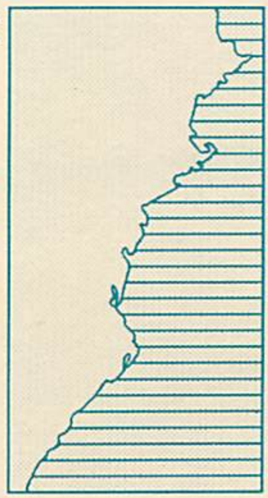
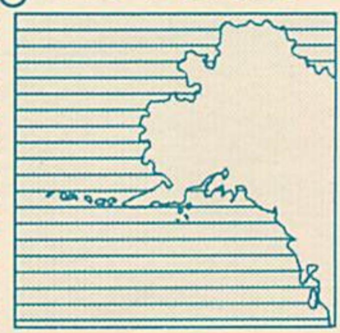
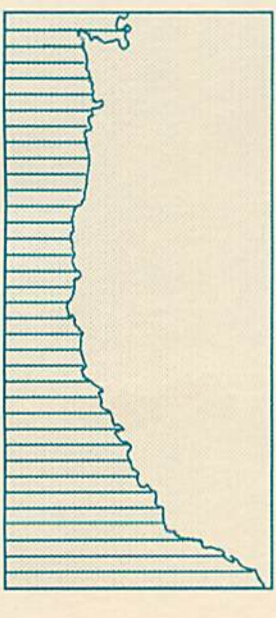
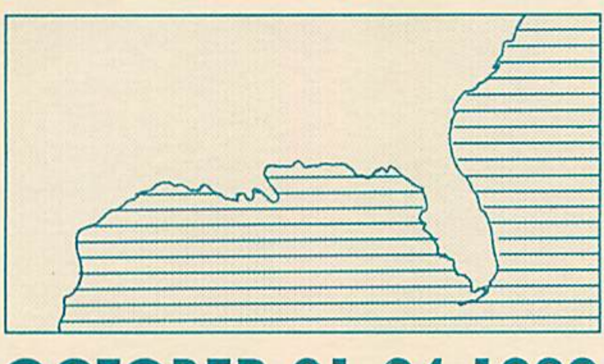
The Coastal Society Twelfth International Conference

CONFERENCE PROCEEDINGS

Our Coastal Experience: Assessing the Past, Confronting the Future



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U.S. Army Corps of Engineers' Ocean Dredging Policy and its Relationship with the Coastal Zone Management Act

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University of Mississippi

Introduction

For years, the oceans were thought of as man's great sink, with the ability to assimilate wastes and to absorb or dilute otherwise harmful materials. However, by the late 1960's, it had become evident that the oceans were not necessarily a safe and easy disposal site. By 1972, so much concern had grown worldwide that a group of nations negotiated the Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matters (Ocean Dumping Convention). This treaty came into force in 1975; by it 1979 had been acceded to or ratified by forty-nine nations, including the United States.

In the U.S., the first concerted effort to address the issue of ocean dumping came in the early 1970s. In 1970, the President's Council on Environmental Quality released a study on the issue, and recommended a "comprehensive national policy on ocean dumping of wastes to ban unregulated dumping of all materials and strictly limit ocean disposal of any material harmful to the marine environment." (Council on Environmental Quality, "Ocean Dumping: A National Policy" at v (1970)). In response to this report, Congress passed the Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) 33 U.S.C.§ 1401 et seq. (1988). Titles I and II of MPRSA pertain to ocean dumping and are commonly known as the Ocean Dumping Act.

Ocean Dumping Act

The Ocean Dumping Act (ODA) establishes a permit system under which dumping is regulated by the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps). EPA sets the criteria for evaluation of all permit applications and is the permitting agency for transportation of non-dredged materials for the purpose of ocean dumping. The Corps is responsible for granting permits for dumping dredged material, using criteria developed by EPA and subject to that agency's review authority.

The portion of the ocean dumping program that regulates the dumping of dredged material is particularly significant because of the large volume of material involved. The Environmental Protection Agency's 1980 annual report to Congress on the implementation of MPRSA revealed that approximately 75% of material dumped into the ocean each year was dredged material (EPA, 1980). However, despite its importance, the dredge component of the program has been problematic and the subject of much criticism. Observers have questioned the adequacy of EPA's criteria for ocean dredge spoil dumping, and the Corps has been attacked for failing to strictly apply the criteria, either when granting permits to others or when conducting its own dredge spoil disposal activities. (Hildreth and Johnson, 1983).

Most recently, controversy has arisen over the relationship between the Ocean Dumping Act and the Coastal Zone Management Act (CZMA). The Corps and EPA have both argued that the ODA preempts the CZMA and its requirement that federal activities be consistent with state coastal programs. Additionally, these agencies have claimed that, by virtue of the 1984 United States Supreme Court decision of Secretary of the Interior v. California, 464 U.S. 310 (1984), its activities are exempted from the CZMA's consistency provisions.

Coastal Zone Management Act

When Congress passed the Coastal Zone Management Act of 1972, 16 U.S.C. §§ 1451 et seq. (1984), it envisioned a program of collaborative planning between federal and state authorities. By developing federally-approved coastal management programs, states were given the opportunity to participate in a joint federal-state initiative. The Act provided incentives for states to develop their own coastal management plans: in the form of financial and technical assistance from the federal government and the promise that any federal activities conducted in the state's coastal zone (defined as that area from the shoreline to the boundary of state waters, which in most cases extends three miles seaward) must be consistent with its coastal management program. The Act provides that federal agency actions "directly affecting" a state's coastal zone must be consistent "to the maximum extent possible" with that state's coastal management program. 16 U.S.C. § 1456(c)(1) (1984)..

The requirement for federal agencies to act in a manner that is consistent with state coastal management programs is at the very heart of CZMA. It is one of the elements that induces states to participate in the program and to comply with the requirements set up by law. Furthermore, since interest in and competition over coastal resources have increased, federal consistency provisions have become an important management tool for coastal states. However, problems have arisen concerning the applicability of the Act's consistency provisions, the reach of which has been a point of serious contention between federal agencies and coastal states.

One of the most heated battles has revolved around a 1984 United States Supreme Court decision. Secretary of the Interior v. California, 464 U.S. at 310, involved the Department of Interior's sale of oil and gas leases on the Outer Continental Shelf off the coast of California. The State of

California notified the U.S. Department of the Interior that it had determined that one of the lease sales was an activity that "directly affected" the California coastal zone and requested a consistency determination. The Department of the Interior disagreed with California, and when negotiations failed to resolve the dispute, the parties turned to litigation. The Supreme Court agreed with the Department of the Interior, and in a 5-4 decision ruled that oil and gas lease sales are not activities that "directly affect" the coastal zone within the meaning of the Coastal Zone Management Act, and thus are not subject to state consistency review.

Since the Interior v. California decision, several federal agencies have broadly interpreted it to mean that it applies to their activities as well. The Corps is one of those agencies. In proposed amendments to regulations governing its dredge operations, it stated:

> Section 307 of the CZMA requires that any activity that a federal agency conducts or supports within a state's coastal zone or in a federal enclave within the geographic area of a state's coastal zone be consistent with the program to the maximum extent practicable. 53 Fed. Reg. 14901-14920 (26 April 1988)(codified at 33 C.F.R. Parts 335-338 (1989).

With that language, the Corps expressed its position that federal consistency review was limited geographically and only applied to the area within state waters.

In response to much concern over the language and implications of the new regulation, the Corps issued a "Dredging Guidance Letter" intended to clarify its position. Not only did it interpret the CZMA's consistency provisions as being limited geographically, but it also stated that it intended to comply with the provisions only as a "matter of comity." (U.S. Army Corps of Engineers, "Dredging Guidance Letter," 19 September 1989). This statement was founded in another of the Corps arguments, that the ODA preempted any state consistency requirements. The ODA provides that "no state shall adopt or enforce any rule or regulation relating to any activity regulated" by the Ocean Dumping Act. 33 U.S.C. § 1416(d) (1988). The Corps interpreted this language to mean that states are preempted from exercising their consistency authority granted by the CZMA.

The Corps has not been alone in its position. In 1988, EPA released a legal opinion stating that it did not have to comply with consistency provisions when making proposed dump site designations. (Memorandum "CZMA Compliance for Designation of Dredged Material Disposal Sites" from Lawrence J. Jenson, General Counsel to Rebecca W. Hanmer, Acting Assistant Administrator for Water). In reaching this conclusion, the EPA relied on the same arguments as those of the Corps, namely, that the ODA preempted any state consistency requirements and that its activities were analogous to OCS oil and gas leasing and thus did not "directly affect" the coastal zone. EPA came under fire for this position, and later issued a statement that it would comply with consistency provisions "as a matter of policy." However, the agency expressed its belief that, as a matter of law, the subject was "open to debate." (Memorandum "Coastal Zone Management Act Consistency Provisions and Designation of Ocean Dumping Sites Under Section 102(c) of Ocean Dumping Act," from Rebecca W. Hanmer, Acting Assistant Administrator for Water to Water Management Division Directors, Regions I, II, III, IV, VI, IX, X (October 23, 1989)).

While EPA altered its position, the Corps did not, provoking serious concern from states with approved coastal management programs. In a 15 December 1989 letter to Brigadier General Patrick J. Kelly, Director of Civil Works for the Corps, NOAA's Office of Ocean and Coastal Resource Management (OCRM) expressed strong disagreement with the Corps' proposed amendment to its regulations and its Dredging Guidance Letter. OCRM argued that Secretary of Interior v. California dealt only with OCS oil and gas lease sales and did not address the broader issue of the geographic scope of the CZMA. Furthermore, as to the argument that the ODA preempts consistency provisions, OCRM asserted that the states' authority to enforce consistency provisions is by virtue of a federal statute, not state regulation. Thus, unless one federal statute preempts the CZMA, compliance with its consistency requirements is mandatory. (Letter from Timothy R.E. Keeney, Director, Office of Ocean and Coastal Resources to Brigadier General Patrick J. Kelly, Director of Civil Works of the U.S. Army Corps of Engineers, 15 December 1989). This position was formally supported by over 60 members of Congress. In a 30 November 1989 letter to President Bush, 68 Congressmen and Senators expressed agreement with OCRM's position, stating, "We find that the regulations are a clear misinterpretation of federal law for they conflict with federally approved...coastal zone management programs." (Letter from sixty-eight members of Congress to President George Bush, (November 30, 1989)).

Current Status

By the summer of 1990, there had been no response from the Office of the President or from the Corps regarding this issue. As a result, the Coastal States Organization had prepared pleadings in anticipation of litigation over the matter. However, that litigation is currently on hold pending the passage of legislation that would unequivocally answer any ambiguities that exist regarding the relationship between state consistency determinations and Corps or EPA activities under the Ocean Dumping Act. That legislation is contained in the reauthorization and amendment of the Coastal Zone Management Act, which was passed in the final hours of the second session of the 101st Congress.

The new Act was included as part of the budget reconciliation package that was passed by Congress on 26 October 1990. It is an a malgamation of the House and Senate bills, and makes a number of substantive changes to the existing CZMA. One of the most important changes is the very specific language that expressly overrules Secretary of the Interior v. California. In so doing, the Act amends the federal consistency provisions, and clarifies that all federal agency activities, whether in or outside the coastal zone, are subject to the consistency requirements of the CZMA. The Act provides:

> "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 amanner which is consistent to the maximum extent practicaable with the enforceable policies of approved State management programs." Coastal Zone Act Reauthorization Amendments of 1990, Title VI, Subtitle C, Sec. 6208, Omnibus Budget Reconciliation Act of 1990, Pub. L. 101-508.

This language establishes as a codified rule of law that any federal agency activity, regardless of its location, is subject to consistency review if it will affect any natural resources, land uses, or water uses in the coastal zone. The language of the Act specifically responds to Supreme Court findings in Interior v. California. First, the geographic scope is broadened by inserting the phrase, "within or outside the coastal zone." Second, the "directly affecting" standard is replaced by a new standard, "...affecting any natural resources, land uses, or water uses in the coastal zone." 136 Cong. Rec. H8076 (26 Sept. 1990).

The amendment makes it clear that all federal agencies must comply with consistency provisions and that no federal agencies are catagorically exempt from consistency requirements. However, an amendment specifically addressing the applicability of consistency review to the Ocean Dumping Act was contained in the House bill, and did not survive passage into law. Offered by Congressman Jim Saxton of New Jersey, that amendment provided:

"The consistency requirements of section 307 of the Coastal Zone Management Act (16 U.S.C. 1456) shall apply to federal agency activities or federally permitted activities under Title I of the Marine, Protection, Research, and Sanctuaries Act of 1972, if the federal activity affects land uses, water uses, or natural resources of the coastal zone.H.R. 4450, 101st Cog., 2d Sess., Sec. 205 (1990).

Although the final legislation does not include the statutory language from the House bill, the members of the conference committee that drafted the final bill addressed the controversy. The legislative history that accompanies the new legislation makes it clear that the conferees were concerned about this issue:

> "The conferees agreed that this statutory provision is unnecessary because the amendments to section 307(c)(1) leave no room for doubt that all federal agency activities and all federal permits are subject to the CZMA's consistency requirements/ The conferees support and endorse the intent of the House provision, but agreed that a statutory listing of activities should be avoided to prevent the implication that unlisted activities are not covered." Conference Committee Statement of Managers at 4 (October 26, 1990)(accompanying Coastal Zone Act Reauyhotization Amendments of 1990, Title VI, Subtitle C, Sec. 6208, Omnibus Budget Reconciliation Act of 1990, Pub. L. 101- 508).
>
> The conferees also addressed the preemption argument:
>
> "[T]he conferees are aware of the argument that the application of federal consistency to activities under the Ocean Dumping Act amounts to state regulation of ocean dumping for purposes of section 106(d) of that Act. The conferees reject this argument." Id.

With this language, there is strong support for the premise that Corps and EPA activities under the Ocean Dumping Act are definitely subject to the consistency requirements of section 307 of the CZMA.

Conclusion

The major focus of the comments presented here deal with the relationship between the CZMA and the Ocean Dumping Act and the Corps' and the EPA's role under them. That the House of Representatives would include the language contained in the Saxton amendment, which expressly--and specifically--provides that activities conducted pursuant to the Ocean Dumping Act be subject to state review, evidences its strong concern over that particular federal ocean activity. Although the language did not survive final passage of the Coastal Zone Act Reauthorization Amendments of 1990, the record from the conference committee negotiating the final package evidences that there is support for the Saxton amendment and concern over this issue in both houses of Congress.

However, the ramifications of the new consistency provisions are obviously much broader than applicability to the Ocean Dumping Act. The amendment applies the consistency review standard to all federal activities that affect land or water uses, or natural resources of the coastal zone. This language is sweeping and has the potential to affect not only a greater number of federal activities, but also the manner in which states currently interact with the federal agencies that are involved in those activities. Clearly, with this language Congress intended to strengthen what it considers an important and unique aspect of the CZMA: its function as a federal-state partnership whose goal is to promote orderly and balanced management of the nation's coastal resources. The Coastal Zone Act Reauthorization Amendments of 1990 has the potential to be the most significant coastal initiative since the passage of the original Coastal Zone Management Act in 1972. With stronger tools from the federal government, coastal states can better manage the important resources that exist along their shorelines and in their waters, and can more effectively control the federal activities which have an impact on them.

References

21 Coastal Zone Management 27 (Nautilus Press, September 28, 1990).

Coastal Zone Management Act 16 U.S.C. 1451 et seq. (1984).

Coastal Zone Act Reauthorization Amendments of 1990. Title VI, Subtitle C, Sec. 6208, Omnibus budget Reconciliation Act of 1990, Pub. L. 101-508.

136 Cong. Rec. H8076 (Sept. 26, 1990).

Conference Committee Statement of Managers at 4 (October 26, 1990)(accompanying Coastal Zone Act Reauthorization Act Amendments of 1990, Title VI, Subtitle C, Sec. 6208, Omnibus Budget Reconciliation Act of 1990, Pub. L. 101-508).

Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matters (Ocean Dumping Convention) done Nov. 13, 1972, reprinted in 11 I.C.M. 1291 (1972).

Council on Environmental Quality, Ocean Dumping: A National Policy (1970).

53 Fed. Reg. 14901-14920 (April 26, 1988)(codified at 33 C.F.R. Parts 335-338).

H.R. 4450, 101st Cong., 2d Sess., (1990).

Hildreth and Johnson, Ocean and Coastal Law, (1983).

Letter from Sixty-eight members of Congress to President George Bush,(November 30, 1989).

Letter from Timothy R.E. Keeney, Director, Office of Ocean and Coastal Resources to Brigadeer General Patrick J. Kelly, Director of Civil Works for the U.S. Army Corps of Engineers, December 15, 1989).

Marine Protection, Research and Sanctuaries Act of 1972 (MPSRA) 33 U.S. C. 1401 et seq. (1987)

Memorandum "CZMA Compliance for Designation of Dredged Material Disposal Sites," from Lawrence J. Jensen, General Counsel to Rebecca W. Hanmer Acting Assistant Administrator for Water.

Memorandum "Coastal Zone Management Act Consistency Provisions and Designation of Ocean Dumping Sites Under Section 102(c) of Ocean Dumping Act," from Rebecca W. Hanmer, Acting Assistant Administrator for

Water to Water Management Division Directors, Regions I, II, III, IV, VI, IX, X (October 23, 1989).

Secretary of the Interior V. California, 464 U.S. 310 (1984).

U.S. Army Corps of Engineers, "Dredging Guidance Letter," September 19, 1989.

U.S. Environmental Protection Agency, Annual Reoport to Congress (Jan.-Dec. 1979) on Administration of the Marine Protection, Research and Sanctuaries Act of 1972, as Amended (P.L. 92-532)and Implementing the International Ocean Dumping Convention (1980).

Assessing the Past and Confronting the Future of Marine Protected Area Designation: Analysis of Cases from the United States and Ecuador

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Introduction

The policy process for designating marine protected areas is not fully understood. However, as the protection of marine habitats through creation of special marine protected areas is one component of marine resources management, it is vital to understand the designation process. Some areas worthy of protection on the basis of biological assessments do not achieve protected status for many years. Delays occur in the policy process. In confronting the future of marine protected area designation, it is useful to learn whatever lessons can be gleaned from these cases of delayed implementation.

Two cases of marine protected area designation are compared in this study to identify salient characteristics of the policy process in each. The United States case involved the East and West Flower Garden Banks; the case from Ecuador involved the waters of the Galapagos archipelago. In the Flower Garden Banks case, these northernmost coral reefs in the Gulf of Mexico had been proposed several times as a National Marine Sanctuary but three times had been withdrawn from consideration. In 1984, the Flower Garden Banks were again nominated as a Marine Sanctuary but still had not achieved protected status by 1990. The other marine protected area case is that of the Galapagos Marine Resources Reserve of Ecuador. Recommendations had been made to protect the surrounding marine area even before the terrestrial Galapagos National Park came into being in 1971, but no protection of the waters had been implemented as late as 1990.

In this paper, the cases are presented only briefly in chart form and the hypothesis and objectives used to compare them are explained. The methods will also be mentioned, followed by several examples from the analysis. Finally, conclusions drawn from the analysis are given.

