eastern United States tide gauge data was performed to determine the dominant temporal and spatial modes of sea level change for the past 40 years. The results of this analysis agreed well with previous works and we verified that their work is correct. The residual sea level movement of this analysis was calculated to be 1.127 mm/yr.

Eastham, Mass. was analyzed to determine the effect of predicted sea level rise scenarios on land use type. The results indicate that even the continuation of the historical trend would produce significant losses on all land use types. The author recommends increased spending for planning and other activities related to the coastal zone.

Acknowledgments

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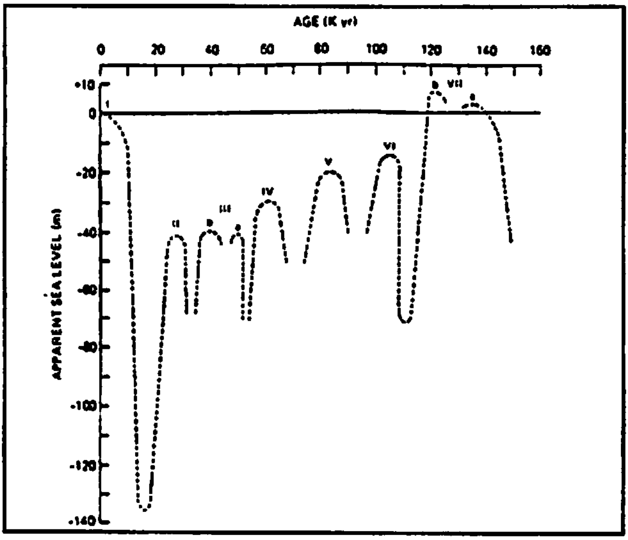

Figure 1. High stands of sea level during the past 150,000 years. Note 6-m terrace above present sea level 120,000-125,000 years ago, and 2-m terrace 135,000 years ago. (Source: Moore, 1982.)

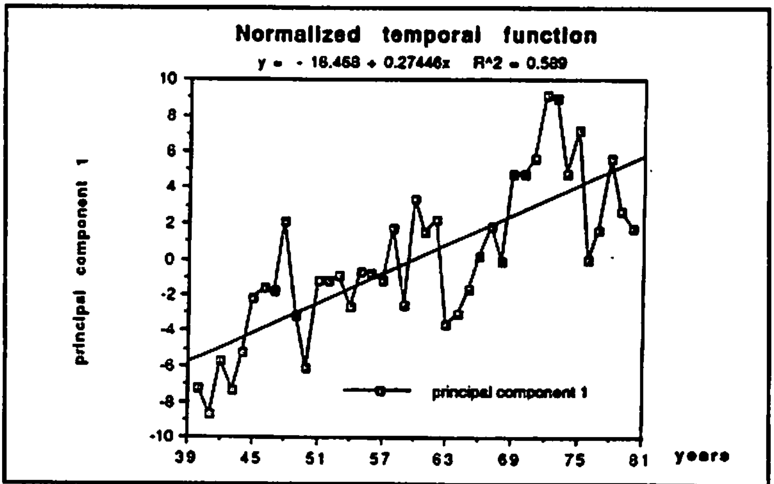

Figure 2. First temporal score of factor analysis of 25 eastern U.S. tide gauge station data, 1940-1980.

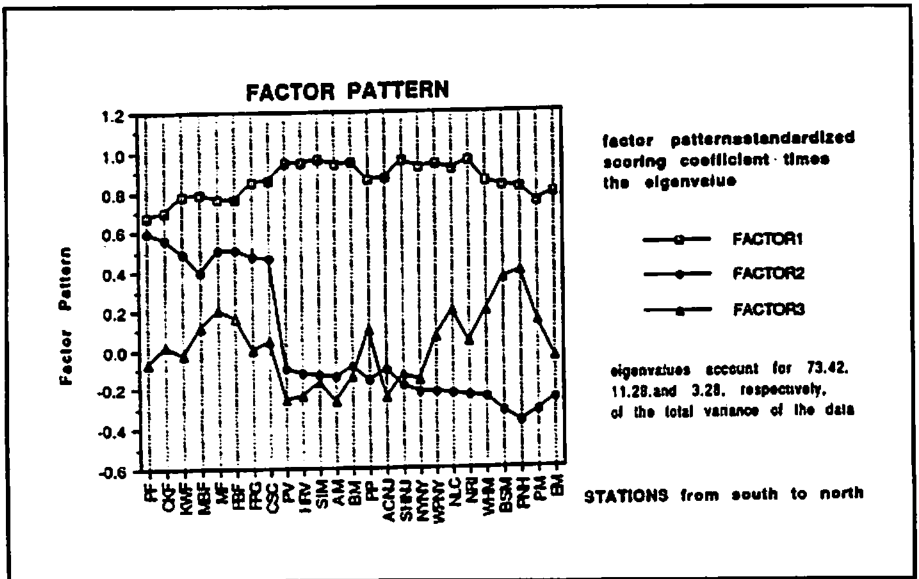

Figure 3. Factor patterns from factor analysis of 25 eastern U.S. tide gauge station data, 1940-1980.

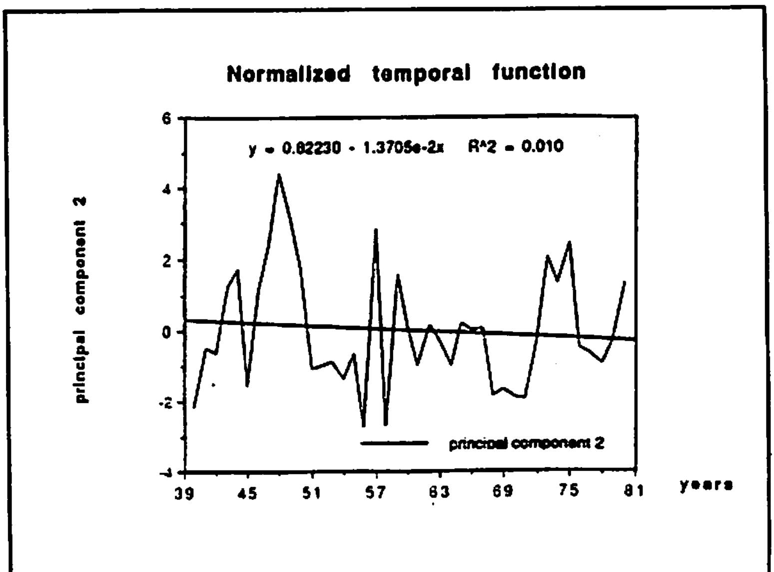

Figure 4. Second temporal score of factor analysis of 25 eastern U.S. tide gauge station data, 1940-1980.

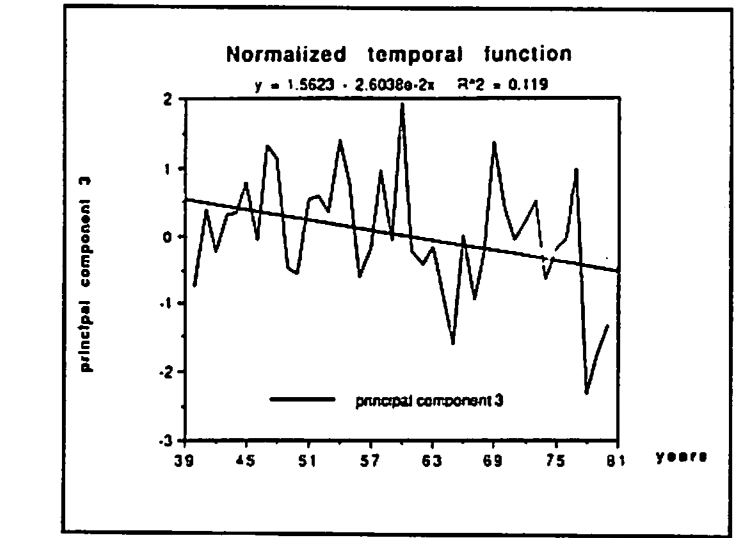

Figure 5. Third temporal score of factor analysis of 25 eastern U.S. tide gauge station data, 1940-1980.

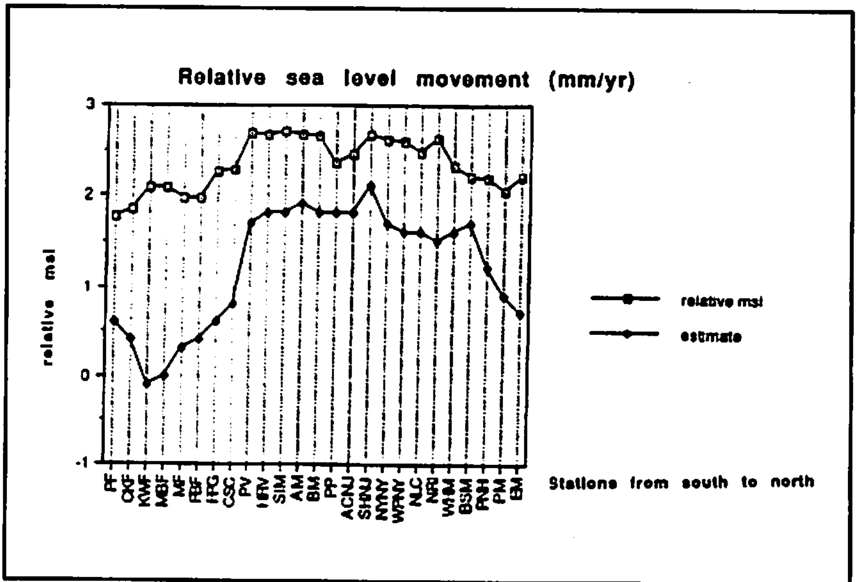

Figure 6. Relative sea level movement at 25 eastern U.S. tide guage sites, 1940-1980.

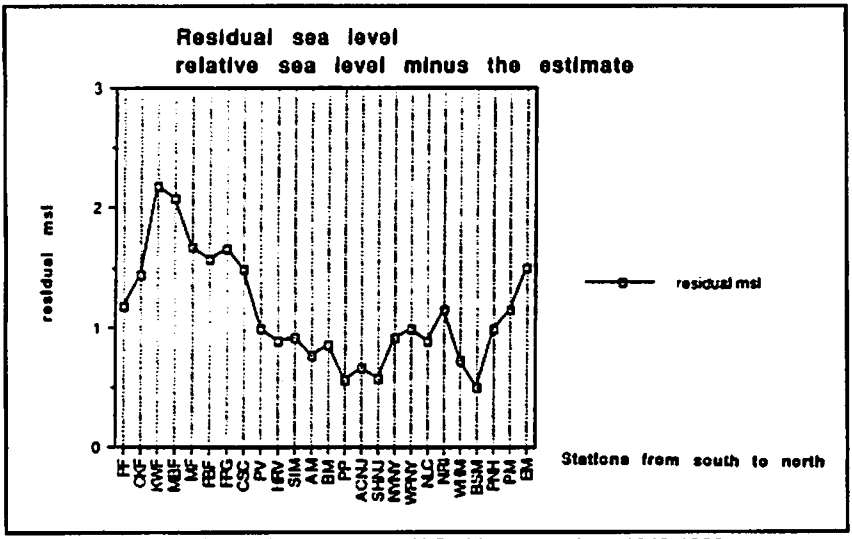

Figure 7. Residual sea level at 25 eastern U.S. tide gauge sites, 1940-1980.

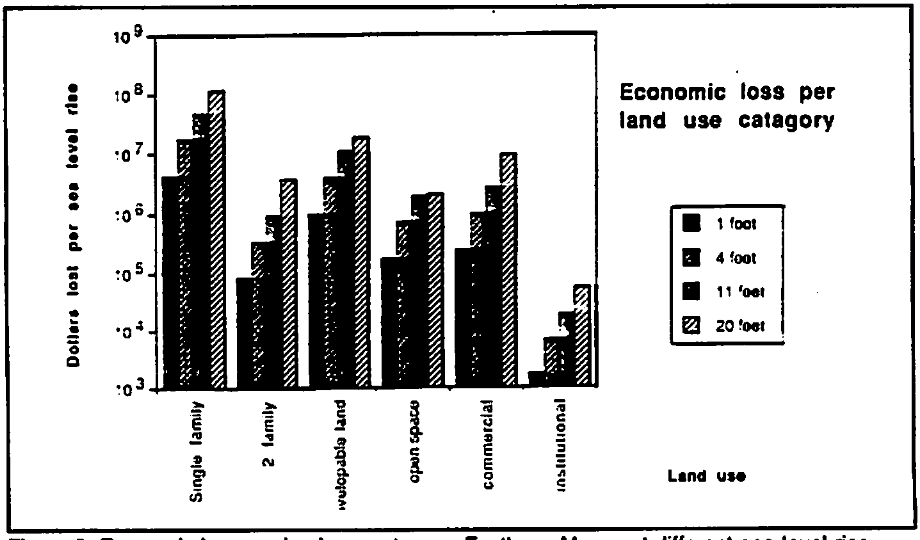

Figure 8. Economic loss per land-use category, Eastham, Mass., at different sea level rise scenarios.

HOLDING THE LINE ON WETLANDS: A ROLE FOR THE SOUTH ATLANTIC STATES

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As the federal government vacillates in its determination to formulate and maintain a consistent national policy on wetlands protection, several states are in various stages of beginning debates regarding their participation in the national wetlands protection effort now known as the "§404" program. That section refers to a provision of the present version of the Federal Water Pollution Control Amendments of 1972, now called the Clean Water Act (CWA), that is intended to protect water quality by controlling the discharge of dredged and fill material into wetlands.

While all states but one have chosen to remain aloof from the inevitable controversies that swirl about the regulatory intrusions of the §404 program, many of them have some sort of freshwater wetland protective state policy. This paper focuses on what one state, Georgia, has accomplished in living up to its self-proclaimed sensitivity to environmental protection issues, and it compares this claim with a recently enacted, ambitious land-use-influencing policy that expressly but generally addresses the issue of freshwater wetland protection.

That policy is found in legislation that responded to recommendations made by a diverse, high level commission that was appointed by the governor in 1987 to bring Georgia's local land use planning procedures into the 21st century. This 35-member group, called the "Growth Strategies Commission," had two basic goals: first, to propose a plan or course of action that would accommodate growth while maintaining some undefined, existing "quality of life"; and second, to improve this elusive "quality of life" in "low-growth" areas through practical programs aimed at economic development. One has to know Georgia politics to appreciate the potential for environmental damage in these two apparently contradictory policy goals.

The growth strategy that eventually emerged from this group of classic insiders was a rather sophisticated restatement of the most pleasant dreams of any Chamber of Commerce, but it revealed vastly improved attitudes toward and provisions for environmental protection. The commission's plan addressed nine topical elements that include almost every area of human community concern, but I will address only those that relate to wetland protection and local, state and federal government interaction in that context.

There is a historic tension in Georgia between people in rural counties and "city people"—spelled "Atlanta." This distrust has pre-Civil-War roots, and its ultimate expression was in the now discredited county-unit voting system. However, even now, people in Georgia's rural areas are especially sensitive to oversight and decrees emanating from the central state government. This dynamic was one of the fundamental reasons Georgia was unsuccessful in promulgating a program that was approvable under the federal Coastal Zone Management Act (CZMA). Against this traditional state of affairs, the degree to which recommendations of the Growth

[1]Funding for attendance of this conference was provided by the Marine Extension Service, University of Georgia.

Strategy Commission were incorporated into legislation is very significant, and it portends an improved and more rational approach to environmentally sound local government action.

Another element of this historic tension between local and state government in Georgia, and the resulting implications for wetland protection, arose in the context of "zoning and planning"—activities once seen as tenets of Marxism in Georgia! Initially, these governing prerogatives were made respectable for and available to local governments through an explicit constitutional amendment. Subsequently, the authority for local governments to "plan and zone" was the subject of several other constitutional amendments! Thus, central government statutes affecting various manifestations of "zoning" have been threatened with constitutional challenges, the effect of which has been to either chill enlightened central, holistic perspectives or to excuse leadership neglect of growing environmental problems that transcended political boundaries. However, after a bizarre chain of events that is typical of Georgia politics, exclusive authority to "zone and plan" remained the province of local governments, but there was included in the constitution a specific reservation of authority to the state to protect "natural resources, the environment, and vital areas." This has been a rarely used state-level authority in the context of land use control.

When the state constitution was recodified and amended these changes included the areas that deal with the authorities of local and state governments to influence land use. Rather than the initial language that excluded state level involvement in "zoning," the new language is that: "The governing authority of each county and of each municipality may adopt plans and may exercise the power of zoning. This authorization shall not prohibit the General Assembly from enacting general laws establishing procedures for the exercise of such power." The 1983 constitution also addressed specifically the subject of land use as follows: "Without limitation of the powers granted under Paragraph 1, the General Assembly shall have the power to provide by law for: Restrictions upon land use in order to protect and preserve the natural resources, environment, and vital areas of this state." Regarding state government's power and authority *to affect land use decisions that impact wetlands*, I believe the state constitutional provision *resembles* the commerce clause power of the federal constitution as it has been applied to wetlands *though it is not nearly so sweeping*. Whether the legislature will ever have the courage and vision to actually test the scope of this authority is another question. I predict that it *will not* and that, absent an imaginative extension of this clear grant of power, the state will fail to qualify for "delegation" of permitting authority pursuant to provisions of §404 of the CWA. However, this will be a failure of will rather than of constitutional *authority* because I believe the language quoted above is clearly adequate to the task.