Hypothesis and Objectives

The single hypothesis of this study was drawn from previous public policy research: that the process of designating marine protected areas can be protracted because of obstacles inherenin the policy setting process itself. By knowing the obstacles and avoiding the pitfalls, advocates can develop approaches that guide and quicken the implementation of policies to protect marine areas.

The objectives of the study were:

1) to use examples from two different settings to analyse and explain the process of formulating and implementing policies to protect marine habitat areas;

2) to identify geographical, economic, political, and legal features important in influencing the process of policy formulation and implementation for marine protected areas;

3) to use the analysis of the above features to develop recommendations on how best to formulate policy to protect a marine area.

Methods

The case study method and techniques of naturalistic inquiry were used in the research (Yin, 1984; Lincoln and Guba, 1984). This involved study of multiple sources of evidence, including interviews with participants in each case. Documents produced in the course of each case, and analyses subsequent to the events in the cases, were also studied.

Analysis

Highlights of the case analysis are given here. Critical incidents are described as a useful tool for examining the data. Then, three sub-stages of the formulation stage of the policy process are outlined. Finally, reference is made to other concepts from the policy literature such as agenda-building and issue expansion. These concepts assist in development of ideas about how the designation process works.

Each case transpired over nearly twenty years, convoluted by changes in leadership and agency direction, but identification of the cases' critical incidents provided a means of simplification for analysis. A critical incident is a specific event which occurs in the policy process and which reflects on a significant feature of the process, whether a typical or an atypical feature (Erlandson, 1986, personal communication). The critical incidents are shown in Figure 1.

After grouping the critical incidents of the two cases by similar types of delays or actions in the policy process, a set of propositions became evident. These were propositions about delay factors and other aspects of the process. The propositions provided a link to other policy literature.

The process studied in these two cases falls within the formulation and legitimation stage as characterized by Ripley (1985). Within this stage, each case can also be divided into three sub-stages: 1) the early sub-stage, where policy is not formulated; 2) the middle sub-stage, where formulation begins; and 3) the late sub-stage, where formulated policy approaches implementation. Figure 2 shows these overlapping sub-stages.

Concepts of agenda-building (Kingdon, 1984; Cobb and Elder, 1983) enrich the analysis of these sub-stages. The **agenda** is the list of issues to which government officials and people outside government closely associated with those officials are paying some serious attention at a given time (Kingdon, 1984). **Issue expansion** is a process by which a problem becomes of sufficient general significance to a wide-enough public to be kept on the agenda (Cobb and Elder, 1983). Focusing events and feedback are mechanisms by which issues are brought to the attention of governmental officials. A **focusing event** is often a crisis, such as a threat to a marine resource, which captures the attention of people in and out of government. **Feedback** is information which calls the attention of a government official to a problem, such as the failure of an existing program to meet intended goals. The **specification of alternatives** is the part of agenda-building where the large set of possible policy alternatives to a specific issue is narrowed to the set from which policy choices are actually made (Kingdon, 1984).

In the early sub-stage of policy formulation, neither the Flower Garden Banks nor the Galapagos Marine Resources Reserve protected area proposal reached the agenda. Although there was sufficient scientific justification provided in the early proposals about the value of both habitat areas, there was a failure to expand the issue to a greater public. Partly due to ignorance of the governance system in each case, the proposals were not included on the list of alternatives under consideration by government officials. The mechanisms of focusing events and feedback worked against the Flower Garden Banks Marine Sanctuary proposal at this substage. Government officials were strongly supporting the oil and gas industry in the 1970's, due to the energy crisis, and in light of the Presidential push for U.S. independence from foreign oil dependency. The Galapagos proposal for extension of the national park into the surrounding marine waters remained an "in house" idea within Ecuadoran the Ministry of Agriculture and the Charles Darwin Foundation and did not get attention at a higher or more general government level.

In the middle sub-stage, the proposals were formulated into policy as various factors expanded each issue. Specification of alternatives and focusing events began to shape the Flower Garden Banks policy, while issue expansion influenced the Galapagos policy and propelled it onto the agenda. The Flower Garden Banks proposal reached the agenda in 1979 and a Draft Environmental Impact Statement was produced. This document caused controversy because it specified a non-feasible alternative; the proposal was shelved and eventually withdrawn. Later in this same sub-stage of the Flower Garden Banks case, an opponent reversed his position and became a supporter of the proposal. This time, focusing events and feedback worked in favor of the marine protected area proposal. The focusing event was a filmed anchoring incident on the reefs, while the feedback came in the form of correspondence to legislators protesting the anchoring on the reefs. In the Galapagos case, the proposal moved at this sub-stage from an "in house" idea to a high-level government consideration. In other words, the issue expanded to a greater public. A presidential commission on Galapagos matters recommended that protection of marine resources be a priority, and the President of Ecuador approved this in 1982.

In the late sub-stage of each case, the marine protected area policy approaches implementation. Each has been mostly formulated by this sub-stage, affected by the long lapse of time, by corresponding changes in leadership and direction in the governance system, and by the other mechanisms mentioned. The model of decision-making which fits the imminent implementation decision in each case is incrementalism (Lindblom, 1957). In the Flower Garden Banks case, the 1989 Draft Environmental Impact Statement and Management Plan proposes to change the status quo only slightly by preventing anchoring. All other uses of the reef and its immediate vicinity are still to be managed in coordination with the other agencies on the Outer Continental Shelf. Implementation of the Galapagos Marine Resources Reserve declared in 1986 is blocked by a failure to select a management option. The Ministries involved must choose a feasible way to manage the Reserve, and this is likely to be a minor change from the existing operation of the different agencies. The option chosen may be only a set of written agreements between agencies.

Conclusions

Several elements appear to be crucial in both cases of delayed implementation. One element is the complexity of the policy setting--interactive resources and fragmented managing authorities (Cicin-Sain, 1982). Another key factor is the necessity for issue expansion to occur if a proposal is to reach the agenda for a decision (Cobb and Elder, 1985). The third element is the importance of identifying feasible alternatives that are agreeable to the various interested parties. Related to this last element is the incremental character of marine protected area policy when it is finally implemented (Lindblom, 1957).

In the cases of the Flower Garden Banks and Galapagos Marine Resources Reserve, the complex marine policy setting was not understood by proponents of the early proposals for protected area designation. Initially, the proposals were presented in ways which did not invoke the support of other management agencies with jurisdictions in the relevant area. Instead, these early proposals went against focusing events, or stayed within a single ministry and failed to reach the agenda. Issue expansion was the turning point for the proposals, when they could begin to be formulated as policy. The issue expanded when agencies other than the agency which parented the proposal and legislators from various constituencies saw the marine protected area as something which was in their interest to support. The proposals then reached the agenda. In one of the cases (Flower Garden Banks), a focusing event worked to put the proposal on the agenda.

Feasible alternatives were important as there is a need to link each proposal with a solution agreeable to all interested parties before the policy can be implemented. To find alternatives which different sectors view as feasible limits the choices and is a slow process. Once the policy is implemented, the change it makes from existing policy will only be minimal. For the same reasons which lie behind incremental decision-making in all bureaucracies, and compounded by the complex policy setting of many interest groups, marine protected area policy in these settings will probably be only a small step from the status quo.

References

Cicin-Sain, B. 1982. Management of marine conflicts in marine recreational fisheries. Pages 127-140 In: R.H. Stroud (ed.), Proceedings of the Seventh Annual Marine Recreational Fisheries Symposium. Sport Fishing Institute, Washington, D.C.

Cobb, R. W. and C.D. Elder. 1983. Participation in American Politics: The Dynamics of Agenda-building. The Johns Hopkins University Press. Baltimore and London.

Erlandson, David. 1986. Professor of Educational Administration, Texas A & M University

Hennessey, T. M. and D.D. Robadue. 1987. Lessons for the experiment in estuarine governance: establishing evaluative criteria. Proceedings of the Coastal Society Conference.

Kendrick, A. W. 1990. Designating marine protected areas: cases from the United States and Ecuador. Draft masters' thesis. Texas A & M University, Dept. of Wildlife and Fisheries Sciences.

Kingdon, J. 1984. Agendas, Alternatives, and Public Policies. Little, Brown and Company, Boston and Toronto.

Lincoln, Y. and E. Guba. 1985. Naturalistic Inquiry. Sage Publications, Inc. Beverly Hills, CA.

Lindblom, C. E. 1959. The science of 'muddling through'. Public Administration Review (19):79-88.

Ripley, R. B. 1985. Policy Analysis in Political Science. Nelson Hall Publishers, Chicago, IL.

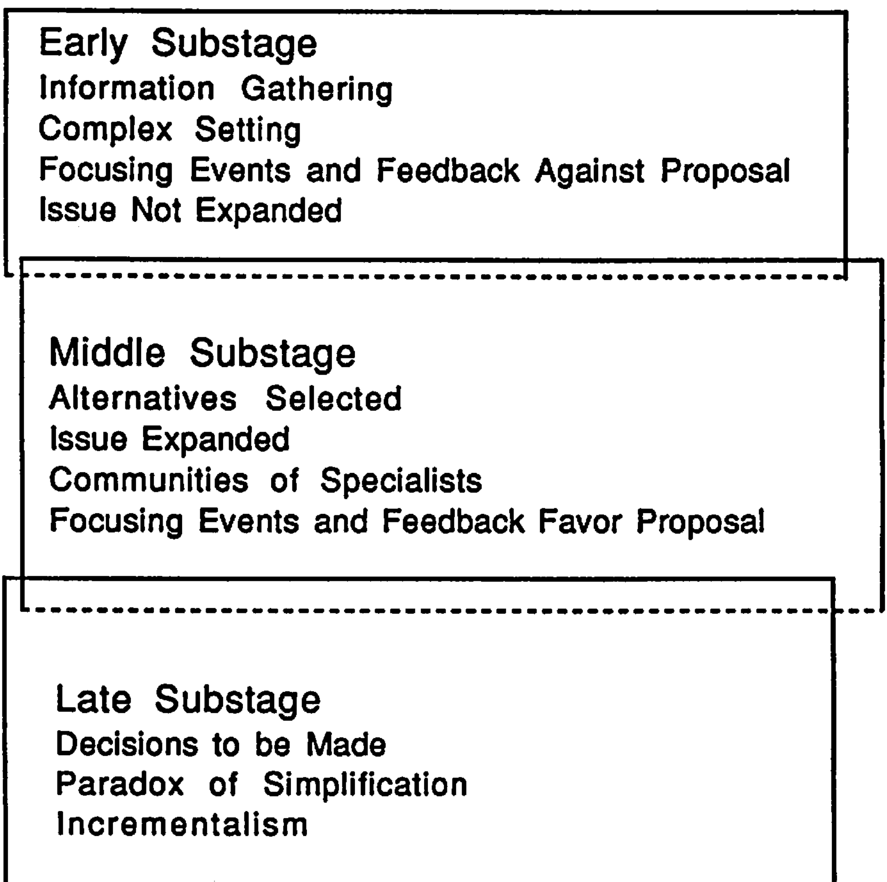
Figure 1. Chart of Critical Incidents in Flower Gardens case and Galapagos case

Critical Incidents in the Two Cases

FLOWER GARDEN BANKS	GALAPAGOS
Nominated as Marine Sanctuary candidate, based on scientific data, but withdrawn due to controversy (1973-1977)	First Mention in Writing (1966)
	Proposal backed by scientific data, CDRS and Wellington (1975)
White Paper issued, and area nominated again by various entities (1978-1979)	
DEIS produced and comments received (1979)	Recommendation approved by President Hurtado (1982)
DEIS and proposal shelved, then withdrawn; Marine Sanctuaries Office reassesses their role (1982)	Protection invalidated, but idea retained (1984)
Renominated through Congressional channels, following Nick Candies anchor damage incident (1984)	Decreed as Galapagos Marine Resources Reserve by President Febres-Cordero (1986)
	Change of presidents (1988)
New DEIS issued, with Draft Management Plan included (1989)	

Figure 2. Schematic of Substages of Policy Formulation in Two Marine Protected Area Cases

Substages of Policy Formulation in Two Marine Protected Area Cases



Trust in Sources of Technical Information About Coastal Resources Among the General Public

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Introduction

The study reported here discusses the issue of technical information as it pertains to the coastal issue arena, specifically the level of trust which exists in competing providers of technical information. It does this by looking at the degree to which technical information is trusted by the general public, a most significant actor in the policymaking process.

One of the more interesting topics related to the study of technically complex issues, such as those pertaining to the coastal area, relates to the sources of information with whom the highest degree of trust lies (Pierce and Lovrich, 1983; Soden, 1990). The coastal policy arena relies heavily on technical information and reflects the "information age" of both popular and scholarly literature. Yet, as technical complexity has grown, similar demands for increased citizen action has occurred. In this political environment, it is argued that, as technical complexity has grown, similar demands for increased citizen action have occurred, but the technical and scientific complexity of contemporary policy questions causes problems for the efficacy of public participation in democratic governance schemes. Further, it is proposed that the public will no longer accept as dogma the scientific proclamations of government officials and experts (Lovrich et al., 1979). In this environment, who will be sought out for technical information and knowledge?

The Study

This study is based on a larger study which explored the views of the general public, activists, and coastal policy professionals about a set of natural resource and technical information issues in Florida (Soden, 1990). The results reported here for the general public are based on mail survey questionnaires randomly distributed to 1700 residents of Florida. The surveys were distributed in proportion to the percentage of Florida residents who live in a specific county; all counties in Florida were included. Some individuals identified through the sampling process could not be contacted, resulting in 311 undeliverable questionnaires. Of the remaining 1389, 699 or 50.3% responded to the survey.

Findings

In the coastal area, identification of those sources of technical information which are highly trusted by the general public is important if policy professionals and public managers are to maximize the effects of the information dissemination process. Table 1 records an index score for the degree of trust among 21 alternative and often competing sources of technical information.

Table 1 illustrates that four groups are seen as enjoying considerable trust among the general public. College/University educators receive the highest index score (84.5), followed by the National Park Service with a score of 81.5, the Florida Department of Natural Resources (DNR), the Department of Environmental Regulation (DER), Water Management Districts, scientists, and environmentalists, all of whom obtain index scores in excess of +50. The least-trusted groups as sources of technical information are labor unions and developers, each with scores below -50. These low scores are not unexpected since these would be groups who place economic goals above environmental interests and are not expected to be among the trusted sources of technical information about coastal resource issues.

Patterns of Information Holding and Sources of Variation

Public involvement in the coastal resource arena increasingly entails the consideration of an enormous range of very complicated issues. Even in the most political issues, the technical range of the subjects which must be dealt with is staggering (Lovrich et al., 1979; Soden, 1990). Because outcomes of the public decision-making process often affect a multitude of actors, many matters are dealt with in great detail to insure that all the facts are presented. Today, a large amount of knowledge and expertise is required by participants in coastal issues, regardless of their stance on the issues.

The political system has few means for dealing with technical complexity. We must rely on public negotiations and on public hearings, the press, and group activities to disseminate knowledge. Thus, it may be anticipated that social, political, and socio-economic patterns greatly affect knowledge levels (Steel and Soden, 1989). From another perspective, it is generally viewed as not rational for individuals to participate in the decision-making process either by voting or becoming knowledgeable, hence producing "rational ignorance" about the issue at hand. Because participation is not rational, Downs (1957) argues neither is it rational to incur the costs of obtaining information. However, if the "stakes" are high enough, the costs of obtaining information about a particular policy are less than the benefits which might be lost if the policy under consideration were enacted.

When rational ignorance is overshadowed by interest in the issue, one concern with respect to the role of knowledge in the public policy process is the degree of respect or trust accorded technical expertise. What level of trust in alternative sources exists among the public, and how that knowledge relates to social and political values, is then of considerable interest. Earlier research found that trust in alternative sources of technical information follows consistent patterns related to the general policy orientation of individuals (Lovrich et al., 1979). For example, those with strong environmental orientations are more likely to trust information from environmentalists and are less likely to trust information from developers, energy companies, or timber interests. These studies suggest that people tend to "trust sources of information with whom they agree in policy alternatives." While this is not unexpected, it suggests that there may be strong variations in trust and that these variations, once defined, may become important indicators of potential alignments as issues become more salient on the public agenda.

Three sources of variation are considered as having potential impact on trust in sources of technical information: (1) personal characteristics; (2) political orientations; and (3) environmental orientations. In the following analyses, measures of ordinal association (Spearman's Rho) are relied upon to consider the association between potential sources of variation and the various measures relating to technical information and knowledge holding.

Personal Characteristics

Five personal characteristics are considered for the impact they have on trust in sources of technical information. Education is viewed as one potential source of variation. Higher education increases the ability of the individual to process information, reducing the costs of evaluation and the application of information to policy settings. Goldberg (1969) notes, for example, that "education increases rationality in the special sense of lowering information costs and developing innate intelligence toward its fullest potential." Education also relates to lifelong learning and it is expected that higher education levels will associate with higher levels of knowledge and potential knowledge sources (Kessel, 1980).

A second personal characteristic worth considering is an individual's age. In Florida, with a considerable elderly and retirement population, age may be an especially significant factor. Are older people less interested in new information than younger people? Age may be considered a step towards wisdom, reflecting the ability to put a broader number of life's experience into better perspective. To this end, older individuals may be more likely to support public involvement and pay closer attention to issues as they emerge. Viewed from a negative light, age may be associated with old-fashioned values, with younger individuals being more likely than their older counterparts to entertain new ideas and obtain the requisite knowledge to participate in the policy process (Soden et al., 1989).

Income levels and social standing (class) may also bear on the role individuals take in pursuing new information and the sources they are most likely to draw upon in formulating decisions. Clearly, those with higher levels of income and members of the upper middle-class or upper-class have better access to a greater number of information sources than do members of the lower class and low-income cohort. Moreover, those who have fulfilled their basic subsistence and security needs are more capable of focusing their attention on issues of environmentalism and to take the time to seek information about policies relating to natural resources than are those who focus the majority of their attention on basic needs (Maslow, 1970).

Gender differences may provide a clue about who is more likely to be informed about coastal issues. Knowledge of and behavior towards wildlife, for example, is different between males and females (Kellert and Berry, 1980). Typically, participation rates in natural resource activities have been higher among males. However, women register higher scores on humanistic and moralistic scales, and show strong proclivities to get involved in the policy process and to be quick studies about environmental issues (Bammel and Bammel, 1986).

Table 2 provides correlations between personal characteristics and trust in group sources of technical information. Several significant associations arise in Table 2. Personal characteristics do appear to have a bearing on trust in group sources, especially among those in higher social classes and upper income strata, as well as those with higher levels of education.

Political Orientations

Four political orientations are posited as affecting information-holding and trust in sources of technical information within the coastal issue arena: citizen participation; ideology; partisanship; and values related to post-industrialism. Citizen participation in western democracies, and in environmental affairs particularly, has been the subject of a large body of literature (Pierce and Doerkson, 1976). If citizen participation is maximized in defining societal goals, then democracy is seen as strong, underscoring the general belief that public involvement in politics should be encouraged and maximized. It has been argued that citizen participation is linked to knowledge in complex issue areas and that the manner in which information-holding varies and is distributed has major repercussions on the ability of the general public to participate in the governing of society (Bellak, 1975; King, 1975; Beer, 1977). Group involvement is also seen as important in the citizen involvement equation. Public involvement mechanisms have provided the springboard into the public policy arena for many interest groups. As a consequence, some scholars argue that environmental politics remains largely a group-dominated process (Groves and Thompson, 1982). Recent years also have shown an increase in the sophistication of the general public and a growth in participation, especially through group actions, where policy measures are citizen-initiated. Does the same hold true in the coastal resource issue area? Do attitudes about citizen participation play a role in how individuals contend with the technical complexity and the large pool of existing knowledge sources?

The second source of political variation that is expected to have an effect on the issue of information-holding and trust in sources of technical information is ideology, which can be examined in tandem with the third source, partisanship. Many studies have illustrated the fact that political ideology is strongly related to support for or opposition to environmental policy among state legislators and the general public (Pierce and Lovrich, 1980; Calvert, 1987). It has been suggested that partisan attachment and ideological orientation are each linked to attitudes concerning group roles in the policy process (Pierce and Lovrich, 1982). As in other issue areas, it is expected that, as environmental issues become politicized, participants in the policy process will seek out traditional sources of information with whom they align on political issues (Lovrich et al., 1979; Soden, 1990).

The fourth political orientation is based on the idea that a number of fundamental changes have transpired in industrial nations since the end of World War II, especially in those identified as "western democracies." In contrast to the pre-war era, the 1950s and 1960s were characterized by rapid economic growth which led to fundamental change in the structure of society, catching the attention of students of societal phenomenon. Western democracies are viewed as having gone into a new stage of social development known as "post-industrial" or "post-materialist." A plethora of studies exist that examine the social and political implications of post-industrialism (Tourraine, 1971; Bell, 1973; Huntington, 1974). While some differences exist in defining post-industrialism, general agreement has been reached that:

". . . the major features of post-industrial society that emerge . . .include, among others, the majority of labor employment to be in the so-called service sector, the service sector generating a larger share of the gross national product (GNP) than the agricultural and manufacturing sectors combined, a high level of affluence and mass material well-being, the national economy becoming "knowledge-intensive" in contrast to "capital-intensive" and "labor intensive" (Tsurutani, 1977).

It is suggested that post-industrial political and economic systems, coupled with the importance of technology in the policy process and the centrality of specialized policy-specific knowledge in post-industrialism, have obvious impacts and implications for competing demands among the various elements and group interests of society who are competing for influence and authority (Freudenberg and Rosa, 1984). Within post-industrial societies, new experts and policy elites have to find foundations within the post-industrial framework if they wish to continue to hold and exercise influence (Dahl, 1985). Thus, one might reasonably expect that attitudes that are more post-industrial in nature will be more sympathetic to environmental concerns and show greater cognizance of the needs for information about complex social issues.

Table 2 reveals a number of linkages between political orientation and trust in group sources of technical information. Overall, these findings support the results of previous research that argue that participants in the policy process trust sources of information with whom they already share general policy positions. Those with liberal leanings favor government agencies while conservatives do not. The reverse is true of business and developer sources, which receive conservative support but little support from liberals. It also becomes apparent that a pattern exists where liberal leanings, support for post- industrial values, and an enhanced role for the general citizenry is associated with environmentalists in the policy process.

Environmental Orientation

Environmental orientations presume that conflict over scarce natural resources is rooted in the degree to which individuals are strongly committed to either preservation or development. General orientations towards the environment have been measured in a number of ways, each founded on either methodologically or literature-supported grounds. In this section, two measures pertaining to environmental orientation are employed. First, it has been previously noted that a value change is occurring in which society is paying greater attention to post-industrial or post-materialistic needs. This change in attitude is believed to have brought about changes in many types of personal attitudes--especially those relating to the natural environment. As a consequence, it is argued that popular demand for the exploitation of natural resources in the interest of creating employment and generating economic growth has been partially supplanted by interest in higher order needs--such as the valuation of natural beauty and the enjoyment of recreation in its natural setting.

Opinion surveys undertaken in North America indicate a growing disposition, especially among the well-informed and highly educated, to accept elements of the New Environmental Paradigm (Milbrath, 1984; Lovrich et al., 1984; Steel and Soden, 1988). Acceptance that environmental concerns are an important part of contemporary policy-making suggests that those supportive of such policies will have a greater propensity to attempt to firm up their support with knowledge acquisition.

A third dimension of environmental orientation relies on attitudes about preservation as opposed to development of natural resources, and has proved quite useful in predicting and explaining support for, or opposition to, a given policy (Pierce, 1979; Pierce and Lovrich, 1982). Does the same hold true in regards to technical information and knowledge-holding? Do individuals with preservationist leanings systematically display more knowledge than those with development leanings, or is the reverse the case? Or does a mix of attitudes exist among those with high knowledge levels, suggesting that the preservationist-developmentalist distinction does not play a role in explaining the knowledge level of policy actors?

Table 2 shows a number of associations between environmental orientations and trust in various sources of technical information. Beginning with trust in business, it is clear that those with strong preservationist leanings are the least trusting of business sources of information, as are those who support the New Environmental Paradigm. Environmentalists, in comparison, obtain high trust among those with preservationist leanings, as well as from followers of the New Environmental Paradigm and those who perceive the environmental problems facing Florida as quite serious. This obviously is not surprising given the nature of the issue under study. However, the relative degree of association with other potential sources of technical information does indicate the high regard that environmentalists maintain in the environmental issue area. In light of this, it is not surprising that the scores of developers/construction companies are almost the inverse of environmentalists among those with preservationist leanings. College/university educators also are recipients of considerable trust among those in the general public with strong environmental orientations.

Summary and Conclusion

The overall levels of trust in sources of technical information among the general public indicate that transituational forces such as personal characteristics, political, and environmental orientations do bear on trust in sources of technical information. While a large body of literature suggests that the public may be relatively unknowledgeable until the "stakes" are raised, their general orientation towards available technical information, whether they choose to use it or not, appears to reflect linkages which will provide further clues about how best to disseminate information relating to our coastal regions.

References

Bammel, L. and G. Bammel. 1986. Gender test differences during an environmental camp. Journal of Environmental Education. 17(3): 8-11.

Beer, S. H. 1977. Political overload and federalism. Polity. 10 (Fall):5-17.

Bell, D. 1973. The Coming of Postindustrial Society. Basic Books, New York, NY.

Bellak, L. 1975. Overload: The Human Condition. Human Sciences Press. New York, NY.

Calvert, J. W. 1987. "Partisanship and Ideology in State Legislative Action on Environmental Issues," paper presented at the Annual Meeting of the Western Political Science Association, Anaheim, CA.

Dahl, R. 1985. Controlling Nuclear Weapons. Syracuse University Press. Syracuse, NY.

Downs, A. 1957. An Economic Theory of Democracy. Harper and Row. New York, NY.

Freudenberg, W. R. and E. A. Rosa, eds. 1984. Public Reactions to Nuclear Power. Westview Press. Boulder. CO.

Goldberg, A. S. 1969. Social determinism and rationality as bases of party identification. in American Political Science Review. 63: 5-25.

Groves, D.L. and B.J. Thompson. 1982. Natural resource planning: the complex web of special interests. The International Journal of Environmental Studies. 19:17-24.

Huntington, S. P. 1974. Postindustrial politics: how benign will it be? Comparative Politics. 6 (January): 163- 191.

Kellert, S. and J. Berry. 1980. "Gender variations in relationship to animals." Paper presented at the Annual Meeting of the Rural Sociology Society. Corpus Christi, TX.

Kessel, J. 1980. Presidential Campaign Politics: Coalition Strategies and Citizen Response. The Dorsey Press. Homewood, IL.

King, A. 1975 Overload: problems of governing in the 1970s. in Political Studies 23 (June-September): 284-296.

Lovrich, N. P., J. C. Pierce, and A. K. Cook. 1979. Public Policy, Public Opinion and the Technical Information Quandary. in William J. Grenney, (ed.) Utilizing Scientific Information in Environmental Quality Planning. American Water Resources Association. Minneapolis, MN.

Maslow, A. 1970. Motivation and Personality. Harper and Row. New York, NY.

Milbrath, L. W. 1984. Environmentalists: Vanguards for a New Society. SUNY Press. Albany, NY.

Pierce, J. C. 1979. Conflict and consensus in water politics. The Western Science Quarterly. XXXII: 307-319.

_______ and H. Doerksen. 1976. Water Politics and Public Involvement. Ann Arbor Science Publishers, Inc., Ann Arbor, MI.

_______ and N. P. Lovrich. 1980. Belief systems concerning the environment: the general public, the attentive publics and state legislators. Political Behavior. 2: 259-286.

_______ and _______. 1982. Knowledge and politics: the distribution and consequences of policy relevant information among citizens, activists, legislators and experts. Knowledge, Creation, Diffusion, Utilization. 3: 521-554.

_______ and _____. 1983. Trust in the technical information provided by interest groups: the views of legislators, activists, experts and the general public. Policy Studies Journal. 11: 626-639.

________, __________. and T. Tsurutani. 1987. Enviromental policy elites' trust of information sources. American Behavioral Scientist, 30 (6): 578-596.

Soden, D. L. 1990. "Coastal Resources: Technical Complexity and Public Attitudes," Report No. 96, Florida Sea Grant College, Gainesville, FL.

_______, N. P. Lovrich, J. C. Pierce and B. L. Lamb. 1989. Public involvement, natural resource policy processes: a view from the inside out. The Environmental Professional.

Steel, B. S. and D. L. Soden. 1989. Acid rain policy in Canada and the United States: attitudes of citizens, environmental activists and legislators. Social Science Journal. (Winter).

Touraine, A. 1971. The Post Industrial Society. Random House,New York, NY.

Tsurutani, T. 1977. Political Change in Japan. McKay Publishers, New York, NY.

Table 1: Index Scores for Trust in Group Sources of Technical Information

Rank	Group	Score*	Rank	Group	Score
1	College/University	+84.5	12	Fishing Industry	+20.1
2	National Park Services	+81.5	13	Dept. of Comm. Affairs	+18.1
3	Technical & Science	+76.6	14	Industry	+7.5
4	Dept. of Nat. Resources	+75.7	15	Local Government	+7.1
5	Environments	+67.8	16	Public Utilities	-13.6
6	Dept. of Envir. Regulation	+64.3	17	Business	-21.5
7	Water Mgmt. Districts	+50.4	18	State Legislators	-22.8
8	Outdoor Rec. Advocates	+40.9	19	Timber Cos.	-38.6
9	Sea Grant	+34.2	20	Developers	-61.6
10	Farmers	+28.1	21	Labor Unions	-77.0
11	Federal Agencies	+25.0			

*The index score is the sum of those responding "Some" or "A Great Deal" minus the sum of those responding "None" and "Not Much" to the question "Many groups supply technical information about coastal resources. How much trust do you have in the technical information supplied by each of the groups listed?

Table 2: Significant Correlations Between Sources of Variation and Trust in Group Sources of Technical Information*

GROUP	
Business	Ed, Age, Inc, Class, Gen, PI, Party Pre, NEP
Environmentalists	Age, Gen, Cit, PI, Ideol, Party, Pre, NEP
Developers	Ed, Age, Inc, PI, Party, Pre, NEP
Universities	Ed, Age, Cit, PI, Ideol, Party, Pre, NEP
Farmers	Ed, Age, Class, Gen, Pre, NEP
Fishing Industry	Ed, Age, Inc, Class, Gen, NEP
National Park Service	Age, Cit, PI, Pre, NEP
Outdoor Recreationists	Age, Class, Cit, Ideol, Party, Pre, NEP
Industry	Age, Inc, Gen, PI, Ideol, Pre, NEP
Labor	Age, Ideol, Party
Legislators	Inc, Cit, Ideol, Party
Sea Grant	Ed, Age, Inc, Class, PI, Ideol.
Timber Companies	Inc, Party, Pre, NEP
Water Districts	Inc, Class, Pre
Utilities	Inc, Gen, Party, NEP
DNR	Age, Cit, Ideol, NEP
DER	Age, Cit, Ideol, Pre, NEP
DCA	Ed, Age, Cit, Ideol
Federal Agencies	Ed, Inc
Local Government	Ed, Inc, Class, Ideol, Pre
Scientists	Ed, Age, Inc, Class, NEP

CODE

Personal Characteristics

Ed = Education, Age = Age, Inc = Income, Class = Social Class

Political Orientations

Cit = Citizen Participation, PI = Post-Industrial Values, Ideol = Ideology
Party = Political Party

Environmental Orientations

Pre = Preservationist Self-Identification, NEP = New Environmental Paradigm

*Spearman Correlation Coefficients ≤ .1

Assessing Public Opinion Regarding Beach Restoration

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Introduction

Questions concerning differences in attitudes about funding for beach restoration programs are investigated in this paper through data collected from three sets of policy actors residing in the State of Florida: the general public; activists; and policy experts. Florida is a state and region quite appropriate for examination of this question because of its involvement in numerous beach restoration and management programs, exceeding $16 million for 1990-1991 (FSBPA, 1990). For this study, three factors hypothesized as having an impact on positions taken either in support of or in opposition to, funding for beach restoration programs are considered. First, political orientations are considered for their impact on beach restoration program proposals. Second, factors associated with preservationist-oriented, versus developmentalist-oriented, interests are evaluated. A third concern is the effect that technical information and knowledge holding have in the formulation of policy positions about these programs.

The data used in this study were gathered during 1988 using mail surveys distributed to samples of the general public and policy experts. From the general public sample, 699 respondents completed usable questionnaires -- a response rate of 50.3%. From the general public sample, an activist subset was defined comprising 207 individuals who recorded the highest levels of political activity in regards to natural resources in Florida. The expert sample was made up of individuals whose professional activities include the coastal resources arena; 208 such responses were obtained for a response rate of 53.2%.

Findings

The results depicted in Table 1 show that, in general, there is strong support for funding beach restoration programs among all three samples, with activists registering slightly stronger support than the general public or policy experts. These initial findings suggest that this is an area of minor controversy in Florida and that the public and its representatives share similar attitudes. These initial positions will help to determine some of the causes of variation in the positions taken about funding for restoration programs across political orientations, environmental orientations, and levels of technical information and knowledge-holding.

Political Orientations

Many studies have illustrated the fact that political ideology is strongly correlated with support for, or opposition to environmental policy in the United States. The literature suggests that those on the liberal end of the political spectrum are supportive of pro-environmental regulation, while individuals on the conservative side of the political/ideological spectrum have generally been found to be "less supportive or even hostile to environmental concerns."

Using chi-square analysis to test variables identifying political orientations for statistical significance with respect to support for funding of beach restoration programs, only one statistically significant association occurs (Table 2). Among policy experts, those with conservative stances also are likely to oppose funding programs. No statistically significant differences were obtained among the samples for associations between political party and support for program funding.

Environmental Orientations

The prolonged affluence enjoyed in the United States since the end of World War II has resulted in the satisfaction of many of the basic needs of our citizens. The demand for the exploitation of nature in the interest of creating employment and generating economic growth has been partially supplanted by interest in higher order needs, such as the valuation of natural beauty and the preservation of nature (Milbrath, 1984). Using two measures of support for the environment -- the New Environmental Paradigm (NEP) scale and Preservationist Self-Identification -- several statistically significant relationships are defined in Table 2. Among all three samples, strong support for the NEP is matched by strong support for funding. Likewise, except in the case of activists, those who identify themselves as preservationist in their view of the proper use of natural resources are also those who support program funding. The use of beaches and shorelines for any variety of purposes may not always result in what environmentalists expected. Since there can be some negative impacts on coastal areas, what might account for the strong support given to this policy alternative among those with environmental leaning? The most probable explanation is that in general, little is really known about beach restoration. In addition, management programs are viewed more positively than non-management among those with pro-environmental orientations.

Technical Information and Knowledge

Beach restoration programs involve a number of technical and scientific issues. An inquiry into the issue of restoration provides an opportunity to see the impact which technical information-holding has on support for funding programs. In the pursuit of such knowledge, opponents may discover a common ground in technical understanding.

Knowledge of general ecology and self-assessed knowledge of technical terms associated with natural resource and environmental policy in the area of study provide an opportunity to consider the role of knowledge as it affects support for funding of beach restoration programs. Two significant relationships are evidenced in Table 2, both about the knowledge of general ecology, for the general public and policy experts. Knowledge of technical terms does not provide significance in explaining variation among the three samples. Unlike the findings of other studies, there is no suggestion that, in the case of beach restoration programs, greater consensus may derive from an investment in information dissemination. The significant relationships in association with knowledge of general ecology may suggest that beach restoration may be viewed from the focus of applied ecology and restoration. Another explanation may be that there exists little knowledge about such programs among the general public, activists, and perhaps, even policy experts. In time, provision of information, efforts to educate the public and its most active elements, and professional education among experts may have positive effects and thus should not be discounted.

Conclusion

Attitudes about funding for beach restoration programs have been examined. The statistical analysis reveals that, in the State of Florida, there is support for funding beach restoration programs. Although this is the case, those policy experts with a conservative political orientation tend to oppose funding beach restoration programs.

As the general public becomes more enlightened and educated concerning the general and applied ecological impact derived from a laissez-faire approach to the environment, a change in direction towards a more pro-environment policy will develop. Put another way, politicians may see a stronger pro-environment constituency grow and, as a consequence, pressure to protect, manage, and restore the environment will significantly influence their voting behavior on such issues. A new pro-environmental attitude coupled with the goal of maintaining a strong economy is becoming a more compatible and related approach. Thus, environmental issues and economic interests will be increasingly considered in tandem--not as opposing factions. Further investigation clearly will be required as these two major societal concerns become more intertwined.

References

Milbrath, L. 1984. Environmentalists: Vanguards for a New Society, NY: SUNY Press, Albany NY.

FSBPA 1990. "Record Budget for Florida Beaches," Florida 1990 Shore and Beach Preservation Association, Shoreline Magazine. Tallahassee, FL. (Summer 1990.)

Table 1
Comparison of Support for Use of Government Funds
to Support Beach Restoration Projects

Question: Do you favor public funding (i.e., tax dollars, bond revenues, etc.) for restoration of eroded, storm damaged or washed-out beaches and shorelines?

Response Categories	Frequency (%)		
	General Public	Activists	Policy Experts
Strongly Favor	284 (40.6)	113 (54.6)	91 (43.8)
Tend to Favor	248 (35.5)	51 (24.6)	69 (33.2)
Don't Know	49 (07.0)	14 (06.8)	12 (05.8)
Tend to Oppose	67 (09.6)	17 (08.2)	24 (11.5)
Strongly Oppose	45 (05.4)	12 (05.8)	10 (04.8)
No Response	6 (00.9)	0 (00.0)	2 (01.0)
Totals	699 (100%)	207 (100%)	208 (100%)

Table 2

Relationship Between Political, Environmental and Knowledge Factors and Support for Use of Government Funds for Beach Restoration Projects

		General Public	Activists	Policy Experts
Political Factors				
Ideology	x^2 =	27.55	21.73	52.97
	df =	25	20	25
	p =	.329	.356	.001
Party	x^2 =	39.24	29.80	38.26
	df =	30	24	30
	p =	.121	.192	.143
Environmental Factors				
New Environmental Paradigm				
	x^2 =	399.00	118.05	107.11
	df =	35	24	30
	p =	.000	.008	.002
Preservationist Self-Identification				
	x^2 =	93.34	24.97	50.81
	df =	35	24	30
	p =	.000	.408	.01
Knowledge Factors				
General Ecology				
	x^2 =	33.24	13.73	42.38
	df =	20	16	20
	p =	.032	.619	.002
Technical Terms				
	x^2 =	42.94	41.68	29.15
	df =	33	40	40
	p =	.115	.397	.898

Natural Resource Trustee Responsibilities

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Scope of natural resource trustee responsibilities

With the passage of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. §§ 9601 et seq., much attention has been focused on the cleanup of hazardous waste sites. While the cleanup of such sites is a major component of CERCLA, the complementary provisions regarding natural resource assessment, recovery, and restoration have, for the most part, been overlooked during the decade following the enactment of CERCLA. Likewise, similar natural resource provisions in the Clean Water Act (CWA) have not been utilized fully. Only recently has the potential impact of the natural resource provisions of CERCLA and the CWA been explored.