Historical events and attitudes that shaped federal-state relationships in the environmental law revolution of the early '70s still must be kept in mind as the federal government allows states to assume responsibility for wetlands protection. You may recall that short-term self-interest and economic competition among states had allowed development of highly variable commitments to comprehensive environmental protection. States vied with each other to attract industry by promising pollution control leniency or otherwise simply did not address all sorts of depredations on our various "commons."

But this is getting ahead of the facts. Georgia has enacted other progressive statutory provisions potentially applicable to freshwater wetlands; and the state Department of Natural Resources has promulgated rules that are applicable to "comprehensive planning" and "zoning" activities of local governments. The basic aim of these statewide regulations is to affect the *manner* in which local governments exercise their zoning and planning authority regarding how permitted activities impact "... natural resources, the environment, and vital areas ..." of the state, including wetlands.

Before I describe the specific and modest efforts of the state to protect freshwater wetlands, I will briefly review some of the major statutory and regulatory provisions that govern federal suspension of permitting authority in deference to state assumption of that responsibility.

Section 404(g) allows governors who desire to administer state individual and general permit programs to submit to the Environmental Protection Agency (EPA) their statutes, regulations and other legal authorities for evaluation regarding their adequacy to implement federal policies aimed at protecting wetlands. Waters that are "navigable" under traditional tests and tidal waters are excluded to states under this option. Essentially, this limitation would reserve to the Corps of Engineers its historic jurisdiction under the Rivers and Harbors Act.

The submission requesting suspension of federal permitting must be accompanied by a statement from the state attorney general that the laws of the state provide sufficient authority to carry out the wetlands protection program. (If Georgia had had the existing constitutional authority during the period it was considering participation in the CZMA program, the state could have exhibited the authority, if not the determination, to meet the legal prerequisites of that coastal resources program.)

The EPA Administrator will make an assessment of the legal adequacy of the state submission according to several conditions and standards set out in the CWA itself. Probably the most significant such requirement is that the state must have authority to issue permits that "... apply, and assure compliance with ... guidelines" established under §404(b)(1) of the CWA. I am sure that most of you who are involved in coastal matters already know of the imperfect but tremendous implications of the §404(b)(1) guidelines. Essentially, the guidelines were Congress' way of playing the protectionist role of the EPA against the environment-wrecking penchant of the Corps of Engineers. Even in the greatly compromised status of the guidelines, to require a state like Georgia to comply with them is indeed a great leap forward.

Many substantive, administrative, and enforcement standards that characterize progressive federal environmental regulation are required of a state desiring to assume §404 permitting authority—in the CWA itself. For example, the statute specifies that other water quality (§1317) and discharge criteria (§1343) must be complied with. Terms, modification, [(h)(1)(A)(ii)(iii)] entry, inspections, monitoring, and reporting (§1318) requirements must be met. Notice to the EPA, [(h)(1)(D)], to persons and other states must be given and public hearings afforded in appropriate circumstances [(h)(1)(C)]. Those affected must have an opportunity for written comments on applications and, if such written recommendations are not accepted, written explanations must explain supporting reasoning [(h)(1)(E)]. The state must demonstrate authority to enjoin violations and to impose serious civil and criminal penalties [(h)(1)(G)].

There are standards applicable to an EPA decision to withdraw approval of a state program after it has been found out of compliance with the federal scheme (§1344). The EPA must receive copies of applications and proposed general permits—apparently an effort to maintain continual oversight on state compliance. There are options for the EPA to object to particular permit applications as well as standards by which conflicts in this context must be resolved [§1344(j)]. However, the EPA can abandon much of its oversight role by waiving it at the time it approves a state program "... for any category (including any class, type, or size within such category) of discharge within the State ..." [§1344(k)].

These are the statutory "bare bones" of the Congressional policy to allow states to assume wetlands permitting authority. However, as is usual in such circumstances, the regulatory embellishment adds in volume and detail to the subject. The relevance of discussing these regulatory details is to establish a basis for comparison between what Congress and the EPA have required as pre-conditions to the states' assumption of this most important federal environmental protection program and what Georgia has done to meet those requirements.

EPA's initial §404 State Program Regulations were promulgated in 1980. The states groused so long and so loud, the EPA proposed revisions in 1984. (At that time, only one state had assumed §404 permitting responsibility). The states complaints were the typical ones raised against every effective environmental regulation. They were too burdensome and restrictive; too rigid and mandatory; too paperwork oriented; too intrusive with too much oversight; too inflexible; and, the most classic complaint, too confusing.

Of course this is a virtual catalog of state propensities that allowed the problems to develop in the first instance and that now perpetuate them. About this time, the Reagan administration's anti-environment squads directed their attention to the 1980 §404 State Program Regulations, and an amendment was proposed in October 1984 that responded to the gripes of the states and developers.

In the following discussion, I am noting only those most pivotal regulatory requirements and changes that will be determinative of whether Georgia would qualify for assumption of the §404 program if an application were filed with the EPA today. Several years ago, a terse grant of statutory authority was made to the Georgia Environmental Protection Division to negotiate for assumption of §404 program management. To my knowledge, nothing substantive has come of that grant.

The state's §404 program must be at least as stringent as the federal program. (233.11). This requirement includes such important details as the reach or extent of the state's authority or jurisdiction over wetlands, as well as the scope or variety of activities that are subject to the permitting authority. The state must apply permit review criteria that are consistent with federal criteria.

The regulations do not require affirmative, formal assurance from the governor that the level of funding is sufficient to provide for an effective program. As you know, in the "pre-Earth Day" prehistoric past, this lack-of-funds-ploy was often an excuse for inadequate enforcement. As an example, during my last year of law school, in 1970, I was a research flunky for an assistant attorney general whose responsibility was to enforce the state's (not Georgia) environmental or pollution control laws. Imagine how much *one lawyer* and *one law student* could do as the only enforcement resources for a *whole state*! It was a calculated policy to limit intrusions in the name of environmental protection.

In its §404 program assumption regulations, EPA provides that, while it will not require assurances of adequate manpower and funding from the governor, it will make its own assessment regarding these matters. If there is insufficient funding or manpower, the regulations merely observe that this fact will become evident upon review of submission of the program—but there is no statement of the action EPA is *required* to take in such circumstances. Presumably, because of the statutory provisions involved, EPA would be precluded from approving a state submission that is fundamentally lacking in these particulars. There *is* an explicit recognition in the regulations, [§233.15(i)], that EPA will not approve any state submission that is not consistent with the *statutory and regulatory* provisions applicable to state program submissions.

The federal regulations by which state §404 program submissions are judged are detailed and voluminous—and are characterized, in the preamble discussion, as being modeled after those dealing with state assumption of the National Pollution Discharge Elimination System (NPDES) program under §402 of the CWA. Surely, if a state can administer the NPDES program adequately, it can manage the wetlands protection program, too—even Georgia! By far, the most significant limitations on state implementation of the §404 wetlands protection policies is the requirement that the state program comply with EPA's §404(b)(1) guidelines. I am only going to mention a few elements of those rules here to provide a context for comparison with Georgia's Growth Strategies Commission legislation and regulations.

The Clean Water Act[2]

The EPA §404(b)(1) Guidelines. The basic policy of the Clean Water Act is to "... restore and maintain the chemical, physical, and biological integrity of the waters of the United States ..." which includes the control of discharges of dredged and fill material. That policy is reiterated in the EPA's regulations (§230.1(a)). A basic premise underlying the EPA's implementation of these policies is that dredged or fill material should not be discharged into the *aquatic ecosystem* unless it can be demonstrated that such discharge will not have an unacceptable adverse impact either individually or in combination with other impacts on ecosystems of concern (§230.1(c)). The filling of wetlands and the degradation or destruction of *special aquatic sites* is considered by the EPA to be among the most severe environmental impacts that are addressed by the guidelines (§230.1(d)).