The purpose of this paper is to describe the scope of natural resource trustee responsibilities, the process for recovering damages, the opportunities for interaction among the natural resource trustees and between the natural resource trustees and those responsible for the release of the hazardous substance or the discharge of oil, and the challenges confronting natural resource trustees. Special emphasis will be placed on Federal trusteeship, and, in particular, the activities of the National Oceanic and Atmospheric Administration (N0AA) in this area.

Statutory authority

CERCLA and the Oil Pollution Act of 1990 (OPA), which replaces prospectively the natural resource provisions of the CWA, designate the President, Indian tribes, and the authorized representatives of each state as trustees for natural resources on behalf of the public. The OPA further designates foreign governments as trustees "for natural resources belonging to, managed by, controlled by, or appertaining to such country." Those statutes require the President and the authorized representatives of any state, Indian tribe, or foreign government to take certain actions to recover damages for injury to natural resources resulting from the release of hazardous substances or the discharge of oil, 42 U.S.C. § 9607(f)(1); OPA section 1006(a). In addition to the trustee responsibilities under CERCLA and the OPA, the 1988 amendment to the Marine Protection, Research, and Sanctuaries Act (MPRSA) authorizes the Secretary of Commerce to recover response costs and damages, including the cost of damage assessment, from anyone who injures or destroys a national marine sanctuary resource, 16 U.S.C. § 1443.

Both CERCLA and the OPA require the trustees to assess injuries to natural resources; to pursue recoveries of damages, including the cost of assessment; and to use the money recovered to restore, replace, rehabilitate, or acquire the equivalent of the injured resource, 42 U.S.C. § 9607(f)(1); OPA section 1006(b). The OPA establishes a fund from which Federal, state, and Indian tribe trustees can draw money to pay for the costs of the assessment of natural resource injury and the development and implementation of plans for restoration, rehabilitation, replacement, or acquisition of the equivalent resource, OPA Section 1012(a)(2). Because there is not a similar fund available under CERCLA, the trustees must pay for such costs and then seek recovery from the responsible parties, 42 U.S.C. § 9607(f)(1).

Pursuant to the MPRSA, 20% of a recovery is placed in a fund to finance future response actions and damage assessments. For the remaining 80%, the statute establishes a list of permissible uses 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).

Who are natural resource trustees?

The statutes delineate broad categories of trustees while providing for further delegation of such responsibilities. In Executive Order 12580, the President has designated the Secretaries of Commerce, Defense, the Interior, Agriculture, and Energy as the Federal trustees for natural resources, E.O. 12580, Sec. 1(c), Jan. 23, 1987. The Secretary of Commerce, in turn, has delegated this authority to the Under Secretary for Oceans and Atmosphere, who also serves as the Administrator for NOAA. Department Organization Order 10-15, amendment 2, issued November 8, 1989.

Under CERCLA, the governor of each state is authorized to designate state officials to act as trustees for natural resources. 42 U.S.C. § 9607(2). The states which have done so have designated a variety of agencies to act as trustees. For example, Texas has designated the Texas Water Commission and may soon add the Department of Parks and Wildlife. South Carolina has assigned this function to four agencies -- the Division of Waste Assessment and Emergency Response and the Division of Site Engineering and Screening, both of the Department of Health and Environmental Control; the Department of Wildlife and Marine Resources; and the Division of Public Safety Program of the Office of the Governor. CERCLA makes no provisions for further delegation concerning Indian tribes. The recently-enacted OPA authorizes the governor of each state to designate state and local officials as trustees; the governing body of any Indian tribe to designate tribal officials; and the head of any foreign government to designate a trustee, OPA section 1006(b).

Description of trust resources

In order to pursue natural resource trust responsibilities, the trustees must confront the threshold issue of the scope of their trusteeship. CERCLA broadly defines natural resources to include:

> "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act [16 U.S.C.A. § 1801 et seq.]), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe," 42 U.S.C. § 9601(16).

The OPA contains a similar definition, OPA section 1001(20). Neither statute delineates specific resources to individual trustees. Although the potential for conflict exists among the trustees, for the most part, trustees have worked cooperatively as they seek recoveries for injuries to natural resources.

To better understand the scope of the definition of natural resources, this section will examine the basis of NOAA's trusteeship. That trusteeship is broad and is based upon a number of resource statutes that give NOAA management and protective responsibilities.

NOAA is the primary trustee for marine fisheries resources pursuant to the Magnuson Fishery Conservation and Management Act, as amended, (Magnuson Act) which establishes exclusive management responsibility for fishery resources within the Exclusive Economic Zone (EEZ) of the United States, as well as for anadromous species and continental shelf fishery resources of the United States, both within and beyond the 200-mile EEZ, except for highly migratory species, 16 U.S.C. §§ 1801, et seq. NOAA, the Department of the Interior, the several states, and Indian tribes share management authority over anadromous species. NOAA derives additional trustee authority from the Atlantic Tunas Convention Act, 16 U.S.C. §§ 971(a), et seq., the Tuna Conventions Act, 16 U.S.C. §§ 951 et seq., the Pacific Salmon Treaty Act, 16 U.S.C. §§ 3631, et seq., the Atlantic Striped Bass Conservation Act, 16 U.S.C. § 1851 note, and the North Pacific Halibut Act, 16 U.S.C. § 773, among others.

NOAA is responsible for the protection of certain marine mammals under the Marine Mammal Protection Act (MMPA), 16 U.S.C. §§ 1361, et seq., the Whaling Convention Act, 16 U.S.C. §§ 916, et seq., and the Fur Seal

Act, 16 U.S.C. §§ 1151, et seq. Under the MMPA, NOAA and the U.S. Fish and Wildlife Service (FWS) share management responsibilities. NOAA is responsible for seals, sea lions, porpoises, and whales, while FWS is responsible for sea otters, polar bears, manatees, and walruses. NOAA also shares responsibility with the FWS and the states for the administration of the Endangered Species Act, 16 U.S.C. §§ 1531, et seq. In general, NOAA is responsible for the protection of marine species while the FWS is responsible for terrestrial and inland water species.

NOAA, as well, has responsibilities to protect habitat and other environmentally sensitive areas. For example, the Magnuson Act authorizes NOAA to protect habitats of fisheries subject to the Act, 16 U.S.C. § 1802(9). Other statutes also provide authority to NOAA to protect the habitats of fishery resources, including Section 404(c) of the Clean Water Act, 33 U.S.C. § 1344(c), the MPRSA, Title II, 33 U.S.C. §§ 1701, et seq., the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661, et seq., and the National Ocean Pollution Planning Act, 33 U.S.C. §§ 1701, et seq. Section 315 of the Coastal Zone Management Act, 16 U.S.C. § 1461, provides additional authority in estuarine areas by authorizing the designation of estuarine research reserves. In such designated estuaries, NOAA shares trusteeship with the states in which the estuaries are located since the reserves are managed on a cooperative Federal-state basis. Other living and non-living resources and their habitat are managed and protected by NOAA pursuant to Title III of the MPRSA, 16 U.S.C. §§ 1431, et seq. Title III authorizes the Secretary of Commerce to designate areas of the marine environment, subject to the jurisdiction of the United States, which have special recreational, historic, ecologic, aesthetic, or research values as national marine sanctuaries. Because such sanctuaries may be located partially within state waters, trusteeship over national marine sanctuary resources may be shared between NOAA and the relevant state.

Natural resource damage assessment process

With the above background in mind, this section will examine the actual process of pursuing a natural resource claim.

Regulatory framework

Pursuant to CERCLA, the President designated the responsibility for promulgating natural resource damage assessment regulations to the Department of the Interior, 42 U.S.C. § 9651(c); E.O. 12580, sec. 11(d). Interior has promulgated such regulations, see 43 C.F.R. Part 11, "Natural Resource Damage Assessments." While the use of such regulations is optional, a trustee acquires a rebuttable presumption of correction should it follow the procedures in the regulations.

The Court of Appeals for the District of Columbia Circuit invalidated a small portion of those regulations and remanded another provision for clarification in 1989, see Ohio v. Department of the Interior, 880 F.2d 432 (D.C. Cir. 1989)(Ohio decision). At this time, the Department of the Interior is revising the damage assessment regulations in light of the Ohio decision.

The regulations contained in Part 11 can be applied to either the release of hazardous substances under CERCLA or the discharge of oil under the CWA. The OPA, however, directs NOAA, in consultation with EPA, FWS, and other affected agencies, to promulgate regulations for natural resource damage assessment for the discharge of oil. OPA section 1006(e). Currently, NOAA is considering its approach to the regulations and how best to involve the interested public.

Because the steps provided in the regulations offer a logical framework for conducting a damage assessment, trustees like NOAA may do well to retain the option of following those regulations, as modified by the Ohio decision, to take advantage of the rebuttable presumption. The discussion below summarizes the damage assessment process.

Before commencing the assessment plan phase, trustees initially perform a preassessment screen. The purpose of a preassessment screen is to determine whether the discharge or release justifies a natural resource damage assessment. This determination is made based on existing data with a minimum of field work. This step includes a brief determination of what injuries occurred, what resources are at further risk, and the likelihood of making a successful claim if the process were to continue. Also considered at this stage is whether the potential benefits outweigh the potential costs of performing the assessment, 43 C.F.R. §§ 11.23-.25.

The next step is the development of an assessment plan. The damage assessment plan provides the framework for a systemic approach to be conducted at a reasonable cost. One of the major decisions at this stage is to determine whether to proceed with a "type A" or a "type B" assessment. The type A is a simplified procedure for less complex cases and relies upon computer modeling, id. at §§ 11.40-.41. A type B assessment is more complex and expensive. The regulations establish criteria for the decision-maker to determine which approach is appropriate, id. at § 11.33.

The type B assessment is divided into several stages including injury determination, quantification, and damage determination. The purpose of the injury determination is to veridy that an injury has resulted from the release of a hazardous substance or the discharge of oil. Part of that determination is a consideration of how the contaminant was transported from the source into and through the environment, id. at §§ 11.61-.64. Next is the quantification stage, where the effects of the contaminant on the natural resources are calculated to determine the necessary compensation. Both the baseline condition (condition but for the presence of the contaminant) and services are calculated to demonstrate the degree of reduction of the services resulting from the discharge or release. A resource recoverability analysis, estimating the time to restore services to the baseline level, is part of the quantification stage, id. at §§ 11.70-73. The final stage is the damage determination. The purpose of this phase is to estimate the amount of money to be sought for compensation as the result of the injury, id. at §§ 11.80-.84.

Following completion of the assessment phase is the post-assessment phase which includes the development of a restoration plan for restoring, replacing, or acquiring the equivalent of the injured resource. Also included in this phase is the presentation of a monetary demand to the responsible parties, at §§ 11.90-.93.

Recoveries for injury to natural resources must be used to restore, replace, rehabilitate, or acquire the equivalent resource, 42 U.S.C. § 9607(f); OPA section 1006(c) and (f). Assessment costs represent a separate element of the damages and are returned to the trustees without further appropriation, OPA section 1006(f); 43 C.F.R. § 11.92.

Opportunities for coordination and cooperation

The statutes and the natural resource damage assessment regulations encourage trustees with affected resources to act together to coordinate a single damage assessment plan, see, e.g., 42 U.S.C. § 9607(f)(1) and OPA section 1006(d)(prohibition on double recovery for natural resource damages resulting from same release); 42 C.F.R. §§ 11.20(c), 11.32(a).

During the past year, natural resource trustees, lead by the efforts of NOAA, have worked closely together on both hazardous waste sites and oil spills. NOAA has encouraged the use of memoranda of agreement (MOAs) among the trustees. These MOAs outline the responsibilities of the trustees and typically establish a trustee council which makes decisions concerning strategies for recovery and uses of damages recovered. To date, these MOAs have been site- or incident-specific. NOAA, though, is drafting a "model" MOA, emphasizing flexibility to address most sites or incidents. By having such an agreement in place prior to a spill, trustees will save time and will be able to focus on trustee concerns immediately. NOAA is coordinating this model MOA at the Federal level and will soon begin discussions with interested states.

NOAA's experience has shown that coordination and cooperation between trustees and potentially responsible parties (PRPs) are productive avenues to pursue. As specific sites are considered, NOAA and co-trustees meet with PRPs and request their cooperation by providing "upfront" money to conduct a damage assessment or pre-damage assessment studies. Because PRPs will be liable for damage assessment costs anyway, many understand that their cooperation at such early stages may stave off litigation while providing them with input into the damage assessment process. An excellent example of this process is the 1990 Mega Borg oil spill off the coast of Texas. Because much of the oil evaporated or incinerated, the trustees hypothesized that there had been no significant injury to natural resources. To test this theory, the trustees developed studies and requested funding from the PRP. The PRP agreed and provided $275,000 for studies now underway. It should be emphasized that the trustees did not file a claim in court to secure the cooperation of the PRP. Rather, the trustees and the PRP held a series of discussions that culminated in a signed agreement between the representative of the Mega Borg, NOAA, and the Texas Water Commission. Obtaining such upfront funding for other sites is the goal of NOAA, and NOAA is currently negotiating such an approach at several of the sites at which it is involved.

Should, however, the PRPs decline to cooperate, litigation remains a viable alternative. In fact, NOAA is involved in several cases that have been filed in Federal district court, including United States v. AVX , CA No. 83-3882-Y (D. Mass. 1983) (Acushnet River & New Bedford Harbor: Proceedings re Alleged PCB Pollution) involving contamination of New Bedford Harbor and adjacent waters with polychlorinated biphenyls (PCBs). Filed in 1983, this case was the first Federal claim for damages to natural resources under CERCLA. The case is still pending. Additionally, on 19 March 1990, the Justice Department, on behalf of NOAA, filed suit against the City of Seattle and the Municipality of Metropolitan Seattle for injunctive relief and damages to natural resources in Elliott Bay, United States v. City of Seattle and Municipality of Metropolitan Seattle, No. C90-395 (W.D. Wash. 1990). NOAA and other trustees are actively pursuing a natural resource damage claim in the southern California area. There, massive quantities of DDT and PCBs have been discharged into the marine environment from the local county sewer system, from barges directly into the ocean, and by means of storm water runoff and aerial transport, United States v. Montrose Chemical Corp., No. CV 90-3122-AAH (JRx)(C.D. Cal. 1990).

These cases are just part of a continuing effort. NOAA also is currently working on a number of promising cases on the east coast of the United States and in the Gulf of Mexico. Natural resource damage cases represent a new effort, and as such, present new demands on the scientific, economic, and legal communities.

Challenges ahead

One of the challenges confronting the legal community is that there has not been a significant amount of Federal natural resource damage litigation. Thus, the rulings from these initial cases will be instrumental in shaping future efforts of natural resource trustees. There have, though, been some interesting rulings from the Acushnet River case, which, on the whole, have been favorable to the trustees. For example, that court held that for the purposes of joint and several liability, the sovereigns need only show that a PRP "contributed" to the natural resource injury, and not that its contribution was "substantial," Acushnet River, 722 F. Supp. 893, 896, n.8 (D. Mass. 1989). That court also opined that Congress intended to increase the scope of liability of responsible parties by not releasing from liability those who later owned a facility while there was further injury to the environment from continuing releases caused by disposal of hazardous materials by a previous owner (id. at n.6.).

Moreover, new doors are being opened in the areas of economics and science. Natural resource economists are exploring the area of contingent valuation for natural resources. While this methodology has been widely debated, the Ohio court upheld it in the CERCLA context. Trustees also are increasing their understanding of how to quantify injury to a marine environment and how restoration on a large scale can be conducted effectively.

The challenges presented to the attorneys, scientists, and economists by natural resource claims become opportunities to foster interaction among these disciplines and to develop further all three disciplines in the upcoming years.

Note: The views of the author do not necessarily reflect those of the National Oceanic and Atmospheric Administration.

III. COASTAL ENVIRONMENTAL QUALITY

Plastics in the Ocean: More Than a Litter Problem

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Abstract

The Center for Marine Conservation (CMC) has established a National Marine Debris Database to involve citizens in the collection of standardized information on marine debris. This information, collected over time, will serve as a means to monitor the effectiveness of legislative and other efforts to reduce marine debris. During the second year of this program, more than 65,000 volunteers in 25 U.S. states and territories recorded detailed information on the types and quantities of debris collected during one three-hour period in the fall of 1989. Additional cleanups in Canada and Mexico also contributed information to the data base. All completed data cards were returned to CMC for analysis and comparison with similar data collected in 1988.

The 1989 data showed that the composition of trash found on America's beaches has remained relatively unchanged since the first national beach cleanup in 1988, even though an international ban on ocean dumping of plastics took effect prior to the 1989 cleanup. Comparisons with the 1988 data showed that plastics still account for most of the trash, or approximately 63% of the 3,013,778 debris items reported. The most common debris items were fragmented pieces of plastic and foamed (styrofoam-like) plastic. Approximately 60% of all debris was packaging and disposable plastic products that can be generated by a diversity of ocean- and land-based sources. Using indicator items, it was found that approximately 6.1% of all debris reported was indicative of dumping of galley wastes by vessels, 6.7% was fishing and boating gear, 1.6% was operational wastes generated during activities conducted by cargo vessels and offshore petroleum operations, and 0.5% was sewage-associated wastes indicative of inadequate sewage treatment practices. The presence of these indicator items suggest that some of the untraceable items may also be generated by these sources. Only 0.09% of the debris was categorized as medical wastes, suspected to be from illegal dumping, storm water runoff, or inadequate sewer systems. More than 2,000 items were traced to 55 countries; more than 70 items were traceable to specific cruise line companies. Volunteers also reported 65 cases of wildlife entanglement or ingestion of debris, most of which were birds entangled in plastic fishing line.

Introduction

The world's oceans have long been used as a receptacle for various wastes including oil, organic chemicals, heavy metals, sewage, and solid wastes. In addressing the many pollutants entering the marine environment, solid wastes have been considered to be a problem of mere aesthetics. Recent findings, however, have shown that these solid wastes, or marine debris, are much more than a litter problem.

In 1984, an event took place that would provide the impetus for future scientific, government, and citizen efforts to address the marine debris problem--the Workshop on the Fate and Impact of Marine Debris. For the first time, individuals met to discuss the impacts of marine debris. One scientist had compiled worldwide documentation that debris impacted all species of sea turtles through either entanglement or ingestion. Another determined that 50 of the world's 280 species of seabirds were known to eat everything from plastic resin pellets to cigarette lighters. Studies of the northern fur seal population in the Pribilof Islands of Alaska indicated that entanglement in debris items, such as fishing nets and plastic strapping bands, could be causing an annual mortality of 50,000 northern fur seals. In addition, several scientists reported that lost or discarded fishing nets and other gear had the ability to "ghost fish," thereby wasting fishery resources (Shomura and Yoshida, 1985).