It is customary in the quasi-legislative role of administrative agencies in the U.S. to provide an extensive glossary of terms or "definitions" in each regulation. Two such definitions in the EPA's guidelines have special relevance to one who is

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[2]Note: These materials are largely taken from a chapter written by the author for a book edited by Dr. Bernard Patten on case histories of wetland despoliation around the world—yet to be published—used here by permission of the author.

interested in securing compliant and effective state program submissions. "Aquatic ecosystem" and "special aquatic sites" are two terms that deserve special attention because of the extensive nature of the riparian wetland systems in Georgia. "Aquatic ecosystem" is a broad term meaning "... waters of the U.S., including wetlands, that serve as habitat for interrelated and interacting communities and populations of plants and animals" (§230.3(c)). "Special aquatic sites" means geographical areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection and other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to general overall environmental health or vitality of the entire ecosystem of a region (§230.3(8-1)). That regulatory section incorporates another, (Subpart E), to identify more specifically some examples of "special aquatic sites." In Subpart E, those sites are: sanctuaries and refuges (§230.40); wetlands (§230.41); mud flats (§230.42); vegetated shallows (§230.43); coral reefs (§230.44); and riffle and pool complexes (§230.45). Definition of the "wetlands" mentioned in §230.41 is more extensively defined than in the introductory portion of the regulation that simply restated the three primary characteristics of a "wetland." The additional descriptive language recognizes the transitional location of wetlands and notes the propriety of engaging a delineation specialist in establishing boundaries (230.41(a)(1),(2)). It notes the existence and distinction between obligate hydrophytes, those plants that require saturated soil to survive, and facultative hydrophytes, those that can only tolerate prolonged wet soil conditions. The regulation recognizes physical and hydrological wetland indicators and allows incorporation of these characteristics into a delineation calculation (§230.41(3)). Finally, section (b) of the regulation enumerates the potential loss of wetland functional values from discharges of dredged and fill material. Ironically, the list includes many impacts that result from the "creeping losses" of wetland destruction evident in many small projects. Those losses include various habitat benefits; biological productivity decrease resulting from depth, circulation, periodicity and current pattern and velocity changes, nutrient exchange depression, alteration of vegetative succession toward dry land species, and interference with recharge, filtration and storm buffer functions.

The guidelines provide an evaluation process that a state will be required to employ as a prerequisite to its decision that a proposed activity is consistent with the policies and provisions of the CWA and related regulations. Thus, a state will have to evaluate the projected individual and cumulative impacts from the destruction associated with activities it permits. Section 230.10(a) of the Guidelines, among other good things, requires a "practicable alternative" evaluation and assessment process.

The "prohibitions" of §230.10(b) are simply specific references to existing *statutory* provisions, compliance with which *does not* depend upon recognition in an agency regulation such as the ones now under discussion. That section prohibits discharges that violate a state water quality standard or a toxic effluent standard; jeopardize the continued existence of an endangered or threatened species or result in the likelihood of destruction or adverse modification of a critical habitat; or violate protective standards applicable to marine sanctuaries (§230.10(b)(1-4)).

Subsection (c) is a type of "non-degradation" prohibition that is characteristic of several U.S. statutes enacted in the past two decades. The policy, in its general expression, is that air, water and other natural systems should not be downgraded if their present condition exceeds minimum federal quality standards.

The guidelines impose a requirement of no "... significant degradation ..." as a pre-condition of the legitimacy of a permitted activity (§230.20(c)). Findings of significant degradation must rest upon *factual determinations, evaluations* and *tests* found throughout the guidelines. What this means is that a state under an approved program cannot grant a permit if it concludes, after going through the requisite procedures, that "significant degradation" will occur as a result of that permit. Not only does this reverse the presumption against the discharge of pollutants that is at the very heart of the Clean Water Act, it leaves the burdensome task to whatever agency is implementing the policies of §404.

A "finding of significant degradation" that will have the effect of precluding the granting of a permit must issue, if at all, after the considerations required in subparts C through F of the guidelines. These subparts include consideration of "... potential impacts on physical, chemical, (Subpart C), biological, (Subpart D), special aquatic sites, (Subpart E), and human use, (Subpart F), characteristics ..." (§230.10(c)). The *factual determinations, evaluations* and *tests* of Subparts B and G must *follow* the considerations requirements of Subparts C through F. Subpart B is a broad directive to comply with the EPA's guidelines and includes sections 230.10 through 230.12 that are discussed in detail below.

The purpose of the *evaluation* procedures and chemical and biological *testing* of subpart G, required of a state under §230.10(c), is to provide information to make the *factual determinations* required under §230.11 discussed below (§230.60). Information gathered pursuant to these regulations must be "documented" and therefore must be made available by government agencies to interested parties upon request. There exist rather stern enforcement procedures if such data are not forthcoming. The basic broad purpose of the regulations at §§230.60 and 61 is to discover and characterize contaminants, if any, at both the excavation and disposal sites where dredged and fill material will be discharged.

While it is apparent that a great portion of the regulations found in §230.60 and .61 are focused on problematic and large volume movements of fill material, concern is evident for protecting the natural functions of wetland ecosystems. In the context of even small proposed projects not covered by a general permit, insistence on foreknowledge and disclosure by the permitting agency of just what is about to happen to a unique streamside and wetland ecosystem is well within, and is supported by, such regulations.

One must keep in mind the labyrinthine intertwining of regulatory requirements when attempting to discover or conclude whether a particular activity is affected by a particular regulation, and if so, to what extent. While even the cursory attention given here to these regulations may seem plodding, to be an effective influence on the implementation of public policy one must master these guidelines. Often one will be dealing with scientists or highly skilled technicians whose attention is difficult to attract unless the would-be participant has "done his/her homework." There is simply no substitute for constructing this sort of credibility. Even so, law suits are often necessary to gain the attention the law requires to be accorded to interested citizens.

After noting how the provisions of §230.10(c) incorporated regulations found under subparts C through G, next considered are the mandatory protective requirements of §230.10(d). This section requires *appropriate and practicable steps* to minimize potential adverse impacts on the aquatic ecosystem.

At a minimum, since these regulations are relevant to a state's deliberations on most permit applications, permit applicants must have some responsibility to be aware of and to conform their activities to the various requirements. With respect to the requirements for compliance with the guidelines in subpart B, and based on provisions of the many information-gathering and procedural requirements noted in the various guideline subparts mentioned last above, a state must make many "factual determinations" pursuant to §230.11 when it considers the issuance of a permit. Therefore, a state must determine, in writing, the short-term and long-term effects of a proposal on the physical, chemical and biological components of the aquatic environment that will be affected by the particular activity. These "factual findings" under §230.11 *must* be used in drawing conclusions as to whether §230.10 protective restrictions have been complied with! The history of recent systems-sensitive national-legislation in the U.S. often elicits frustration with such apparent regulatory convolutions. One obvious logical response is to recognize that systems as complex as those regulated by the EPA's §404(b)(1) guidelines cannot be protected by simplistic and abbreviated rules. It is hoped that the summary or skeletal treatment of these regulations will lead to a better understanding of the substance of the guidelines.

The "effects" about which factual determinations under §230.11 must be made include: physical substrate (a); water circulation, fluctuation and salinity (b); suspended particulate/turbidity (c); contaminants (d); aquatic ecosystems and organisms (e); proposed disposal sites (f); cumulative effects on the aquatic ecosystem (g); and secondary effects on the aquatic ecosystem. The regulations in each of these subcategories include many guiding details about how the effects are to be determined. A dominating common thread here and throughout the guidelines is that all relevant facts and factors must be discovered, substantively considered *and* result in ecologically improved or sound decisions that will effectuate the "system-sensitive" goals and policies of the U.S. Congress expressed in the Clean Water Act of 1977.

Discharges must be specified as failing to comply with EPA guidelines if there is a practicable alternative to a proposed discharge that will have less adverse effect on the aquatic ecosystem; the proposed discharge would result in significant degradation; or did not include all appropriate and practicable measures to minimize potential harm; or sufficient information to make a reasonable judgement as to compliance does not exist. In such cases, a state will have to issue a finding or statement that the proposed permit did not comply with the EPA's guidelines [§230.12(a)(3)(i-iv)].

Georgia's Legal Capacity to Assume Authority Under §404. The Growth Strategies legislation directed the Georgia Department of Natural Resources (DNR) to promulgate "minimum standards and procedures" regarding *natural resources, the environment* and *vital areas* of the state. Wetland resources are specifically singled out for what is called "protection" although mandates for an improved end result are virtually non-existent. The legislation requires that these "minimum standards and procedures" be used by local governments in developing and implementing comprehensive plans. When the DNR promulgated the rules thus required, it referred to them as *Criteria for Wetlands Protection.* Apparently, the DNR intends for the words "criteria" and "standards" to be used synonymously.

Presumably, because regulations cannot require more than does the statute pursuant to which they are promulgated, the minimum wetlands criteria regulations (MWCR) provide that local governments "*should* acknowledge the importance of wetlands for the public good in the land-use planning process ..." Thus, the DNR established MWCRs "... for local government consideration of wetlands protection" in their land-use planning processes. The MWCRs expressly are designed only to "... assist in the identification and protection of wetlands, and do not constitute a state or local permit program." While these initial and fundamental limitations virtually preclude conformity with federal program assumption prerequisites discussed above, there is still cause to be encouraged about emerging state attitudes toward wetland protection.

The MWCRs acknowledge the existence and probable application of the federal §404 program to local activities that are proposed for wetland areas, and the role of the state under §401 of the CWA. Section 401 of the CWA gives the states the option to comment on federal permits that may result in any discharge into navigable waters within their jurisdictions. In most cases, the federally permitted activity may not proceed without the state's affirmative certification under §401.