Subsequently, in 1985, the Environmental Protection Agency commissioned the Center for Marine Conservation, formerly the Center for Environmental Education, to prepare a comprehensive assessment of the extent of the debris problem in the marine and Great Lakes waters of the United States. The study showed that this is a nationwide problem for wildlife and helped to redirect attention from general marine debris to those problems caused specifically by plastic items. It also identified the major ocean- and land-based sources of debris. For instance, the National Academy of Science estimated that 14 billion pounds of trash are dumped at sea each year by commercial fishing vessels, merchant ships, passenger cruise lines, recreational vessels, offshore petroleum industry rigs and platforms, and naval vessels. The world's merchant shipping fleet alone discards more than 5.5 million plastic, metal, and glass containers each day. Finally, the study noted the absence of appropriate laws to address the plastic debris problem (O'Hara and Iudicello, 1987).

The lack of laws to prevent overboard disposal of trash was highlighted in 1986 by a statewide citizen beach cleanup conducted in Texas during the fall Coastweeks celebration. At this time, the CMC introduced a standardized method for citizen volunteers to record information on the types and quantities of debris collected. The resultant data indicated that the problem of marine debris was not caused merely by beachgoers who disregarded litter laws on land. Rather, it was the result of the centuries-old practice of tossing trash over the rail of ships.

This information helped to mobilize public support and legislative interest and on 31 December 1987 the United States ratified Annex V of the International Convention for the Prevention of Pollution from Ships (also known as the MARPOL Treaty). Annex V prohibits the at-sea disposal of plastic wastes and regulates the distance from shore that all other solid waste materials may be dumped. Annex V became effective on 31 December 1988. The Marine Plastic Pollution Research and Control Act of 1987 (Public Law 100-220, Title II) is the U.S. implementing legislation for Annex V and extends its regulations to all navigable waterways of the United States.

Although legislation was an important step in addressing the marine debris problem, it was recognized that enforcement would be difficult because of competing priorities and limited resources of the federal agencies involved in enforcement. However, there was a growing awareness of the usefulness of involving citizen groups to augment enforcement. By monitoring beach debris, citizens could help to establish long-term trends useful in evaluating the effectiveness of legislation. Moreover, the involvement of citizen groups in monitoring beach debris would also serve as a means to educate the public and promote citizen participation in solving environmental problems.

Recognizing the importance of citizen monitoring, the Marine Plastic Pollution Research and Control Act required the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the U.S. Coast Guard to conduct a program to encourage the formation of volunteer groups, designated as "Citizen Pollution Patrols," to assist in the monitoring, reporting, cleanup, and prevention of ocean and shoreline pollution.

With support from these agencies, CMC initiated the National Marine Debris Database. During the first cleanup in 1988, nearly 1,000 tons of trash were removed from approximately 3,500 miles of America's beaches by more than 47,000 citizen volunteers. More than 60% of the nearly 2,000,000 litter items recorded were plastics.

The following fall, volunteer participation in the annual cleanup increased to more than 65,600. Cleanups were also conducted in two Canadian provinces, Nova Scotia and New Brunswick, as well as Cozumel, Mexico. Volunteers covered nearly 3,000 miles of North America's shoreline (including Canada and Mexico) and collected more than 860 tons of debris. Although the total amount of miles and tonnage of debris collected was less than in 1988, the methods used to measure beach and weigh debris varied among cleanups, and therefore these estimates were not exact. However, the amount of trash collected was not the focus of the 1989 Beach Cleanup. Rather, the questions these volunteers attempted to answer were: what kinds of trash are found on our beaches; where is it coming from; and what progress had been made in the ten months since the MARPOL Treaty had taken effect.

To determine the types and quantities of debris found nationwide, volunteers use a standardized data card developed by CMC. This data has been compiled since 1988 by CMC and is reported each year in a final report with national, state, and local results. The following information represents findings from the 1989 Beach Cleanup and has been published in a report available from CMC entitled, "Cleaning North America's Beaches: Results of the 1989 Beach Cleanup" (O'Hara and Younger, 1990).

Results

During the 1989 Beach Cleanup, volunteers reported finding 3,013,778 debris items on U.S. beaches (Table 1). As in 1988, the amount of plastic reported during this three-hour long cleanup surpassed all other categories, accounting for 1,895,502, or approximately 63% of the total items collected. The percentages of the remaining debris items collected were: 11.1% glass; 10.6% metal; 9.8% paper; 2.4% wood; 2.0% rubber; and 1.3% cloth.

Cleanups conducted in Canada and Mexico brought the total number of debris items collected on North America's beaches to 3,089,341. Based on these cleanups it has become evident that the prevalence of plastic beach debris is not a problem limited to the United States. Plastics accounted for approximately 67% and 58% of the debris collected in New Brunswick and Nova Scotia, respectively, and 61% of the debris in Cozumel.

The majority of debris items found on U.S. shorelines were packaging and disposable plastic products. In 1988, twelve specific types of debris were named the "dirty dozen" of U.S. beaches because these were the most common items found. Essentially the same items were reported for the "dirty dozen" in 1989 and included (in order of abundance): plastic pieces; small foamed plastic pieces (styrofoam-like); plastic eating utensils including cups, spoons, forks, and straws; glass pieces; cigarette butts; plastic caps and lids; paper pieces; glass beverage bottles; metal beverage cans; foamed plastic cups (styrofoam-like); miscellaneous plastic bags; and plastic trash bags. Collectively, these twelve debris items constituted nearly 60% of all debris items recorded.

Sources of beach debris

Since items in the "dirty dozen" may be generated by a diversity of ocean- and land-based sources, they cannot be traced to a single source. However, there are 28 debris items listed on the data card that are used as "indicator items" traceable to specific debris sources. These items are grouped into five categories: 1) galley-type wastes generated by vessels; 2) fishing and boating gear; 3) operational wastes generated by vessels and offshore petroleum operations; 4) sewage-associated wastes indicative of inadequate sewage treatment practices; and 5) medical wastes. An overview of 1989 findings and comparisons with the 1988 results are discussed below.

Galley wastes

The amount of trash attributed to galleys of ships has decreased, but only slightly from 1988. This included findings of plastic trash bags, bleach and cleaner bottles (including one 6-gallon plastic dish washing bottle from the U.S. Navy), milk and water jugs, vegetable sacks, egg cartons, and meat trays. In 1988, galley wastes were the most prevalent category of indicator items reported, accounting for 7.8% of the trash collected nationwide. In 1989, galley wastes accounted for approximately 6.1%. It is hoped that this is the beginning of a downward trend. Yet the prevalence of these items in specific areas of the country has not changed; all states bordering the Gulf of Mexico, the North Pacific, and islands such as those cleaned in Georgia and the Virgin Islands appear to be the most affected by offshore dumping of galley wastes.

Fishing and boating gear

The amount of fishing and boating gear showed little change. In 1988, wastes generated by commercial and recreational fishermen accounted for 6.1% of the total number of debris items reported. In 1989, 6.7%, was attributable to these groups. This includes plastic salt bags used by commercial fishermen in preparing their catch, plastic fishing nets, light sticks, floats and lures, buoys, fishing line, rope, motor oil and lubricant bottles, rubber gloves, and metal and wood traps.

In both 1988 and 1989, the most commonly reported debris items in this category were large and small pieces of plastic rope, followed by pieces of plastic fishing line. Both are known to kill marine wildlife through entanglement and ingestion. In Florida, beach cleanup volunteers collect fishing line separately so that it can be weighed and measured; a total of 467 miles was collected on 911 miles of Florida coastline in 1989; 305 miles of fishing line was collected from 915 miles in 1988.

In general, fishing and boating gear appear to be most prevalent in four regions: in states bordering the western Gulf of Mexico, particularly Texas and Louisiana; the North Atlantic states of Maine, New Hampshire, and Massachusetts; at the mouth of the Chesapeake Bay in Virginia; and the North Pacific states of Oregon and Alaska.

Operational wastes

Annex V of the MARPOL Treaty also applies to wastes generated during offshore operations, such as petroleum industry activities, or gear and equipment used on cargo vessels. These wastes, classified as operational wastes, accounted for approximately 2.0% of the debris collected in 1988. In 1989, the amount of operational wastes was essentially the same (1.6%). This included 18,610 plastic strapping bands and 6,640 large pieces of plastic sheeting used to bind boxes and crates, 1,693 wooden crates, and 2,099 wooden pallets used to transport materials and packages. Other items attributable to offshore operations and vessels included the 8,095 glass light bulbs and 2,531 fluorescent light tubes. Items specifically traceable to petroleum industry operations included the 3,762 plastic pipe thread protectors and 4,204 plastic write-enable protection rings from computer tapes. In addition, many of the 605 plastic hard hats found were probably generated by offshore petroleum operations.

Washington had the highest amount of operational wastes with approximately 5.1%. Neighboring Oregon also had a high amount. Other states with relatively high concentrations of operational waste included all states bordering the Gulf of Mexico and Virginia. The abundance of operational wastes in these areas is attributable to petroleum operations and commercial shipping traffic in the Gulf of Mexico and extensive shipping through the Chesapeake Bay.

In the Gulf of Mexico, certain non-plastic debris items such as light bulbs are a prevalent component of offshore generated wastes. Unfortunately, MARPOL Annex V allows for the discharge of non-plastic items beyond 12 miles from land. However, the Gulf of Mexico not only has a heavy concentration of shipping traffic, it is also a unique repository of marine debris, due to reduced flushing actions of tides and currents. For these reasons, U.S. and international authorities are currently working to designate the Gulf of Mexico as a "Special Area" where dumping of all garbage would be prohibited.

Sewage-associated wastes

Sewage-associated wastes are a particular problem in the northeast where antiquated sewer systems discharge plastic items directly into marine areas. Many sewage treatment systems in this area of the United States are combined with storm water systems, producing "combined sewage systems."

In these systems, raw sewage mixes with runoff from storm drains. Under normal operating conditions, these combined sewage systems trap pieces of solid waste materials. However, during times of heavy rainfall the treatment capacities of these systems are exceeded and the overflow--untreated sewage and accompanying solid waste materials--is diverted directly into local waterways.

Plastic tampon applicators are used as an indicator of inadequate sewage systems. A total of 16,318 plastic tampon applicators were reported from U.S. beach cleanups in 1989, 0.5% of all debris items reported. Trends in abundance of tampon applicators show, as in 1988, that this is a noticeable problem in the northeast United States. The number of plastic tampon applicators reported in New Jersey was approximately seven times greater than the national figure. The number in Massachusetts was more than five times greater. New York and Rhode Island also had comparatively high numbers of plastic tampon applicators, and Connecticut was equal to the national figure.

The 1988 beach cleanup data revealed that inadequate sewer systems are also present along Lake Erie. Based on the data collected during the 1989 beach cleanup conducted at Presque Isle State Park in Pennsylvania, this problem persists--the number of plastic tampon applicators reported is more than two times the national average. Furthermore, as part of New York's cleanup, a group from Oswego cleaned a beach on Lake Ontario. A total of 218 plastic tampon applicators were found, constituting more than 5% of all the debris collected--almost 10 times greater than the national figure.

Medical wastes

Medical wastes were found in very small amounts compared to other types of debris collected. In 1988, plastic syringes were used to indicate medical wastes since they have been a major problem in some areas of the United States, principally in the New York-New Jersey area during the summers of 1987 and 1988. In 1989, syringes were reported in all but two of the 25 states; the 2,678 syringes reported amounted to only 0.09% of the total debris.

Foreign sources of debris

During the 1988 cleanup, more than 1,000 foreign label items from 49 countries were recorded on U.S. beaches. Although some of these items may have been domestically generated, the majority were food packaging and empty bottles of cleaning agents dumped by the international shipping fleet. At the time of the 1988 beach cleanup, dumping trash at sea was not illegal. However, even after the enactment of Annex V, more than 2,000 foreign label items from 55 countries were recorded during the 1989 cleanup including six international brands of bug spray and seven types of toilet bowl cleaner bottles.

Texas had the largest amount and assortment of international beach debris, with more than 1,000 foreign debris items reported from 36 countries, with Mexican debris items were the most common. Among the Mexican debris items reported were at least 50 plastic bottles of "El Pinador" cleaner, 100 plastic bottles of motor oil, and 260 plastic bottles of bleach.

The participation of Canada and Mexico showed that the U.S. is not blameless--many of the debris items recorded as "foreign" by cleanup volunteers in these countries were of U.S. origin. Although neither Canada nor Mexico are parties to the MARPOL Treaty, countries that are signatory to MARPOL Annex V must comply with the regulations in Canadian and Mexican waters.

In addition to recording information on foreign labels, volunteers reported 44 findings of cruise line trash consisting of more than 70 individual items. Forty of these cases were reported in Florida, primarily in southeastern counties bordering the Atlantic. Many of the cruise lines operate ships out of southeastern Florida to the Bahamas and the Caribbean.

Wildlife entanglement

Finally, volunteers were asked to note any cases of wildlife entanglement or strandings found during the beach cleanup. In 1988, 42 animals affected by debris were reported, 38 of which were birds, primarily entangled in plastic fishing line. The number of reported entanglements in 1989 increased to 67 animals. This number includes 46 entangled birds, 25 of which involved fishing line. Other entanglements that were discovered during the cleanup but were not recorded on data cards included three sea turtles in Florida found entangled in fishing nets; two of these were still alive and were freed by cleanup volunteers.

The number of animals found affected by debris during 1989 is alarming not only because the number of reports has increased, but these animals were noted on just a fraction of our nation's coastline and within just three hours.

Conclusion

In general, the composition of trash found on America's beaches has remained relatively unchanged since the first national beach cleanup in 1988. Despite the fact that an international ban on ocean dumping of plastics took effect prior to the 1989 cleanup, plastics still account for most of the trash found on our coasts and shorelines.

Realistically, however, a dramatic change in the composition of beach debris was not expected. Effective implementation and enforcement of the treaty will take time. In addition, it is not known how long the plastics collected in the fall of 1989 were afloat at sea, or how much of the beach cleaned had not benefited from previous cleanups. As was reported, the percentage of items traceable to the galleys and operations of vessels, and other maritime activities, including those of petroleum industries, commercial and recreational fisheries, and pleasure boats, has changed very little. But with the ability to compare two years of data, certain trends are becoming apparent, such as the concentration of offshore-generated wastes on beaches in the Gulf of Mexico, the North Pacific, and New England. Hence, if a decrease in the amount of plastics collected during beach cleanups occurs over the next few years as a result of Annex V, it will be these areas where it will be most evident.

Turning attention to land, it is clear that coastal municipalities contribute to the marine debris problem specifically with regard to sewage associated wastes. Tampon applicators are an aesthetic problem that can negatively affect the economies of coastal communities. This type of impact was clearly demonstrated as a result of the medical debris wash-ups of 1987 and 1988 which contributed to $600 million in lost tourism revenues in New Jersey (Doherty 1990). Repeated findings of plastic tampon applicators will certainly not enhance the image of states that fail to address this problem, primarily New York, New Jersey, and Massachusetts, and to shoreline areas of Lakes Erie and Ontario. Moreover, plastic tampon applicators are just the "tip of the iceberg." In essence, applicators not only indicate inadequate sewer systems, but also the presence of less visible forms of pollution discharged by these systems.

Finally, it was noted that citizens are becoming very adept at data collection. Attention to accuracy has improved, the level of detail has increased, and many volunteers are becoming very specific in their identification of beach debris. While these people are volunteering three hours of their weekend to pick up someone else's trash, most do so because they realize the importance of individual action in solving the debris problem. Now it is time for governments, industries, private organizations, and other individuals to use this information to implement solutions to the marine debris problem.

References

Doherty, L. 1990. Pilot project to encourage proper handling and recycling of marine debris at a series of small ports in New Jersey. New Jersey Department of Environmental Protection. New Jersey. September 1990. 13 pp.

O'Hara, K.J. and S. Iudicello. 1987. Plastics in the Ocean: More Than a Litter Problem. Center for Environmental Education. Washington, DC. 128 pp.

L.K. Younger. 1990. Cleaning North America's Beaches: 1989 Beach Cleanup Results. Center for Marine Conservation. Washington, DC. 310 pp.

Shomura, R.S. and H.O. Yoshida (editors). 1985. Proceedings of the Workshop on the Fate and 4 Impact of Marine Debris. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. NOAA-TM-NMFS-SWFC-54. 580 pp.

Table 1. Total number of debris items collected during 1989 U.S. beach cleanups.

PLASTIC	
Bags:	
trash	93,184
sal	3,983
other	98,078
Bottles:	
beverage, soda	78,015
bleach, cleaner	24,782
oil, lube	17,597
other	28,008
Buckets	8,557
Caps, Lids	145,938
Cigarette Butts	164,141
Cups, spoons, forks, straws	170,805
Diapers	7,741
Disposable Lighters	14,767
Fishing Line	21,902
Fishing net:	
longer than 2 feet	5,773
2 feet or shorter	8,430
Floats & lures	9,109
Hardhats	605
Light sticks	14,052
Milk or water gallon jugs	30,759
Pieces	242,119
Pipe thread protector	3,762
Rope:	
longer than 2 feet	32,379
2 feet or shorter	58,985
Sheeting:	
longer than 2 feet	6,640
2 feet or shorter	13,422
Six-pack rings	35,090
Strapping bands	18,610
Syringes	2,678
Tampon applicators	16,318
Toys	12,896
Vegetable sacks	8,625
"Write protection" rings	4,204
Other	48,805

GLASS	
Bottles:	
beverage	135,352
food	10,709
other	4,293
Flourescent light tubes	2,531
Light bulbs	8,095
Pieces	167,657
Other	6,561

CLOTH (clothing, pieces)	39,233

STYROFOAM	
Buoys	11,313
Cups	106,301
Egg cartons	8,968
Fast-food containers	32,095
Meat trays	17,246
Pieces:	
large	48,730
small	197,364
Other	16,245

RUBBER	
Balloons	18,251
Gloves	8,137
Tires	5,191
Other	28,259

METAL	
Bottle caps	68,249
Cans:	
aerosol	14,462
beverage	125,512
food	9,207
other	9,406
Crab/fish traps	1,575
55 gallon drums	
rusty	2,356
new	328
Pieces	21,807
Pull tabs	26,732
Wire	11,869
Other	29,434

PAPER	
Bags	27,530
Cardboard	22,416
Cartons	20,275
Cups	34,503
Newspaper	14,792
Pieces	142,110
Other	35,228

WOOD	
Crab/lobster traps	1,402
Crates	1,693
Pallets	2,099
Pieces	58,785
Other	8,719

TOTAL = 3,013,778

The Failure of Federal Regulations: An Analysis of Federal Boat Sewage Regulations

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Abstract

Federal legislation regulating sewage from recreational boats has existed since 1972 (The Clean Water Act). Marine sanitation device (MSD) regulations enacted by EPA and the U.S. Coast Guard to implement the legislation have failed to prevent the discharge of untreated sewage discharge from boats. The MSD regulations were evaluated using nine possible sources of regulatory failure. Seven of the nine were found to be involved in the failure of these regulations, including: lack of technology; lack of enforcement; inadequate issue salience; poor public perception; economics of compliance; conflicting interest groups; and administrative errors. Analysis of regulations for these types of sources of failure can be useful in identifying potential problems and correcting them, prior to regulatory failure.