The MWCRs incorporate the definition of wetlands used by the U.S. Army Corps of Engineers and the EPA with a few additional explanatory comments. Intertidal wetlands encompassed within the jurisdiction of the state's Coastal Marshland Protection Act are excluded from the state's definition of freshwater wetlands.

The MWCRs require local governments to define, identify and map certain categories of wetlands and aquatic habitats and include this information in local plans. The categories identified in the regulation are: open water; non-forested emergent wetlands; scrub/shrub wetlands; forested wetlands; and altered wetlands.

Whatever protection shall result from defining, identifying and mapping wetlands, it may not be applicable to wetlands that are less than five acres in size. The MWCRs grant or recognize administrative discretion to disregard "minimum area" wetlands through processes that are conditioned upon the methodology employed in developing the state's wetlands database. At the least, this means that plans and, presumably, their implementation can exempt from classification or protection wetland areas that are less than five acres in size.

Local government land-use plans should address a long list of facts and factors that bear upon the wetlands identified. The MWCRs use the word "consideration" rather than "facts and factors." However, there is no requirement that taking into account such "considerations" must result in any particular protective outcome. In that regard, the MWCRs resemble the ultimate outcome of the National Environmental Policy Act, a federal statute that has been interpreted by the U.S. Supreme Court as not *requiring* environmentally improved decisions.

A list of preferred uses of wetlands is provided in the MWCRs from which local governments can choose to include in their land use plans. Similarly, the MWCRs permit the exclusion from wetlands uses such as toxic or hazardous waste disposal and hazardous or sanitary landfills.

These regulations reflect a positive attitude of the state and of local governments toward wetland protection and wise use. However, state assumption of the §404 permitting authority will require more comprehensive and mandatory legislation and rulemaking before the federal government will suspend its activity in these wetland areas.

THE LAKE BLUFF BILLOW: RE-CREATION OF ILLINOIS' PRE-SETTLEMENT HIGH BLUFF SHORELINE WITH NATIVE VEGETATION AND SOFT-SHORE COASTAL ENGINEERING

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Abstract

A low-cost, low-impact shore protection system using soft-shore engineering and native vegetation has been designed and built for the community beach at Lake Bluff, Illinois.

Intense urban development of the Illinois shore of Lake Michigan has nearly eradicated natural beaches and a native plant community adapted to actively eroding glacial till bluffs. During the early part of the 20th century, bluffs were armored against high lake levels and storm wave attack. This slowed or halted the natural movement of the bluff face that was essential to the maintenance of beaches and the high diversity eroding bluff plant community. The result is an engineered shoreline of groin fields, seawalls and revetments, and bluffs dominated by later stages of successional plants that typically inhabited the more stable zones.

In the past, prairie, savanna or woodland vegetation at the bluff top was transported down the bluff face in discrete clumps of topsoil and glacial till, moving at rates of up to 15 m per year. In some cases, large scale rotary failures created massive slump blocks that slid across narrow beaches into the lake. This produced temporary vegetated headlands, referred to in this paper as billows.

In 1991 an interdisciplinary team of coastal geologists, engineers and environmental scientists cooperated in the reconstruction of a bay-beach, billow and native plant community system for the Lake Bluff Park District, Lake Bluff, Ill. The challenge was to design a system that would look and act like a naturally occurring component while achieving the goal of beach preservation in a manner both aesthetically pleasing and environmentally sensitive. Construction began in the fall of 1991. The first phase of planting of native species will begin in the spring of 1992. Monitoring is planned for five years following construction.

Introduction

In this paper, we describe the reconstruction of a Lake Michigan coastal eroding bluff plant community, armored headland and bay-beach at Sunrise Park, Lake Bluff, Ill.

Lake Bluff is a north shore community located approximately 35 km north of Chicago on the western shore of Lake Michigan. Winter storms coupled with fluctuating water levels have historically caused severe erosion to this section of high-bluffed lakeshore. Construction of revetments, seawalls and groins has provided some bluff protection over the years. Recently, damaged shore protection structures and inadequate amounts of sand in the littoral drift system have caused beaches to narrow, allowing storm waves to once again erode the bluffs in many locations.

The site, Sunrise Park and Beach, is operated by the Lake Bluff Park District and extends 500 m along the shore of Lake Michigan. Most of the park bluffs have been stabilized and are vegetated with a closed canopy of mature trees. The subject of this report is a beach and eroding bluff at the south end of the park. This area is protected by a steel sheet pile groin that is becoming less effective over time at maintaining the narrow beach to the north (Figure 1).

The lakebed and 21-m-high bluffs at the site are composed of Pleistocene Wadsworth Till. The lower bluff is a dense silty clay glacial till. The top 3 m of the bluff is a highly permeable layer of cross-bedded outwash sands and gravel overlain by 0.5 m of topsoil. The water table lies at the top of the clay causing active seeps even during extended dry periods. Gullies form where the seeps are most active. Thin gravel and sand layers in the clay till were observed to aggravate bluff failures by saturating the surrounding clay. Several processes including gullying, soil sliding and rotary failure were observed at the site.

Plan Development

The task, based on several meetings with members of the Lake Bluff Park District Commission, was to develop a plan to expand the beach and protect the bluffs from further erosion and provide access for viewing, walking and sailboating in an environmentally sensitive manner. Following these meetings, draft plans were developed including conventionally engineered structures, beach nourishment and the use of plants for bluff stabilization.

Five public hearings were held in order to share the plans and get input from citizens, neighbors, the Lake Bluff Yacht Club and interested groups including the Lake Michigan Federation, Open Lands, Lake Bluff Garden Club and others.

Coastal Processes Study

In order to design the system it was necessary to understand the site's history and present status of bluff and lakebed erosion and relationships to the sand supply (littoral drift system) and protective structures.

Photographs from as early as 1897 show well-developed wood sheet pile and rock-filled piers on the Illinois north shore. These first piers acted as groins trapping sand on the updrift (north) sides. In addition, Waukegan Harbor, a total littoral drift barrier to the north, was constructed in the late 1800s. A deficit in littoral drift sand caused by Waukegan Harbor and continued lakebed and bluff erosion have flanked and undermined the piers over time. None of these structures remains intact and ruins are a serious hazard to boaters. Many of the wood piers were later replaced with concrete modular groins in the 1930s. The last generation of groins constructed of steel sheet pile in the 1950s and later have recently begun to fail for the same reasons.

Results of a study of Illinois beach and nearshore sand deposits sponsored by the U.S. Geological Survey, Northeastern Illinois University and Illinois-Indiana Sea Grant (Shabica et al., 1991; Shabica and Pranschke, 1992) show the system to be sediment-starved where littoral drift sands moving from the north are diverted offshore by the jetties and breakwaters at Waukegan Harbor. The beach and nearshore sands are typically less than 1 m thick and extend no more than 300 m offshore. Net littoral drift is estimated to be about 10,000 m^3 per year to the south. The potential littoral drift is estimated to be 200,000 m^3 or more per year south.

Construction of groins is no longer recommended for beach protection along the Illinois lakeshore. In 1985, the City of Highland Park commissioned a two-year intensive survey of their 6 km shoreline. At that time 80 percent of the shore was armored. Primary recommendations for short-term management include artificial beach nourishment and construction of breakwaters on the lakeward ends of failing groins (Shabica, 1986). Since then, 12 breakwaters have been built along the Illinois north shore, the most prominent being the Forest Park Project in Lake Forest. Plans for regional beach nourishment proposed by north shore communities are in the formative stages and are being considered by the U.S. Army Corps of Engineers.

Plant Community Study

The modern bluffs along the Illinois lakeshore are dominated by later stages of successional plants that typically inhabited the more stable zones. This, coupled with the intrusion of alien woody plants, severely reduced the diversity of the beach and bluff plant community, particularly the pioneering and early seral stages.

During the early part of the 20th century, large scale planting of woody plant material (thought to stabilize soil movement) such as black locust, coupled with native woody colonizing plants, such as cottonwood, aspen and ash, quickly overtook the newly protected bluff face community. Alien woody plants, buckthorn and honeysuckles also colonized the bluffs or were planted. The resulting shade and aggressive growth suppressed the native plant community. Fragmentation of the original eroding bluff plant community resulted in a net loss of available natural seed source for colonization of areas with recent soil movement.

Plants most suited to the original unstable environment were able to tolerate extremes in soil quality, temperature, moisture and high winds. The species makeup of the coastal bluff plant community was thus a combination of a few hardy survivors of the plant community living at the top of the bluff and species tolerant of the high-energy bluff-face conditions.

To assist in the planning of the development of the plant community on the Lake Bluff site, an existing ecological model was located and studied. One of very few and probably the best remnants of an actively eroding glacial till bluff plant community in Illinois occurs approximately 7 km south of Lake Bluff at Fort Sheridan. All seral stages are present at this site displaying varying levels of disturbance. Plant inventories were completed and the various plant communities analyzed for clues as to the environmental factors that shaped them.

All native herbaceous plants present at the Fort Sheridan site were included in a seed planting list for Sunrise Park. What is not commercially available as seed will be collected at Fort Sheridan and contract grown as plugs for future planting. Additional plants not found at the Fort Sheridan site but thought to have grown at other sites and since lost to erosion were also included in the initial seed mix. A cover crop will be used to protect the new seeding and recently disturbed soils from surface erosion. Annuals and biannual flowers were included to provide immediate aesthetic appeal for the restoration. (The plant list is available from the authors and will be published in a separate report.)

Design of Shore Protection Structures

The bluff and beach protection method determined to be best suited to this site is a combination quarrystone breakwater at the north end of the beach and a armored headland to the south. The armored headland was designed to mimic the large-scale soil slump blocks (billows) observed in areas of high bluff erosion. In this case the headland must be well armored with stone for longevity.

Project Construction

A low crested spur-breakwater 30 m in length was constructed off the sheet pile groin at the north end of the beach shore parallel to the south (Figure 2). The armored headland (billow) was built along the south groin and shore-perpendicular. The billow is constructed of stone surrounding a landward section filled with bluff clays and soil. The billow will be planted with species considered most resistent to this highly exposed part of the system. The stone used in the structures is three- to five-ton boulders of Waterloo quartzite.

The near vertical scarp at the top of the bluff was graded back to a more stable angle. Curtains drains were dug in areas of intense seeps on the bluff face to reduce the possibility of future rotary failure slump blocks. Wave damaged areas at the bluff toe were filled with concrete rubble and quarrystone and covered with local bluff soil.

Beach Nourishment

To assure that the new breakwater and headland will not interfere with the littoral drift system, 8,500 tons of sand and gravel were added to the beach cell. The existing groin at the north end of the beach was buried in the sand and gravel.

Planting

Soils on the disturbed zones of the bluff were protected by erosion control blankets over the winter and will be planted in the spring of 1992. The blankets will be removed and balled and burlaped woody plants will be planted. The undisturbed sections of the north bluff that were revegetated with alien grasses and crown vetch from an earlier restoration project will be herbicided and the entire site will be hydroseeded. Erosion control blankets will be reinstalled on the disturbed soil sections.

No topsoil was added to the site to best mimic the original soil conditions and reduce competition from the annual alien weeds typically present in the topsoil seed bank.

A drip irrigation system will be installed for the balled and burlaped plant material. No watering will be done on the hydroseeded areas. This should minimize surface erosion problems that may occur on the sloped site due to standard watering practices.

Existing woodland plant communities on the undisturbed bluff sections at Sunrise Park will be thinned of invasive alien woody plants and aggressive native colonizers to increase the diversity and quantities of herbaceous plants to help control surface erosion.

Project Monitoring and Management

The project will be monitored for five years to assure that there is no adverse impact on lakefront properties downdrift. The plant community will also be monitored and thinned of invasives and seeded as necessary. As the bluff will be stabilized, on-going management is necessary to maintain the pioneering and early seral stages of succession.

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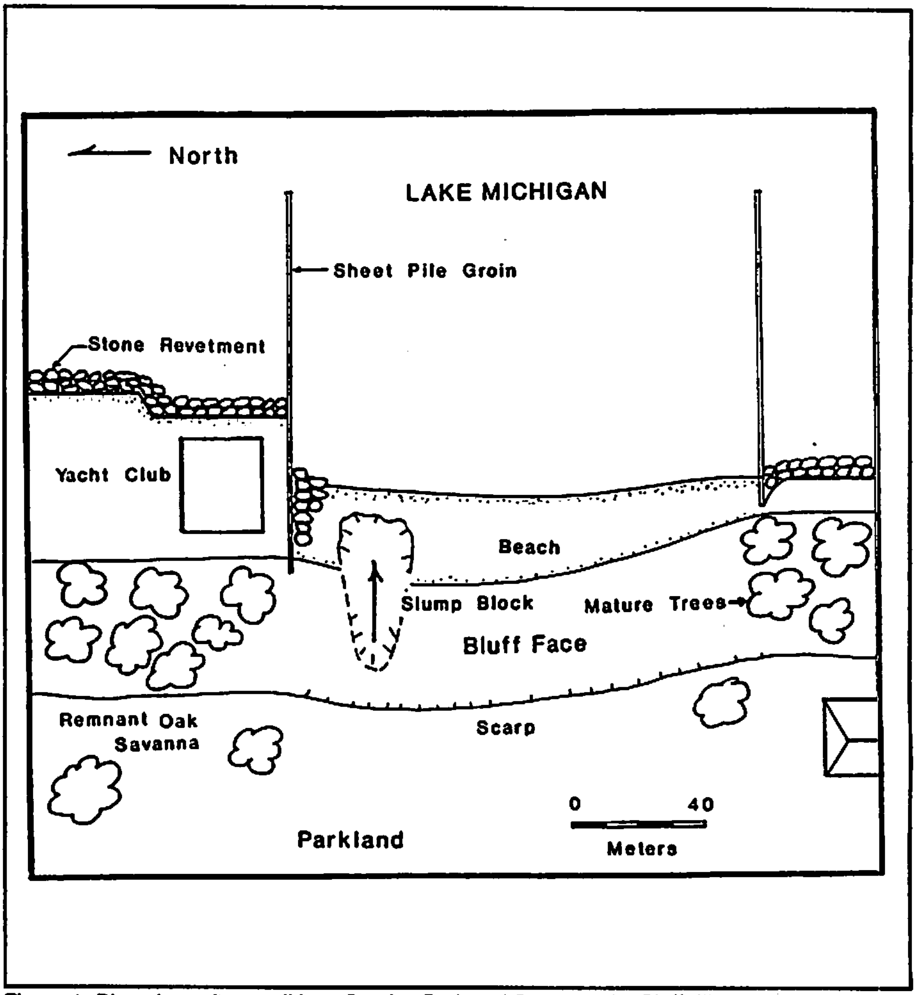

Figure 1. Plan view: site conditions Sunrise Park and Beach, Lake Bluff, Ill.

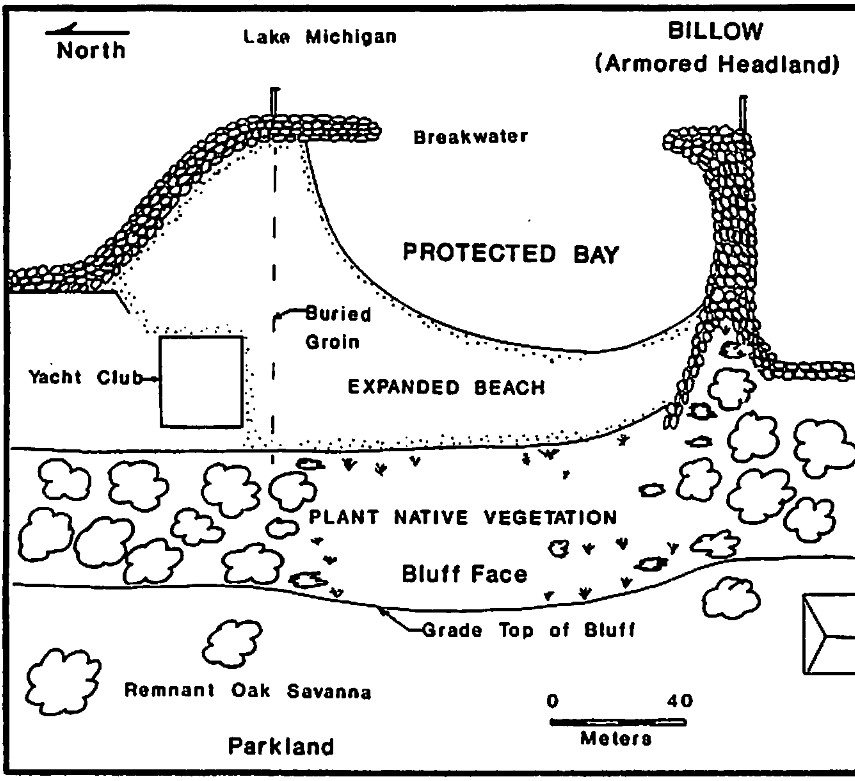

Figure 2. Plan view: Sunrise Park and beach restoration, Lake Bluff, Ill.

Organizing to Manage Coastal Resources

ORGANIZING TO MANAGE COASTAL RESOURCES: COULD CCMPs BE A VIABLE SOLUTION?

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When Congress formalized the National Estuary Program (NEP) as part of the Clean Water Act in 1987, it was an acknowledgement of several realities:

The traditional command and control approach to water quality management is not adequate for estuaries;

Estuary management has to include habitat and resource protection in addition to water quality protection;

Estuaries are affected by multiple sources of pollution and virtually all land uses; and

Some successes have been achieved in estuaries where totally new conceptual frameworks were developed.