Hypothesis

The 1972 Clean Water Act (CWA) directed EPA to promulgate regulations prohibiting the discharge of untreated sewage into the navigable waters of the United States. It also directed the U.S. Coast Guard to develop regulations for the design and installation of marine sanitation devices (MSD's) on recreational and commercial vessels and to enforce these regulations.

This paper examines the regulatory system put in place by the CWA (1972, as amended) for controling sewage pollution from boats. Nine possible sources of regulatory failure have been analyzed. It is hypothesized that given the lack of compliance to MSD regulations, most if not all, of the nine possible sources of regulatory failure have contributed to the failure of the regulations preventing the discharge of untreated sewage from recreational boats.

Methods

The Federal MSD regulations were evaluated using nine criteria for regulatory failure. Existing literature, legislation, congressional reports, interviews, and boater surveys were used to determine which, if any, of the nine possible sources of regulatory failure were acting in this case. The nine sources considered are: (Meier, 1985)

1) technology.
2) enforcement.
    a. availability of sanctions
    b. effort
3) authority, both to issue regulations and to enforce them.
4) issue salience.
5) perception of the regulated population.
6) economics of compliance and noncompliance.
7) interest group pressure.
8) the administrative process.
9) legislation.

Results

Of the nine possible sources of regulatory failure, seven were found to be operating in the failure of MSD regulations.

1) The lack of adequate technology was a factor. Although equipment was available to treat wastes to the required levels, efficient, well-designed equipment was not. Type I devices treat sewage to primary levels, but require a power supply not generally available on sailboats and require significant space. No type II devices are suitable for boats under 65 feet in length. Type III devices have significant space requirements. These devices require on-shore counterparts, pump-out stations, to be effective. Pump-outs were never mandated in federal legislation. Where they are installed, they have received infrequent use (Tanski, 1989; Rogers et al., 1982; Strand et al., 1988).

2) Lack of enforcement was a major reason for the failure of MSD regulations. Since boaters opposed regulations, voluntary compliance was not likely.

All three categories of enforcement-- availability of sanctions, level of effort (i.e police per square mile, arrests per 1000, etc.), and visibility of effort-- were acting. Enforcing MSD regulations has not been a high priority of the U.S. Coast Guard. In the early 1970's, some on the water enforcement occurred in conjunction with routine patrols and boardings for other reasons (Ellison, 1989). Funding for most of these patrols was cut in 1980 (Hearings, 1983). In 1981, the U.S. Department of Transportation (DOT) reported to the U.S. Commission on Regulatory Relief that MSD regulations were the most onerous regulations they administered (Hearings, 1983). Given a limited budget and a wide variety of responsibilities, the Coast Guard chose not to enforce a program that was opposed by the regulated population and of concern only in localized areas (Amson, 1989).

The lack of a wide variety of sufficiently stringent penalties contributed to the lack of compliance. Currently, the only sanction for operator violations is a fine of up to $2000. However, this fine is rarely applied. Ontario, Canada, has fines of up to $10,000 for offenders (JRB, 1981). The high fines reinforce the seriousness of the offence. Avalon, CA has achieved a high level of compliance by combining a fine with expulsion from the harbor for one year (Harbormaster, Avalon, CA, 1989). Monetary penalties may be less effective in this issue than restrictions on behavior.

3) Issue salience encompasses the value of the issue to the political elite, and the perception of the issue's importance to the general public (Meier, 1982). The general public, if aware of the MSD regulations, is disinterested (JRB, 1981). It remains an issue only where boating is popular. In such places, Congressmen are more likely to appease their boating constituents than to call for stricter enforcement of MSD regulations. Congressman Donald Young (AK), Senator John Chafee (RI), and Congressman Holt (MD), all from areas where boating is popular, have attempted to pass bills and influence oversight hearings to remove the MSD requirement for smaller (<65') boats (H.R. 1421, S.793, Hearing, 1983). In areas where boating is not a major recreational activity, MSD regulations are not important enough to be followed by a Congressman. There was little if any Congressional oversight on boat sewage regulations.

4) The perception of the regulated population served as one of the greatest obstacles to regulatory success in this case. Opinions on the subject show a distinct geographical difference. Great Lakes states supported the regulations, with environmental groups pressing for stronger regulations controlling boat sewage (Hearings, Minnesota, 1977). The fact that the Great Lakes are enclosed freshwater may engender a greater feeling of the need to prevent water pollution, thus increasing the support for the MSD regulations.

Attitudes in coastal ocean states were that MSD regulations were an unnecessary burden on the boater. Coastal waters were perceived to be capable of assimilating the "miniscule" amounts of sewage produced by boats (Hearings, Seattle, 1977). A 1980 survey of boating organizations reported that not one of them felt that MSD requirements were needed, nor desirable (JRB, 1981). Another survey reported 85% of boaters felt that pleasure boats do not make a significant contribution to water pollution; and finds that 73% of boaters felt they were a victim, rather than a willing partner, in the MSD regulations (Cruising World, 1979).

Today, attitudes on the East and West coasts remain opposed (Ross, 1989). Most boaters feel that the 1972 regulations were overkill and placed unfair burdens on boaters (Amson, 1989; Sisson, 1989). Many of the survey responses from a 1988 summer survey in Rhode Island included comments that indicate boaters still feel victimized by anti-pollution laws that they feel should be directed at industrial and municipal pollution sources (Eldredge, 1989). A Narragansett Bay Project user survey also showed that boaters feel themselves to be minimal contributors to sewage pollution (Ward et al., 1987). Opposition to MSD regulations has continued at high levels since the promulgation of the regulations. In light of this, voluntary compliance was and is not likely.

5) A factor to consider in any regulation is the costs of compliance. These costs include the initial cost of new treatment devices, annual operating costs, and the costs of non- compliance. The costs of non-compliance include fines, lawyers fees, and time spent in court that could ensue if the violation was detected. Therefore, the probability of detection is also a factor. For commercial vessels, the costs of compliance are high but can be passed on to clients. The costs of non-compliance are also high and the probability of detection of non-compliance is great due to yearly Coast Guard inspections. Loss of the ability to do business because of non-compliance is sufficient incentive to generate a 90-95% compliance rate among large, commercial vessels (EPA, 1981).

The costs of installation and annual operation of MSD's is much less for recreational boats, but compliance is also less. The installation cost per boat ranges from $350 to $1000 with average annual operating and maintenance costs ranging from $18-$43, depending on type (JRB, 1981). However, investment and operating costs are only part of the picture. The fine for operating a boat without an approved, functioning MSD is no greater than $2000. The probability of detection in the first year of installation would have to be 33% to 16% (depending on type/cost) to make the risks of non-compliance too costly (Appendix A). Actual probabilities of detection are less than 1% (Amson, 1989; Ellison, 1989). To ensure compliance at very low levels of enforcement, penalties would have to be greater than $400,000 (see Appendix A).

6) There are several interest groups involved in the MSD regulations. The relative strength of these groups drives the success of the regulations. In this issue, it appears that the major lobbying groups involved, the environmental lobby and the boaters, have functioned to counteract each other.

Most boating organizations have sufficient size to generate localized political pressure, but may not be large enough to exert influence at the national level. The fact that there are many boating organizations, divided by state and local boundaries, further decreases their power. The environmental interest groups appear to have the resources necessary to push for stringent regulation and are more organized. This pressure is weakened by a lack of cohesion and intensity of commitment on the boat sewage issue. Save the Bay, an environmental lobby in Rhode Island, has only recently put boat sewage on the agenda. Boater membership in this group is a likely factor in this delay. Environmental groups seeking to solve pollution problems are not likely to focus on boat sewage as a major issue.

7) The administrative process involves both the number of groups and agencies involved in rule-making and the subsequent actions of the lead agency. Boaters, manufacturers, and environmentalists had input into the original legislation through lobbying efforts and public hearings. In the 1972 CWA and subsequent amendments, boating organizations were ineffective in creating less stringent regulations, but did manage to gain control by means other than legislation.

Delays in the promulgation of the regulations and changing MSD requirements indicate that boating group pressures exercised some control. Shifting compliance deadlines allowed boaters to stall enough to avoid more stringent regulations. In addition, the shifting position of EPA from no-discharge to flow-through devices gave the impression that the final step to no regulations for smaller boats may be forthcoming. This attitude further delayed compliance.

Sources Not Acting

1) Authority. The Clean Water Act clearly gave the EPA authority to mandate MSD regulations of any type, and the Coast Guard the authority to enforce the EPA's regulations. Lack of sufficient authority was not a factor.

2) Legislative weakness was not a factor in regulatory failure. The Clean Water Act (1972, as amended) was clear in both its directives and intent on this issue.

Discussion and Conclusion

There are several causes of regulatory failure which have been examined for MSD regulations. The major sources of failure were the lack of enforcement and, more importantly, opposition from the regulated population. Where this opposition did not exist or was not as strong, as in the Great Lakes, compliance was high and there was less need for strong enforcement (Coker, 1988). On the East and West coasts, where boaters felt victimized by the MSD regulations, strong enforcement would have been necessary to achieve compliance.

Other factors contributed to the failure of the MSD regulations. There was a lack of adequate technology, a lack of issue salience, low costs of non-compliance, competing interest group pressures, and administrative errors. Of the nine sources of regulatory failure only two, legislative weakness and lack of authority, were not operating in federal MSD regulations. The aggregate of the sources of regulatory failure resulted in a poorly designed regulation that did not achieve the desired outcome.

Evaluating regulations to determine which of the possible sources of regulatory failure will act to decrease the effectiveness of the regulation can be used as a management tool to prevent regulatory failure. Once sources are identified, steps can be taken to correct them. For example, in this case, an increase in boater education about sewage and pollution could have reduced boater opposition to the regulations. Increased awareness of the technological problems may have resulted in a change in requirements or more efforts in technology development. Greater and more visible levels of enforcement also could have helped compliance.

A closer look at the probability of the success of the regulations, prior to their promulgation, might have eliminated some of the regulatory confusion that exists now. Policies initiated without careful consideration of the possible sources of regulatory failure will be ineffective in solving the problem.

References

Amson, Jonathan, Chief Scientist, Marine Operations Division, EPA. 1989. personal communication.

Chafee (Sen.-RI). 1985. Bill No. S.793. 99th Congress, 1st Session.

Coker, P. Dean. 1988. Marina Developer, personal communication.

Cruising World, 1979. Survey of Boaters.

Ellison, Don. 1989. US Coast Guard Recreational Boating Product Assurance Branch. personal communication.

Eldredge, Maureen. 1989. The Regulation of Sewage Discharge by Recreational Boats in Rhode Island Coastal Waters. Thesis, Univ. of Rhode Island.

EPA. 1981. Report on the Existing Program for Regulation of Marine Sanitation Devices Under Section 312 of the Clean Water Act.

Federal Water Pollution Control Act 1948, 1966, 1972 (Clean Water Act).

Harbormaster, Avalon, CA. 1989. personal communication.

Hearings Before Subcommittee on Environmental Pollution, Minnesota, June 2-3, 1977. 95th Congress 1st Session, part2.

Hearings Before Subcommittee on Environmental Pollution, Seattle, Washington, June 6, 1977. 95th Congress 1st. Session, part 3.

Hearings Before Subcommittee on Coast Guard and Navigation, Oct. 18, 1983. 98th Congress 1st Session, part. 2.

JRB Associates. 1981. Analysis of Wastewater Discharge from MSD's. Prepared for EPA, Washington, DC, PB82-158072.

Meier, Kenneth J. 1985. Regulation: Politics, Bureaucracy, and Economics. St. Martins Press, NY. 334 pps.

Rogers, Spencer et.al. 1982. Availability and Use of Pumpout Facilities in North Carolina: A Survey of Marinas. UNC Sea Grant, UNC-SG-WP-82-1.

Ross, Neil. 1989. International Marina Institute. personal communication.

Sisson, William. 1989. Holding Tanks, the Issue That Just Won't Go Away.

Soundings, Jan. 1989.

Strand, Ivan and George Gibson. 1988. The Use of Pump-out Facilities in Maryland by Marine Recreational Boaters.

Tanski, Jay. 1989. Boater Use of Pumpout Facilities in Suffolk County, Long Island, NY. Paper presented at the International Marina Research Conference, Jan. 1989, Narragansett, RI.

Ward, Harold et.al. 1987. Narragansett Bay Issue Assessment: Public Perceptions. Report to the Narragansett Bay Project Submitted by the Center for Environmental Studies, Brown University. 77pps.

Young (Rep.-Alaska). Bill No. H.R. 1421.1983. pB'=

Appendix A

Costs of Compliance

E = (1-P)(B) - (P)(C)

P= Probability of detection for violations
1-P= Probability of avoiding detection
B= Benefits from noncompliance
C= Penalties (on detection)
E= Expected Value (+)-no compliance, (-)-compliance.

Case I. Probability of Detection Needed at Current Costs and Penalties

B=$1018 (cost of type I device plus maintenance)
C=$2000 (highest possible fine)
0 = (1-P)(1018) - (P)(2000)

P= .33 (33%) minimum probability of detection needed for compliance

Case II. Penalty Needed at Current Levels of Detection and Costs

B=$1018
P= .002
0 = (1-.002)(1018) - (.002)(C)

C= $400,000 Penalty needed at very low enforcement levels.

n.b. This analysis assumes that individuals are not risk averse and are only concerned with their expected value. This is a highly simplified analysis of possible penalties needed. Many other factors, both economic and social, are not included and could act to decrease or increase the required level of enforcement. The numbers given here should be taken as representative of possible orders of magnitude, and not as exact values.

A Preliminary Comparison of Vegetation and Soil in Healthy and Deteriorating Brackish Marsh, Marsh Island, Louisianna

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Abstract

Previous work in coastal marshes indicates that soil mineral matter is important in binding with free sulfide (a plant toxin) and providing plant nutrients, and commonly accepted causes of marsh loss involve plant stress as the mechanism. It was expected that deteriorating marsh at Marsh Island, LA would be characterized by less robust vegetation, resulting from waterlogging stresses, and lower soil bulk density resulting from isolation from sediment sources; but the opposite was found. Soil water levels at the time of visit were 18 cm below the marsh surface at the broken marsh site, and flush with the marsh surface at the solid marsh site, indicating greater soil drainage at the broken marsh site. End-of-season standing crop biomass averaged 1,610.7 g/m^2 at the broken marsh site, and 1,317.1 g/m^2 at the solid marsh site, but did not statistically differ. Seven plant species occurred at the broken marsh site, and 3 occurred at the solid marsh site, suggesting less soil waterlogging at the broken marsh site. Soil at the broken marsh site had a greater bulk density and contained 2 times more mineral matter than soil at the solid marsh site, which indicated that the broken marsh site was flooded with sediment-laden water more often than the solid marsh site. Collectively, these data suggested that the broken marsh site was better drained and received more mineral sediments than the solid marsh site because it was more linked to a tidally-influenced water body than the solid marsh site. More intensive sampling is planned to further investigate the possibility that marsh loss at Marsh Island was not related to soil waterlogging-induced plant mortality.

Introduction

This pilot project was the next step in one line of investigations into processes governing marsh soil formation and marsh stability. Previous efforts resulted in estimates of the amounts of mineral and organic matter needed to maintain the surface of submerging coastal marshes in the intertidal zone (Nyman et al., in press(a)). One of the conclusions of that investigation was that saline marshes required almost twice as much mineral matter as brackish marshes and 4 times as much mineral matter as fresh marshes. The large requirement for mineral matter by saline marshes may be partially related to the role of soil iron in binding with sulfide, a plant toxin. In waterlogged soils, free sulfides that form from the sulfate in seawater have been implicated in the die-back of salt marsh vegetation (Mendelssohn and McKee, 1988). In addition to precipitating sulfides, soil mineral matter may also be a source of plant nutrients and may influence plant growth (DeLaune and Pezeshki, 1988).

Previous work by the authors noted that the aboveground biomass of the salt marsh species, Spartina alterniflora, was related to the soil bulk density, which is a measure of the mineral matter content (DeLaune et al., 1979). One purpose of the current investigation was to search for similar soil mineral matter/plant biomass relationships in brackish marsh, which is usually dominated by Spartina patens.

Marsh Island, Louisiana was selected as the study site because previous work disclosed that marsh loss there proceeded primarily via the spread of broken marsh into areas of solid marsh, and also because broken marsh was usually found farthest into the marsh interior, away from large lakes and bayous (Nyman et al., in press(b)). Commonly-accepted possible causes for marsh loss, e.g. inadequate vertical accretion (DeLaune et al., 1983), interference with marsh drainage (Mendelssohn et al., 1983), and salt water intrusion (Sasser et al., 1986), all involve plant mortality as part of the mechanism of marsh loss. A second purpose of this study was to compare vegetation of the healthy marsh to that of the deteriorating marsh to confirm that marsh loss was related to stresses on marsh vegetation.

Thus, it was expected that deteriorating marsh would be characterized by less robust vegetation, resulting from waterlogging stresses, and lower soil bulk density, resulting from isolation from sediment sources. Future studies were anticipated that would discern the primary causes of plant stress and low mineral matter content of the soil at the broken marsh sites of Marsh Island, and, hopefully, the causes of marsh loss.

Study Area

Marsh Island is a 31,000 ha. island on the central Louisiana coast. The Gulf of Mexico lies to the south, but most bayous are north-draining. North of Marsh Island are 3 bays: Vermilion Bay; West Cote Blanche Bay; and East Cote Blanche Bay. The island is undeveloped and the Marsh Island Wildlife Refuge, operated by the Louisiana Department of Wildlife and Fisheries, occupies the entire island. The marsh is classified as brackish and the vegetation has been extensively described (O'Neil, 1949; Chabreck and Hoffpauir, 1962; Larrick and Chabreck, 1976).

The rate of marsh loss at Marsh Island averaged 0.37%/yr between 1957 and 1983, lower than at many other marshes in Louisiana (Nyman et al., in press(b)). Marsh loss occurred primarily via the conversion of solid marsh to broken marsh and appeared to spread from existing broken marsh areas in the marsh interior (Nyman et al., in press(b)). Broken marsh areas are in the marsh interior, whereas solid marsh areas are closer to large lakes or bayous. Aerial photographs made in 1978 were used to select 2 sites which appeared typical of solid and broken marsh areas at Marsh Island. The sites were located within the drainage system of a north-draining bayou unaffected by weirs and were approximately 2 km apart. The solid marsh site was approximately 500 m from a large lake; the broken marsh site was a small islet approximately 20 m in diameter.

Methods

It was hypothesized that marsh loss occurred at the broken marsh site because the broken marsh site was lower in elevation and isolated from sediment sources, and was therefore less well drained, received less sediments than the solid marsh site, and was lower in elevation, increasing waterlogging-induced plant mortality. Thus, it was anticipated that the broken marsh would be characterized by lower end-of-season standing-crop biomass, lower species diversity, and lower sediment bulk density than the solid marsh site.