Five years into this experimental program, we are probably at a point where we can assess whether some of the unique aspects of the National Estuary Program hold long-term promise for improving conditions in our nation's troubled coastal waters. This afternoon we will look briefly at the estuary program in an attempt to answer, in a preliminary way, whether CCMPs are a viable solution to the problems inherent in managing coastal resources.

CCMP stands for Comprehensive Conservation and Management Plan, and developing a CCMP is the goal of participants in the NEP. The Environmental Protection Agency (EPA) provides funding matched by states, for up to five years, during which time the CCMP must be developed. This CCMP is to include an assessment of problems as well as specific management solutions, detailed as to who is responsible for implementing them and how they will be paid for. EPA has just released a guidance document indicating that the agency is willing to support in a limited way the implementation phase—post CCMP—of the process. Until now, only the Chesapeake Bay and Great Lakes have had permanent EPA programs in place.

There are currently 17 participants in NEP, and more coming. Of these, six are finished or finishing the CCMP process: Narragansett Bay, Long Island Sound, Buzzards Bay, Albemarle-Pamlico, San Francisco and Puget Sound. The CCMPs are the result of a deliberate process of characterization, data assembly, some new research and a great deal of public participation. There are a wide variety of problems and conditions—some are trying to protect threatened resources, others are trying to restore. Some of the newer participants have learned from their senior partners and are jump-starting the CCMP process, developing draft plans within two years! The Massachusetts Bays Program is one of these. The belief is that in most cases, we know what the problems are. Proposing solutions, floating them among program participants, refining and building support for implementation seems to be the preferred approach among many of the new NEPs.

Many of you have been around since the days of the 208 program. If you were disappointed at the outcome of that promising section of the 1972 Clean Water Act, your skepticism about CCMPs is understandable. What is different this time around?

To me, the essence of what is different was captured recently by Dr. Theodore Schad. In a keynote address to the Soil and Water Conservation Society, Dr. Schad said, "We've got the technology but not the institutions." How many times have we seen efforts falter because we do not have the institutional framework that empowers us to effectively combine ideas and technology into coherent policy, and then to implement that policy amidst conflicting demands and constraints? The need for institutions capable of dealing with even more complex issues is great. I think our major success on the Chesapeake has been in the building of a new, informal institution that is dedicated to a consensus-based, collaborative decision making process. This structure enabled the scientific community, managers, legislators, and the public to agree on problems, develop a set of solutions, and work to implement those solutions over a long period of time. We have made many mistakes on the Chesapeake, and we surely haven't solved all the problems, but the atmosphere is positive and the institutional structure enables us to constantly refine programs, develop new policy, find new ways to reach people, keep legislators updated, and maintain a high profile for the restoration effort. Puget Sound has achieved a similar level of support and commitment, and others have the potential to achieve it.

The key to institutional success in the CCMP seems to be the inclusionary nature of the process. All levels of government, elected officials, interest and user groups, scientists and academia are required to be involved, from beginning to end. Given the nature of the problems facing our coastal waters, this is more than appropriate. Authority for the breadth of issues we are confronting lies with a myriad of agencies. Traditional point-source pollution abatement concerns have been surpassed by non-point-source pollution from development, from farm fields, and from automobile tailpipes. Loss of habitat—wetlands, forests, submerged plants—threatens the basic stability of coastal ecosystems. To even begin to address this array of issues, everybody has to be at the table.

The estuary programs present an interesting study in ways to organize. All programs are run by committees, but they are structured in a great variety of ways. But no matter who sits on which committee, successful estuary programs are committed to collaborative decisionmaking based on consensus. The notion of consensus is difficult for many, particularly those in the environmental community. They view consensus as compromise, a characterization I believe is unfortunate. Developing consensus is really a search for common ground and a commitment to implement proposed solutions. The consensus process acknowledges the human component of management. The institutions we seek to build are made real and vital by people. The strength of the NEP idea is its recognition of this. Success is not automatic—but it is possible with the CCMP/NEP approach.

Making and implementing water policy is hard. To succeed in these tasks—and we have not yet fully succeeded—will require knowledge and patience and an extraordinary ability to work together. We need to build new networks and institutions, improve our understanding of complex issues and find long-term solutions and the money to pay for them.

One of the painful lessons we are learning in the NEP is that restoring bays is a "forever" process. We can't simply fix old problems and then go back to business as usual. We are challenged to find new and better ways to utilize as well as protect our bays. We know we have begun to address some of the issues, such as nutrient enrichment. We also know that the issues of the '90s and beyond are tougher than any we've yet dealt with—especially the issues related to growth and coastal development, and to the use of "private" property vs. public benefits.

It seems to me that the estuary program approach to managing offers an example of the wonderful potential of government. From Buzzards Bay to Santa Monica, from Delaware to Sarasota, excitement has been generated and new institutions created. The challenge now is for all who have invested in the CCMP process to commit for the long haul. We must be sure that our CCMPs do not get relegated to the shelf, as 208 did, but that they truly be used as blueprints for estuarine management.

The Mass Media and the Coastal Zone

THE MASS POPULATION/MASS MEDIA LINK IN THE COASTAL ZONE

Paul M. Foer
Adventures Afloat

Election years are always interesting times to comment on the media, for the few things which we know for certain about our media become evident: one, the public hates the media; two, the public loves the media; three, the public cannot live without the media; four, the candidates are equally ambivalent about the media; five, the media determine who the frontrunners are; six, the media completely miss who the frontrunners are; seven, media are weak and effete; and eight, media are strong and coercive. And then there is the one rule about media by which I operate. Everyone wants the media to be biased—as long as they are biased in their favor.

Having said that, I'll now turn our attention to an article about coral reefs from the March 17 *Miami Herald*. This lengthy, front-page piece by writer Dan Keating is about disagreements between researchers and environmental advocates as to risks and problems facing the Florida Keys reefs. I'd like to quote from it directly:

"The underwater scene is a grim one. And a University of Georgia researcher's suggestion late last year that parts of the reef were dying as fast as 10 percent a year startled the world.

"The call to action has led to an ugly collision, this one between scientists and environmentalists, between research and politics.

"Scientists say they want time to be sure. Environmentalists say proof may come too late. The scientific uncertainty, though not unique, can be paralyzing. It forms the foundation of animosity between researchers and activists on many pressing subjects, such as AIDS treatment, global warming and silicone breast implants.

"Begin with what we know: The coral reef is dying. Then again, everything that's alive is dying. To see that reefs die naturally, just look at the existing Florida Keys. They are the old reef that died 125,000 years ago when sea level changed. The new reef grew as a replacement."

The article went on for over 20 paragraphs to discuss the tension between scientists' uncertainty and environmentalists' concerns that may or may not outweigh that uncertainty. This is an amazingly in-depth (no pun intended) article for today's newspapers. It concluded with a marine biologist who said "Scientists don't make good advocates and environmentalists don't make good scientists."

That quote defines why journalists are needed in the coastal zone. Journalists are not supposed to be scientists or advocates. They are supposed to report about what the scientists and advocates say and do.

But what is bothersome about this piece is that while it really told us a lot about a conflict, or rather, a reporter's view of a conflict between what the reporter perceived as two distinct communities, it told us little about scientific and environmental problems and issues of the Florida Keys. I would suggest that the issue of conflict was a bit overblown. Perhaps the real conflict is not between research scientists and advocates, but between those who recognize uncertainty and probability as an issue and those who would dismiss the chance of any negative outcome without unanimous agreement between all partes. But, that would have been a much harder story to conceive, research and write, and to pitch to an editor as well. We rarely see any news story without good guys and bad guys, or an issue of contention. Would there be a story if everybody agreed about the future of the coral reefs? The answer is probably not.

Now let's turn to the colder waters of Prince William Sound where culprits were a little easier for journalists to find, at least according to some of them. Some of you may recall that in the aftermath of the Exxon Valdez oil spill, the Exxon Corporation wanted to donate $50,000 to Alaska Public Radio, claiming that it came with no strings attached! The radio network wisely declined the offer. I would like to share some interesting media quotes from a study I did of newspaper reporting about the spill.

From Coast Guard Commandant Paul Yost, who was President Bush's on-scene commander, "This was not a treacherous area, as you people in the press have called it."

I like that quote because he used the term "you people in the press" thereby lumping me together with Willard Scott, Pat Buchanan, Art Buchwald and maybe even Barbara Walters.

Here is a quote from an American Petroleum Institute Executive who said, "The reporting was extensive, but it could have been more objective." By objective, this oil executive may actually have meant it could have been less extensive.

For the voice of reason and reassurance from the media, listen to this advice from a stock market expert on the radio who said, "I would still hold on to your Exxon stock. After these headlines wash over, there will be others to take their place." What was most important to him was that headlines and not necessarily the oil would eventually wash over.

Now that I've quoted from government and industry, here is a quote from a Sierra Club official who told *Newsweek* that, "People have been calling out of the blue ... this has touched a nerve we didn't know was there." No doubt the public was sending money to the Sierra Club as well as pasting "Boycott Exxon" bumper stickers next to the tailpipes on their automobiles.

It is likely that the only other time so many reporters and film crews ever descended upon Alaska was when three whales were trapped in ice near Barrow. That single event generated as much if not more news media coverage than almost any other environmental story in recent memory. It was perhaps one of the biggest media events in history. One might assume that the worldwide slaughter of marine mammals and destruction of their habitat over many decades has not warranted as much media scrutiny as three lone whales trapped in ice. That was probably because the three whales were given names and had recognizable features.

Covering the environment can be among the most challenging tasks facing a reporter. As with all reporting, issues must be accurately explained in limited space or time. But unlike many general beat stories, understanding and writing the environmental story will often involve much more than just accurate description of an event. It involves the complex interaction of science, health, medicine, economics, government, technology and nature. It becomes even more complex in the coastal zone where terrestrial and marine environments meet and where so many different human groups compete for limited space and resources.

One interesting study of the accuracy of coastal reporting was a 1982 journalism masters thesis by a University of Maryland student. After a thorough content analysis of newspaper reporting about the Chesapeake Bay, Boyd Grove found that there was little if any agreement or overlap between what he found was the media's agenda of Chesapeake Bay environmental issues and the official agendas of scientists and scientific groups in the region. He found that newspapers tended to create conflict where it did not exist and even to downplay it when it did. I have wondered whether an updated study of the same newspapers today would reveal any trends or improvement. I suspect that it would. Can anyone here offer me a grant to undertake such a study?

Let me provide another example. I recently covered a national citizen's volunteer water monitoring conference. The welcoming remarks were provided by Maryland Gov. William Donald Schaefer. After he gave what most journalists would probably have described as a chummy, puffy talk about all the great things he has done to restore Chesapeake Bay and Baltimore harbor, I was disturbed because he told the group that the Chesapeake Bay was becoming cleaner. He apparently failed to mention the collapsed oyster, shad and striped bass fisheries, rapidly accelerating growth and development pressures, poor compliance standards at sewage treatment facilities, severe anoxia and hypoxic conditions and an enormously difficult non-point-source pollution problem.

The headline in the local paper the next day read "Water Quality Rising." While it may be true that some indicators are improving, a large headline declaring that water quality is rising is misleading, to put it politely. Such a statement would certainly not pass peer review in a scientific journal and it does not pass peer review with this reporter. What gets me angry is that the reporter swallowed the governor's proclamation without any hard questioning or opposing points.

All of which brings up another problem—the editor, news director or the producer. These people usually have responsibilities that include hiring and firing reporters, assigning news coverage, deciding how much space, time or prominence will be given to coverage, etc. The editor will also usually write headlines. Please keep this in mind when criticizing reporters.

Many are the examples of poor environmental reporting when the reporter misunderstands the science or policy questions. When a group of scientists disagree, imagine what confusion that can cause a journalist, who in turn can confuse the public, which in turn can affect science. The *Miami Herald* article was a good example of this.

Many of us recall the controversy over the so-called "cold fusion" story on the pesticide Alar. In that case, some overly cautious parents supposedly chased down their children's school buses at high speed through traffic to pull apples out of their lunchboxes. Yet, as an aquatic toxicologist told this writer, "Nobody died from Alar." Risk assessment scientists would probably have said the danger of chasing down a school bus is greater than that from eating an apple—even if it did have Alar.

If the public is confused about environmental or science issues, it is probably not just because of or in spite of newspapers or television. The role and influence of the media as educator is hotly debated. No doubt the schools and scientists play a part. But we should appreciate the clear link between mass media and mass population because most people and nearly all of our major cities are in coastal zones.

Because of population circumstances, major news organizations and media outlets are near the coasts. For example, The *Miami Herald*'s offices overlook

Biscayne Bay and *The Baltimore Sun's* offices are five blocks from the city's inner harbor. Coastal media markets are among the largest and most heavily concentrated markets. People and cities create environmental problems, conflicts and resource demands. In other words, the simple equation is that people equal problems equal media coverage. In turn, media coverage equals public awareness which in turn influences decisions and activities. Nothing happens in a vacuum. If a tree falls in a coastal forest, someone will hear it.

Unfortunately, scientists, policy-makers, resource managers and environmentalists have all clashed with the media at one time or another. Even with their different goals and concerns, these groups and media professionals need each other more than they may like to admit. No major coastal initiative will have a snowball's chance in the Florida Keys of succeeding unless the public will support and become a part of preservation or management efforts.

It would be a reasonable guess that many Coastal Society members and conference attendees here today have their jobs because of coastal environmental and development problems. It is ironic that coastal scientists and managers have their jobs for the same reasons that reporters and other communicators also have their jobs. In a sense, they each have a vested interest in problems, and presumably, though not always the case, they have a vested interest in alleviating these problems. These problems and how they are being reported affects the jobs of those studying or managing these problems. Improving media coverage may increase public understanding about pure and applied research or policy implications of this research. Better public understanding will likely support budgetary and legislative initiatives for such research. In a nutshell, that is the mass media—mass population link in so far as it affects the coastal zone.

In the *Proceedings of the Eighth Annual Coastal Society Conference*, L. Eugene Cronin, a distinguished ecologist, wrote about the research perspective of the EPA's Chesapeake Bay Program. He found that only eight percent of the FY 1980 and FY 1981 budget went to information and public education. One of the five specific, important research needs he hoped would be addressed was, "How is new knowledge best communicated to the managers and to the public?" Cronin said that, "This is a field of research, and merits proper study along with other complex questions" (Cronin, L. Eugene, "The EPA Chesapeake Bay Program: The Research Perspective" in M.P Lynch, editor, *Proceedings of the Eighth Annual Conference: Communicating Coastal Information*, The Coastal Society, Bethesda, Md., 1982, page 13).

Cronin recently told this writer that there is still a long way to go in improving Chesapeake Bay communications. "There is such an enormous population and so many factors at work, that we can't have too many effective mechanisms for that kind of communication. So while some are different and some are slightly overlapping, we need them all" (personal communication, Nov. 1, 1991).

In personal communication with this writer, Coastal Society President Dr. Lauriston R. King said, "The coastal and marine science and policy community does not do a very good job of working with journalists. Managers and scientists must keep in mind what is relevant, desirable and necessary for reporters and the news media."

While there are other forms of communication beside mass media, it is true that newspapers, television and radio are the most effective way to reach the greatest number of people, the most number of times. But the major disadvantage of the mass media is that one loses direct control over place, time, date and even the content and context of the messages being communicated. This loss of control is probably the major reason why some scientists or officials often fear, avoid or have contempt for reporters and editors, especially when they disagree with the messages.

The Ecological Society of America, The American Chemical Society, The Scientist's Institute for Public Communications and The Society for Environmental Toxicology and Chemistry stand out as examples of scientific groups which have been promoting science through the media. Other groups are just beginning to actively review their media involvement. On the journalistic side, The National Association of Science Writers, The Environmental Health Center of the National Safety Council and the newly formed Society of Environmental Journalists are working to improve the professionalism of its members and supporters.

The Environmental Health Center will publish a guidebook for journalists covering coastal and ocean issues later this year. This writer produced two chapters for that book and is completing a similar handbook with Maryland Sea Grant to help reporters who are covering the Chesapeake Bay. These guidebooks are designed to help reporters by providing background, placing facts into context, supplying names of experts and other information that will considerably reduce reporters' valuable research time. The expectation is that with more concise information readily available, reporters will be able to concentrate more on writing about issues.

In May 1990 the Council of Scientific Society Presidents (CSSP) hosted a three-day conference on "Bridging the Communications Gap: Strengthening Relationships Between Scientists and Journalists." The CSSP Conference was motivated by the belief "That the flow of timely and accurate scientific information to the general public needs to be strengthened... As a majority of Americans get their news from the mass media, journalists serve as the gatekeepers for the flow of scientific information to the public and thus have an important influence on the public awareness and understanding of science."

Among the recommendations were that scientific groups prepare background sheets, distribute lists of experts to journalists, distribute lists of science journalists to public information officers, establish awards for scientists who are good public communicators, establish awards for journalists who are good science communicators and to have science journalists address meetings.

Well, there are a few straightforward suggestions to help all of us. I hope I've encouraged all of you to takes at least a few steps to improve and increase your own involvement with the media. You can start by taking a journalist to lunch. There's lots of good restaurants nearby and I will be waiting for an invitation.

I'd like to pose this question to all of you. In general, do you find that the media are providing accurate and useful reporting about the coastal zone and how can improvements be made?

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