The study sites were visited on 25 October 1989, and end-of-season biomass was harvested from 10 1 m^2 plots at each site. A sediment core, 30 cm in depth and 15 cm in diameter, was collected from the center of each harvested plot. A water well was dug at each site by removing a 50 cm sediment core. Water levels were determined almost simultaneously at the two sites, two hours after water well construction during a return visit to the two sites. In the lab, the oven-dried weight of vegetation and sediment cores was measured to estimate end-of-season standing-crop biomass and soil bulk density. Plant species that occurred at each site were identified to estimate species richness. Soil cores were ground, mixed, and samples were taken to determine mineral matter and organic matter content. Percent weight of mineral matter and organic matter were determined by loss-on-ignition at 400°C for 16 hrs (Ball, 1964; Davies, 1974). Percent volume of mineral and organic matter was estimated from percent by weight and the estimates of the particle density of soil mineral matter (2.61 gr/cm^3) and soil organic matter (1.14 gr/cm^3) from Delaune et al. (1983). Data were analyzed as 2-way ANOVA to test for differences in end-of-season standing-crop biomass, soil bulk density, mineral percent of soil volume, organic percent of soil volume, and soil pore space between the solid and broken marsh sites. An alpha level of 0.05 was used as the critical limit.

Results

Vegetation appeared vigorous at both sites, but more so at the broken marsh site. But, it was also evident that the solid marsh site had burned the previous year and litter was not common at the solid marsh site. All plots at both sites were dominated by Spartina patens. Three plant species occurred in plots harvested at the solid marsh site: Spartina patens; Scirpus olneyi; and Juncus roemerianus. At the broken marsh site, those species occurred, as well as Distichlis spicata, Vigna luteola, Lythrum lineare, and Aster subulatus. The solid marsh site had water on the marsh surface and the water well was filled when revisited. At the broken marsh site, there was no water on the marsh surface and the water in the water well was 18 cm below the marsh surface when revisited.

End-of-season standing crop biomass averaged 1,608.9 g/m^2 at the broken marsh site and 1,317.1 g/m^2 at the solid marsh site, but the difference was not significant (F = 4.22, df=1,18, P = 0.0549). Soil at the broken marsh site had a greater bulk density (F = 38.88, df=1,18, P = 0.0001) and a greater volume of mineral matter (F = 21.02, df=1,18, P = 0.0002) than soil at the solid marsh site (Table 1). There was 2.1 times more mineral matter in soil at the broken marsh site than at the solid marsh site. There was no difference between the sites in the volume of soil organic matter (F = 0.02, df=1,18, P = 0.8906) (Table 1). Soil pore space was lower at the broken marsh site than at the solid marsh site (F = 7.53, df=1,18, P = 0.0143).

Discussion

Vegetation at the broken marsh site was expected to be less vigorous than vegetation at the solid site, but the opposite appearance was noted. Unfortunately, because the solid marsh site had burned the previous winter and the broken marsh site had not, planned comparisons of the vegetation between the 2 areas were not valid tests of differences between solid and broken marsh areas. Marsh Island biologists reported that fire did not spread across broken marsh; such areas were, in fact, used as fire breaks to control the size of burns in solid marsh (M. Carlos, pers. comm.). Fire is used in brackish marshes to remove nearly monospecific stands of Spartina patens and to promote the growth of Scirpus olneyi (Lynch, 1941; O'Neil, 1949). Although the difference in biomass between the solid and broken marsh sites was nearly significant, any possible difference between the two sites could have also been caused by the different burning histories, and these biomass data could not indicate if the sites exhibited different degrees of waterlogging-induced plant mortality.

Species richness is generally lower in less well-drained brackish marsh areas than in better-drained brackish marsh areas (Chabreck and Hoffpauir, 1962). It was expected that species richness would be lower at the broken marsh site than at the solid marsh site. The opposite was observed. This difference was probably not the result of the previous burn at the solid marsh site because marsh fires generally increase, rather than decrease, species richness (Lynch, 1941). Although not conclusive, the species richness of the two areas suggested that the solid marsh site was less well-drained than the broken marsh site, the opposite of what was expected.

Although the water wells were only visited once, they provided a means to compare the depth of soil drainage between the two sites during low tide. The solid marsh had water pooling on the marsh surface when it was visited and water was apparent in the wells when they were dug. The broken marsh had no water on the marsh surface and there was no water in the wells when they were dug. When the wells were visited 2 hrs later, water in the wells at the solid marsh site was flush with the marsh surface, but water in the wells at the broken marsh site appeared level with the water level in the surrounding pond area, 18 cm below the marsh surface. These observations excluded the possibility that the broken marsh site was less well-drained than the solid marsh site. The tide was low when the site was visited, but not unusually so (M. Carlos, pers. comm.), and the observation period was believed typical of low tide conditions. Horizontal movement of water in marsh soils in response to tidal action is slight on the Atlantic coast (Agosta, 1985; Gardner, 1972; Hemond and Fifield, 1982), and may also be slight in Louisiana marshes. The solid marsh area was apparently too far from a tidally-influenced waterbody to experience soil drainage. However, the size of the marsh islets in the broken marsh area apparently allowed the islets to experience complete drainage in response to tidal drainage of the marsh ponds. All the marsh ponds in the broken marsh area were connected to a large, tidally-influenced bayou via a small bayou. This small bayou was also evident in 1957 aerial photographs, when the area of broken marsh was smaller. Thus, the broken marsh was less isolated from tidally-influenced waterbodies than the solid marsh site, the opposite of what was expected.

The greater soil bulk density and amount of mineral matter at the broken marsh site indicated that the broken marsh site flooded more frequently with sediment-laden waters than the solid marsh site. The mineral matter content was higher at the broken marsh site probably because the site consisted of islets surrounded by a tidally-influenced pond area, and the additional mineral matter was delivered to the broken marsh site by tidal action. Stumpf (1983) found that 80% of the suspended inorganic material in tidal flood water disappeared within 12 m of a marsh creek; even the centers of most marsh islets of the broken marsh area appeared <12 m from the pond area. Recently, Stoddart et al. (1989) demonstrated the importance of drainage systems in distributing sediment across the marsh surface. In saline marshes, differences in soil bulk density between streamside and inland marshes are attributed to differences in the distance between the areas and tidally-influenced waterbodies (DeLaune et al., 1979).

Vegetation at the the broken marsh site may benefit from the greater soil bulk density at that site. Standing crop biomass in saline marshes is positively related to the volume of soil nutrients, which probably is a result of the volume of mineral matter in the soil (Delaune et al., 1979). There appeared to be a relationship between soil bulk density and end-of-season standing-crop biomass, but the soil bulk density effect was confounded with the site effect and that relationship could not be tested (Figure 2).

The observations that the broken marsh site had greater species richness, more soil mineral matter, and a greater degree of soil drainage than the solid marsh site were incompatible with the hypothesis that marsh loss was related to plant mortality induced by soil waterlogging. These data suggested the following hypotheses:

1) Vegetation at the broken marsh site is more robust than at the solid marsh because of greater soil drainage at the broken marsh site. The greater soil drainage results from the shorter distance between the broken marsh site and a tidally-influenced water body relative to that between the solid marsh site and a tidally-influenced water body, rather than from elevational differences. This hypothesis is supported by the higher water levels, lower species richness, and lower soil bulk density observed at the solid marsh site.

2) The broken marsh site has a greater hydrological link to Gulf

waters than the solid marsh area. This hypothesis is supported by the soil bulk density data and the distances between the sites and tidally-influenced water bodies.

3) Marsh loss at the broken marsh site results from erosion at the edge of marsh islets, rather than from waterlogging induced plant mortality. This hypothesis is supported by the above-mentioned observations and by edge erosion observed at the broken marsh site. Marsh loss through this process is known to occur along the edges of marsh canals (Turner and Cahoon, 1987).

Because this pilot project indicated unexpected conditions, initial plans to investigate relationships between brackish marsh loss, plant stress, and low soil mineral matter have been dropped until results of a more detailed study of the vegetation and soil has been completed. More intensive field work and sampling was completed (8-11 October 1990) to investigate relationships between aboveground biomass, species richness, soil mineral and organic matter, elevation, and soil drainage in 3 broken/solid marsh areas at Marsh Island. Hopefully, those data will be analyzed and in manuscript form in late 1991.

Acknowledgements

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References

Agosta, K. 1985. The effect of tidally induced changes in the creekbank water table on pore water chemistry. Estuar. Coast. and Shelf Science. (21):389-400.

Ball, D.F. 1964. Loss-on-ignition as an estimate of organic matter and organic carbon in non-calcareous soil. J. Soil Sci. 15(1):84-92.

Chabreck, R.H. and C.M. Hoffpauir. 1962. The use of weirs in coastal marsh management in Louisiana. Proc. Ann. Conf. Southeast Game Fish Comm. 16:103-112.

Davies, B.E. 1974. Loss-on-ignition as an estimate of soil organic matter. Soil Sci. Soc. Amer. Proc. 38:150-152.

DeLaune, R.D., R.H. Baumann, and J.G. Gosselink. 1983. Relationships among vertical accretion, coastal submergence, and erosion in a Louisiana Gulf Coast marsh. J. Sed. Petrology 53(1):147-157.

______, R.J. Buresh, and W.H. Patrick, Jr. 1979. Relationship of soil properties to standing crop biomass of Spartina alterniflora in a Louisiana marsh. Estuarine and Coastal Marine Science 8:477-487.

______, and S.R. Pezeshki. 1988. Relationship of mineral nutrients to growth of Spartina alterniflora in Louisiana salt marsh. Northeast Gulf Sci. 10(1):55-60.

Gardner, L.R. 1972. The effect of hydrologic factors on the pore water chemistry of intertidal marsh sediments. Southeast. Geology 14(1):17-28.

Hemond, H.F. and J.L. Fifield. 1982. Subsurface flow in salt marsh peat: a model and field study. Limnol. Oceanogr. 27(1):126-136.

Larrick, W.D. and R.H. Chabreck. 1976. Effects of weirs on aquaticvegetation along the Louisiana coast. Proc. Ann. Conf. Southeast. Game Fish Comm. 13:100-115.

Lynch, J.J. 1941. The place of burning in management of the Gulf Coast refuges. J. Wildl. Manage. 5:454-458.

Mendelssohn, I.A. and K.L. McKee. 1988. Spartina alterniflora die-back in Louisiana: time-course investigation of soil waterlogging effects. J. Ecology 76:509-521.

______, R.E. Turner, and K.L. McKee. 1983. Louisiana's eroding coastal zone: management alternatives. J. Limnol. Soc. So. Afr. 9(2):63-75.

Nyman, J.A., R.D. DeLaune, and W.H. Patrick, Jr. in press(a). Wetland soil formation in the rapidly subsiding Mississippi River Deltaic Plain: mineral and organic matter relationships. Est., Coast. and Shelf Sci.

______, R.H. Chabreck, and R.G. Linscombe. in press(b). Effects of weir-management on marsh loss, Marsh Island, Louisiana. Environ. Manage.

O'Neil, T. 1949. The muskrat in the Louisiana coastal marshes. Publ. Fed. Aid Sec., La Wildl. Fish Comm. 152pp.

Sasser, C.E., M.D. Dozier, J.G. Gosselink, and J.M. Hill. 1986. Spatial and temporal changes in Louisiana's Barataria Basin marshes, 1945-1980. Environ. Manage. 10(5):671-680.

Stoddart, D.R., D.J. Reed, and J.R. French. 1989. Understanding salt marsh accretion, Scolt Head Island, Norfolk, England. Estuaries. 12(4):228-236.

Stumpf, R.P. 1983. The process of sedimentation on the surface of a salt marsh. Estuar. Coast. Shelf Sci. 17:495-508.

Turner, R.E. and D.R. Cahoon. 1987. Causes of wetland loss in the coastal central Gulf of Mexico. Volume II: Technical Narrative. Final report submitted to Minerals Management Service, New Orleans, La. Contract No. 14-12-001-30252.

Figure 1. Relationship between soil bulk density and end-of-season standing crop biomass in solid and broken marsh, Marsh Island, Louisiana, 1989.

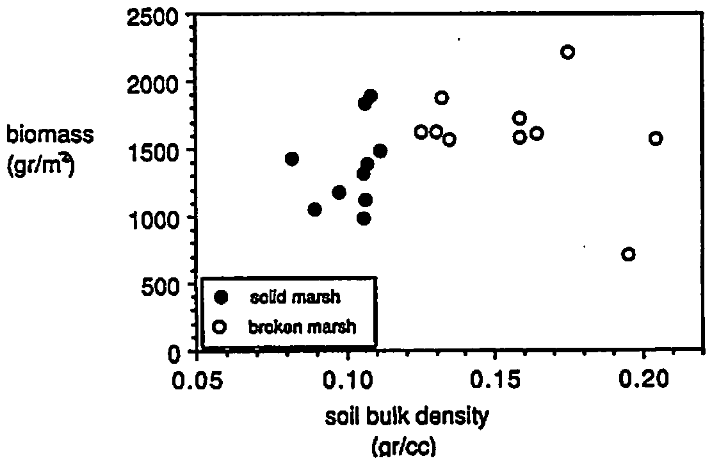

Table 1. Soil characteristics measured in 10 plots in a solid marsh site, and in 10 plots in a broken marsh site, Marsh Island, Louisiana, 1989.

characteristic	broken marsh mean	broken marsh std. err.	solid marsh mean	solid marsh std. err.
bulk density (gr/cc)	0.159	0.008	0.102	0.003
organic matter (% volume)	4.95	1.1	4.74	0.2
organic matter (gr/cc)	0.056	0.008	0.054	0.002
mineral matter (% volume)	3.92	0.31	1.88	0.11
mineral matter (gr/cc)	0.102	0.008	0.049	0.003
pore space (% volume)	91.13	0.56	93.38	0.14

Overview of the First Four Years of the NOAA National Status and Trends Mussel Watch Program

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Abstract

Oysters are utilized as bioindicator organisms to characterize the current status and long-term trends for 13 trace elements and 57 organic contaminants from 75 Gulf of Mexico sampling sites. Sampling sites are distributed throughout the U.S. waters of the Gulf of Mexico, away from known point sources of input, and are sampled yearly in the winter to provide a geographical description of the chronic contaminant loading of the entire U.S. Gulf on a regional basis. Three stations at each site are analyzed individually to assess natural intra-site variability so that significant changes can be detected. Extensive intercomparison exercises assure the comparability of analytical measurements with companion studies on the East and West Coasts. The first four years of data for the Gulf of Mexico represents over 40,000 individual data points. The general trend from this large data set is contaminant concentrations that show no changes during the four-year sampling period. There are, however, certain sites that have experienced significant changes in contaminant concentration over the last four-year sampling period, including monotonic increases and decreases. Generally, the concentrations of the various contaminants do not show any significant relationship to each other. This is probably due to different input sources. Higher concentrations of most contaminants are associated with proximity to large urban areas. Two areas that appear to be exceptions to this generalization, St. Andrew Bay, FL and Choctawhatchee Bay, FL, are discussed in more detail.

Introduction

The National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) Mussel Watch Program has sampled and analyzed bivalves from U.S. coastal areas since 1986. This report summarizes the first four years of NS&T data for the Gulf Coast of the U.S. Sampling sites give coverage of the Gulf Coast from southernmost Texas to southernmost Florida. Portions of the data have been previously discussed (Wade et al., 1988, 1989, and 1990; Wade and Sericano, 1989; Sericano et al., 1990a and b) and only an overview is presented here.

Methods

The NS&T program utilizes standard operating procedures and a strong quality assurance/quality control program for trace element and trace organic analyses. Details of these methods are found elsewhere (Brooks et al., 1989; Wade et al., 1988). The accuracy and precision of these methods have been established by several intercalibration exercises conducted by the U.S. National Institute of Standards and Testing and the Canadian National Research Council.

Results and Discussion

Exact sample location and the years in which samples were collected at each site are presented elsewhere (Wade et al., 1990). The geographical distribution for selected contaminants or suite of contaminants is shown in Figures 1 to 7. The sites are listed in geographical sequence starting with the southernmost Texas site and continuing along the coast to the southernmost Florida site. The smaller bars on Figures 1 to 4 represent "plus one standard deviation".

Trace metal concentrations in oysters varied considerably from site to site; in general, these variations were consistent over the four-year period. That is, the same sites showed consistently above or below average concentrations each year. The high concentrations, with very few exceptions, could not be shown to be associated with known activities of man, such as the presence of industry or oil well drilling operations. However, the fact that high values were often found in only one part of a particular bay (e.g., Tampa or Galveston Bay) while at other nearby sites in these same bays the concentrations were average or below for trace metals, suggests localized inputs of these metals.

Regional trends in trace metal concentrations in oysters are more likely to be due to geologic or climatic factors than to activities of man. Regional trends can be seen for only a few of the 13 metals assessed and, even for these, large site-to-site variations are superimposed on rather subtle regional trends. For example, Figure 1 shows the distribution of selenium (Se) for the entire Gulf Coast. A gradual decrease in concentration is apparent when concentrations from Texas and Louisiana are compared to those in south Florida, even though some high values are found in northern Florida.

Arsenic (Figure 2) is usually thought to be chemically similar to Se, but it shows a distribution pattern almost opposite to that of Se (Figure 1). Arsenic (As) is much higher in some of the Florida oysters than elsewhere on the Gulf Coast, yet some Florida oysters, for example those from most sites in Tampa Bay, had very low arsenic concentrations all four years. Only the Tampa Bay site at Navarez Park near the city of St. Petersburg was significantly enriched in As. Even the new site at Knight Airport on the edge of the city of Tampa was low in As. It is possible that the extensive phosphate rock deposits in Florida are a source of arsenic, but, based on the limited data we have, there is no correlation between As concentration in oysters and phosphate rock occurrence, shipping, or mining. The As distribution does seem to be controlled by local environmental inputs, as do certain other metal distributions. There seems to be no other explanation for high and low concentrations of trace metals to occur at adjacent sites, often in a given bay, and to have these patterns consistent from year to year.

Mercury (Hg) is generally enriched in Florida sites (Figure 3), where 12 of the 25 sites are well above average. The oysters from Old Tampa Bay are especially high in Hg, rivaling even those from Lavaca Bay, Texas which are known to be contaminated with Hg and where harvesting of oysters has been limited because of the potential threat to human health.

Silver (Ag) distribution (Figure 4) was more similar to that of Se than to As, being somewhat enriched in Texas relative to Florida. The most interesting feature of the Ag distribution is the low values in central Louisiana. This same pattern was seen for cadmium (Cd) and is somewhat surprising because central Louisiana Bays have been extensively disturbed by oil exploration activities and are immediately downstream of the Mississippi River outflow. In this area, then, intense activities by man does not seem to be influencing trace metal concentrations in oysters.

The regional geographical distribution of the concentration of the sum of 18 individual polyaromatic hydrocarbons (PAHs) (Wade et al., 1988) is shown in Figure 5. The concentration of PAHs for regional sites are plotted as the average. For example, for Galveston Bay 6 sites are averaged.

Two PAHs, fluoranthrene and pyrene, generally account for more than 25% of the total amounts detected. The predominance of these compounds would suggest the major source of PAHs is probably combustion and not oil seeps or oil spills. In general, higher PAH concentrations are found at major river mouths where you also generally find large urban areas and associated industrial complexes. This is not surprising, since urban runoff and sewage treatment plants are well known chronic sources of PAHs.

The Panama City and St. Andrew's Bay regions are exceptions to this trend. Their is no major river in these locations, yet they have the highest PAH concentrations. It is possible that these sites were affected by an episodic input of petroleum (i.e., spill). The hydrocarbon distribution at these sites indicates they may be contaminated by used crank case oil.

An extensive interpretation of the chlorinated pesticide and polychlorinated biphenyl (PCB) data has been published elsewhere (Wade and Sericano, 1989; Wade et al., 1988 and 1990; Sericano et.al., 1990a and b). Total DDT (sum of o-p'DDE+p-p'DDE+o-p'DDD+p-p'DDD+o-p'DDT+p-p'DDT) regional distribution for oyster samples collected along the U.S. Gulf of Mexico coast is shown in Figure 6. Total DDT is the most abundant chlorinated pesticide found in Gulf of Mexico oysters. Most of the DDT is present as the metabolites, DDE and DDD. Less than 10% of the total contaminant load in oysters is the parent compound, DDT.

The regional distribution of total DDT shows that four of the five highest concentrations are associated with major river outfalls including the Brazos, Mississippi, Mobile, and Choctawatchee Rivers. There were also relatively high total DDT concentrations at St. Andrew's Bay and Panama City, although no major rivers are found there. These are the same regions where the PAHs were the highest. DDTs associated with soils may be transported downstream and collect in estuaries. This process provides a plausible explanation of the higher total DDT associated with major river outfalls. The continued use of DDT in Mexico and other Latin American countries and its atmospheric transport and deposition to the sampling areas is another possible source.

The regional distribution of PCBs is shown in Figure 7. PCBs were detected in all NS&T oyster samples analyzed from Gulf of Mexico waters. The highest regional concentration was in St. Andrew's Bay. As mentioned before for PAH and total DDT, this is an anomalous station and at present we do not know the reason for the high concentrations at this site. Possible sources of contaminants at this site may be nearby oil storage tanks and a paper/pulp mill. The PCB concentrations do not show much difference on a regional basis. All the regions have average concentrations within a factor of 5. There are somewhat higher concentrations near areas of higher population density (i.e., Galveston Bay, Mobile Bay, etc.).

Conclusions

Most of the contaminants monitored by the Status and Trends Program have relatively long environmental half-lives. These contaminants, in general, show no change in environmental concentrations over the first four years of this study as seen in the standared deviation for trace metals (Figures 1 to 4). There are specific sites that are exceptions to this general trend and they merit further detailed examination.

Acknowledgements

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REFERENCES

Brooks, J. M., T.L. Wade, E.L. Atlas, M.C. Kennicutt II, B.J. Presley, R.R. Fay, E.N. Powell, and G. Wolff. 1989. Analyses of Bivalves and Sediments for Organic Chemicals and Trace Elements from Gulf of Mexico Estuaries. Annual Report 1989, 678 pp.

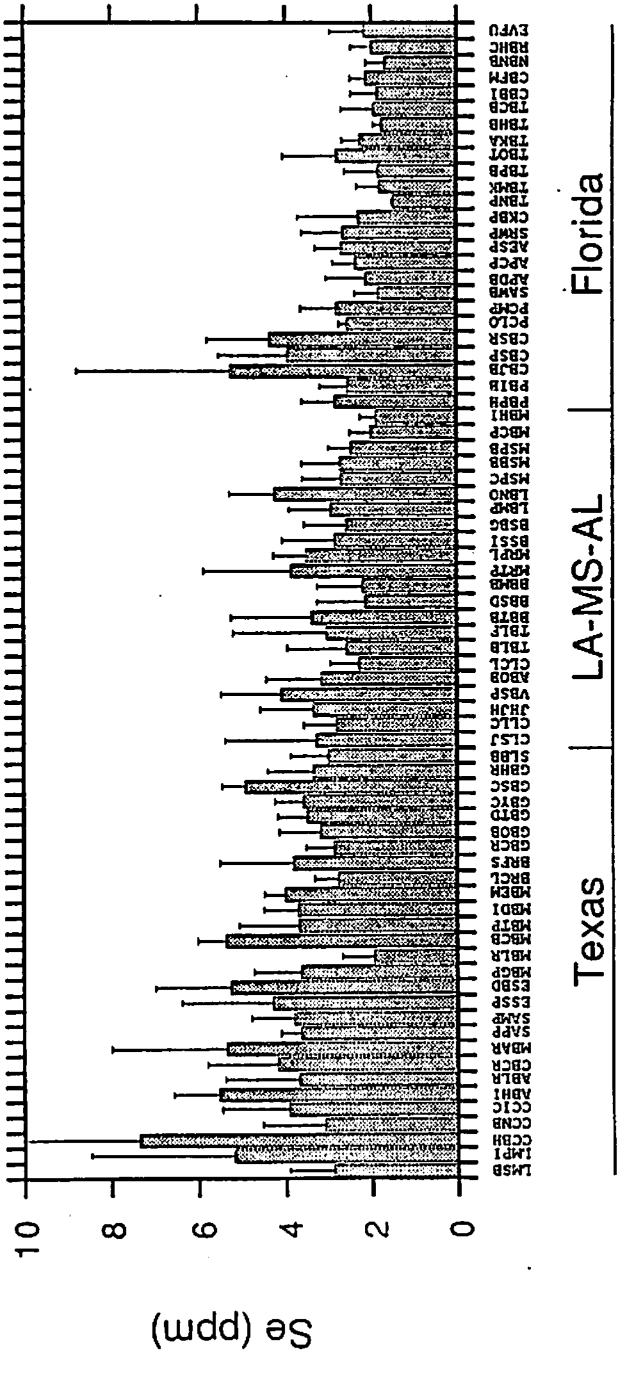
Sericano, J.L., E.L. Atlas, T.L. Wade, and J.M. Brooks, 1990a. NOAA's Status and Trends Mussel Watch Program: Chlorinated pesticides and PCB's in oysters (Crassostrea virginica) and sediments from the Gulf of Mexico, 1986-1987. Marine Environmental Research, 29: 161-203.

______, T.L. Wade, E.L. Atlas, and J.M. Brooks, 1990b. Historical perspective on the environmental bioavailability of DDT and its derivatives to Gulf of Mexico oysters. Environmental Science and Technology, 24: 1541-1548.

Wade, T.L., E.L. Atlas, J.M. Brooks, M.C. Kennicutt II, R .G. Fox, J. Sericano, B. Garcia-Romero, and D. Defreitas. 1988. NOAA Gulf of Mexico Status and Trends Program: trace organic contaminant distribution in sediments and oysters. Estuaries, 11: 171-179.

______, and J.L. Sericano. 1989 Trends in contaminant distribution in oysters from the Gulf of Mexico. Pages 585-589 In: Proceedings of the Oceans '89 Conference, Sept. 18-21, 1989, Seattle, WA, Organotin Symposium, Vol. 2.

______, J.L. Sericano, B. Garcia-Romero, J.M. Brooks, and B.J. Presley, 1990. Gulf Coast NOAA National Status & Trends Mussel Watch: The first four years. Pages 274-280 In: Proceedings, Marine Technology Society '90, Washington, D.C., 1990.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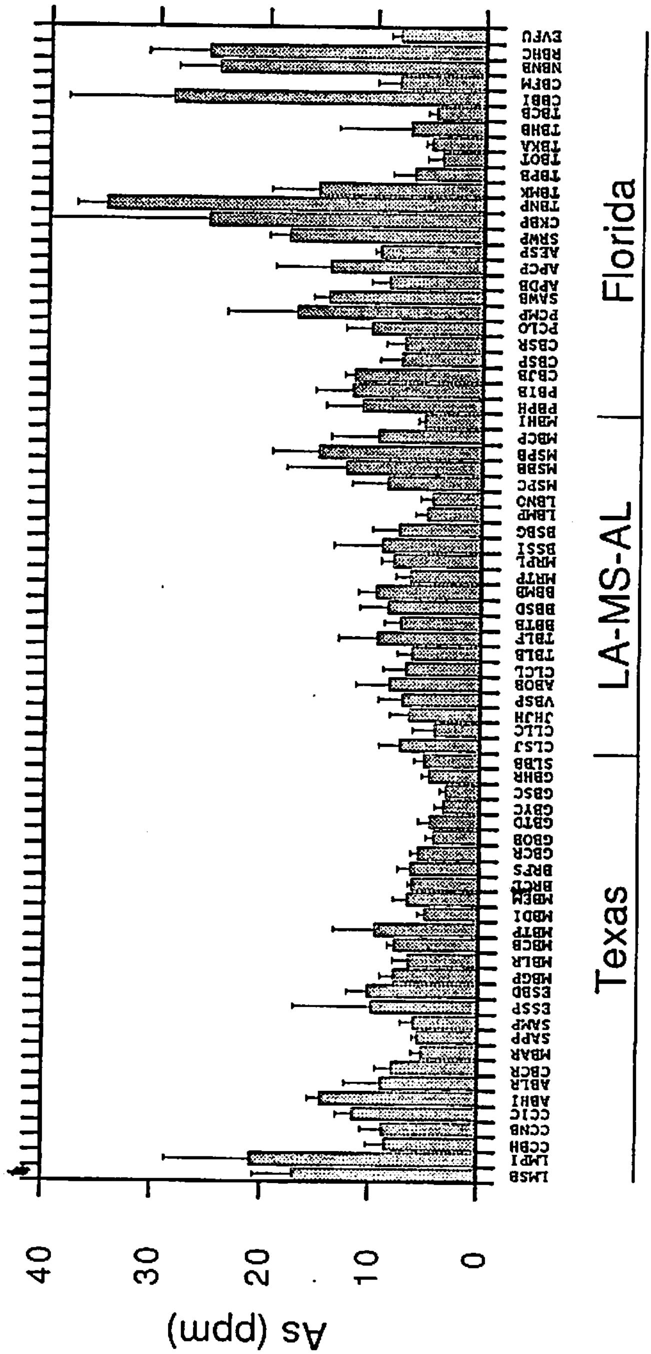
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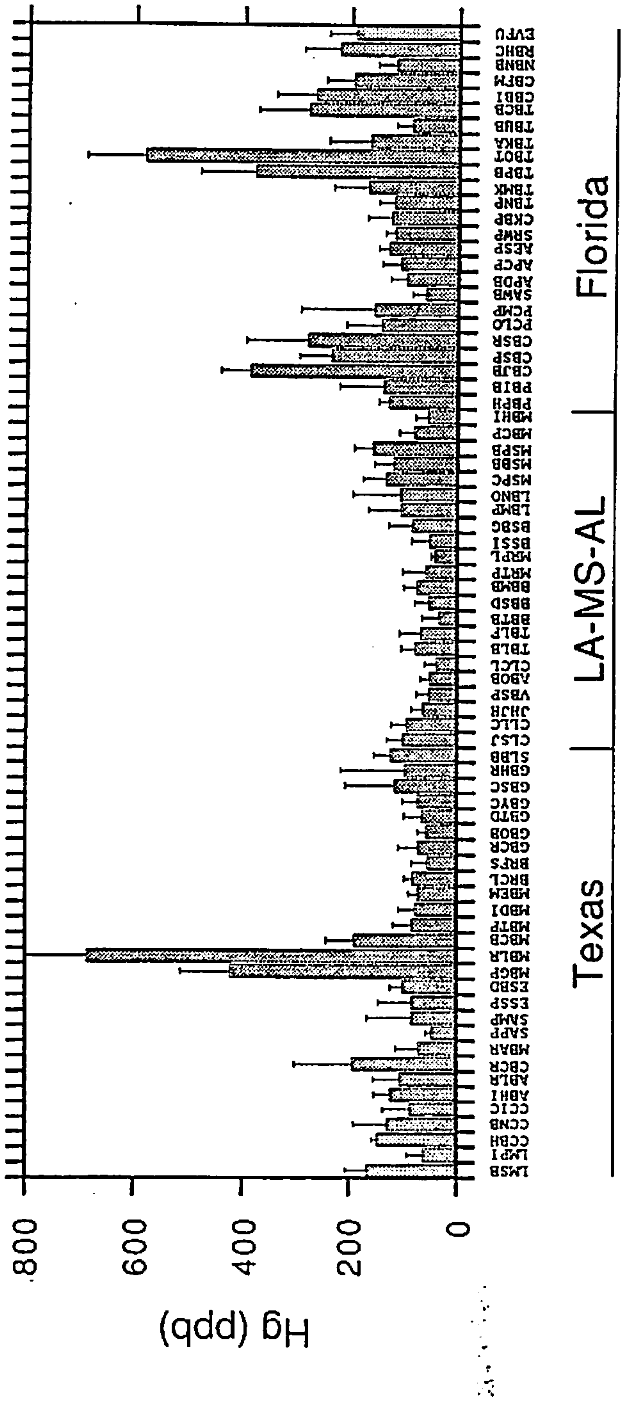
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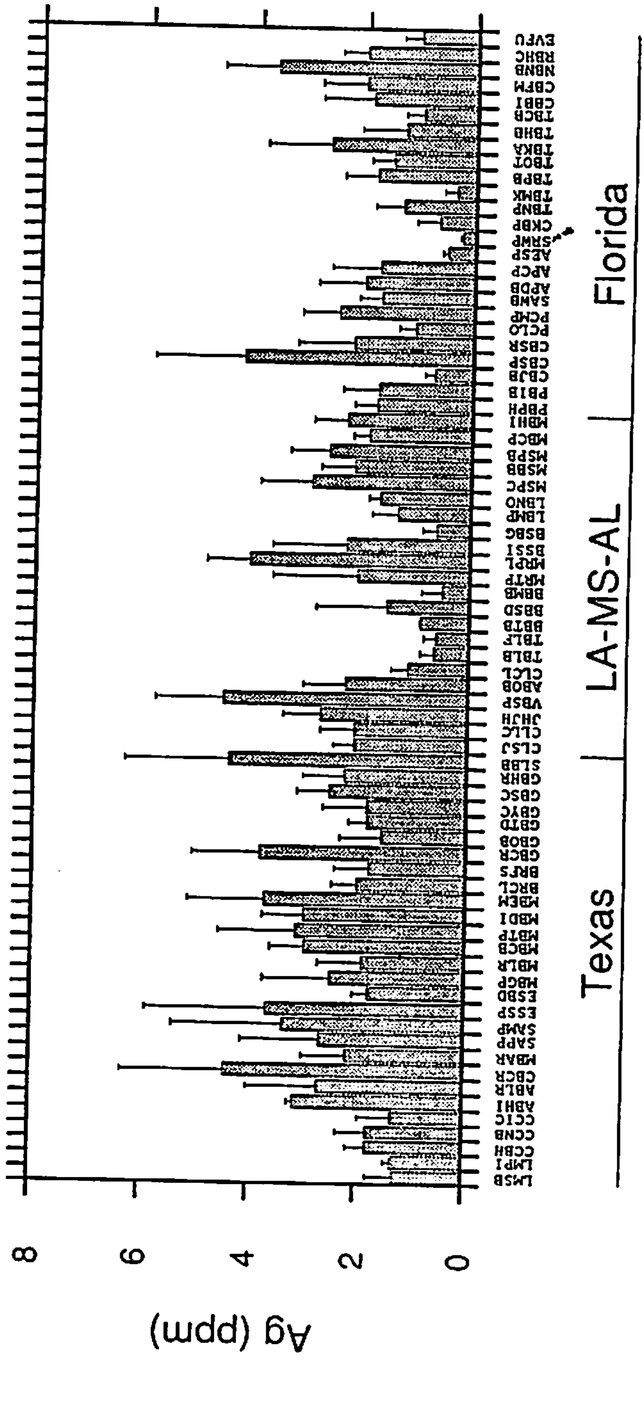
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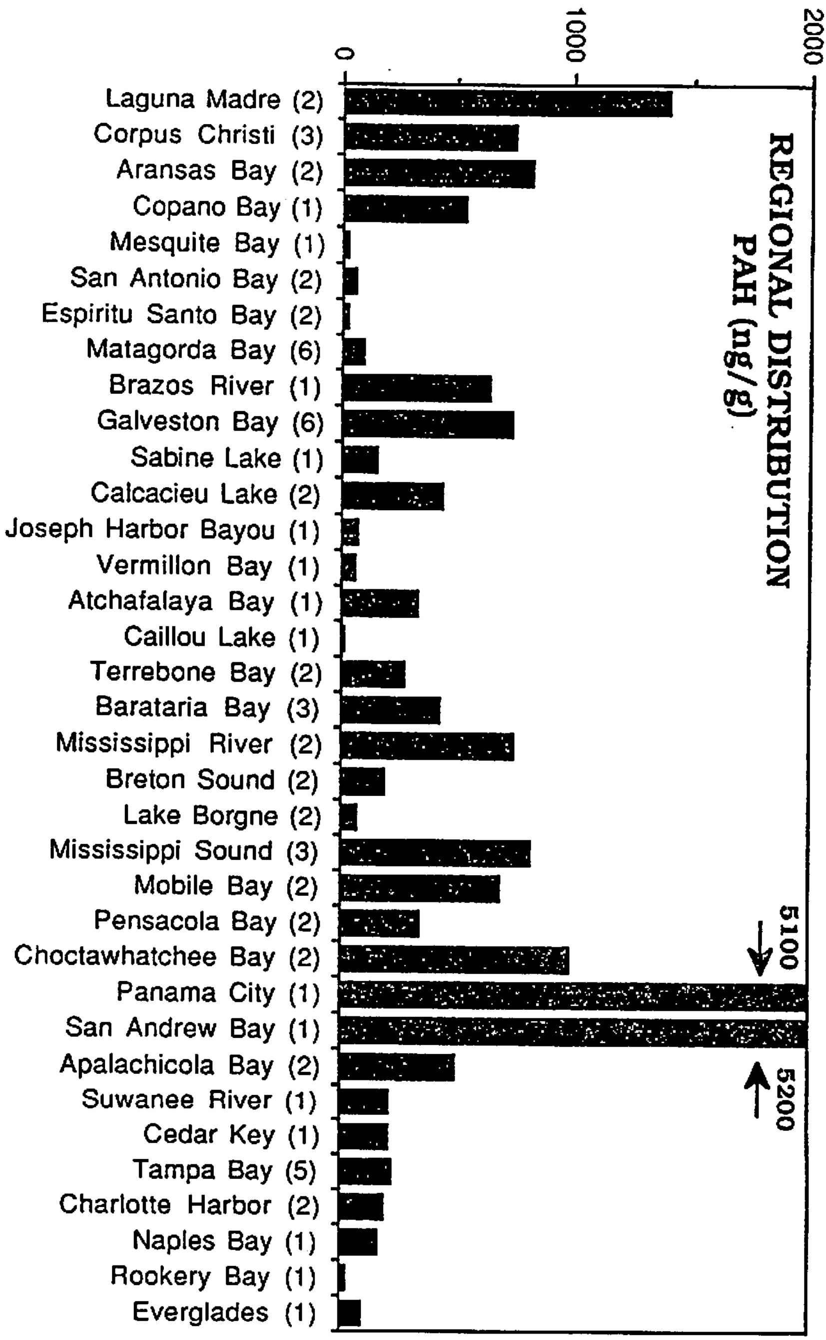
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Mississippi River (2)
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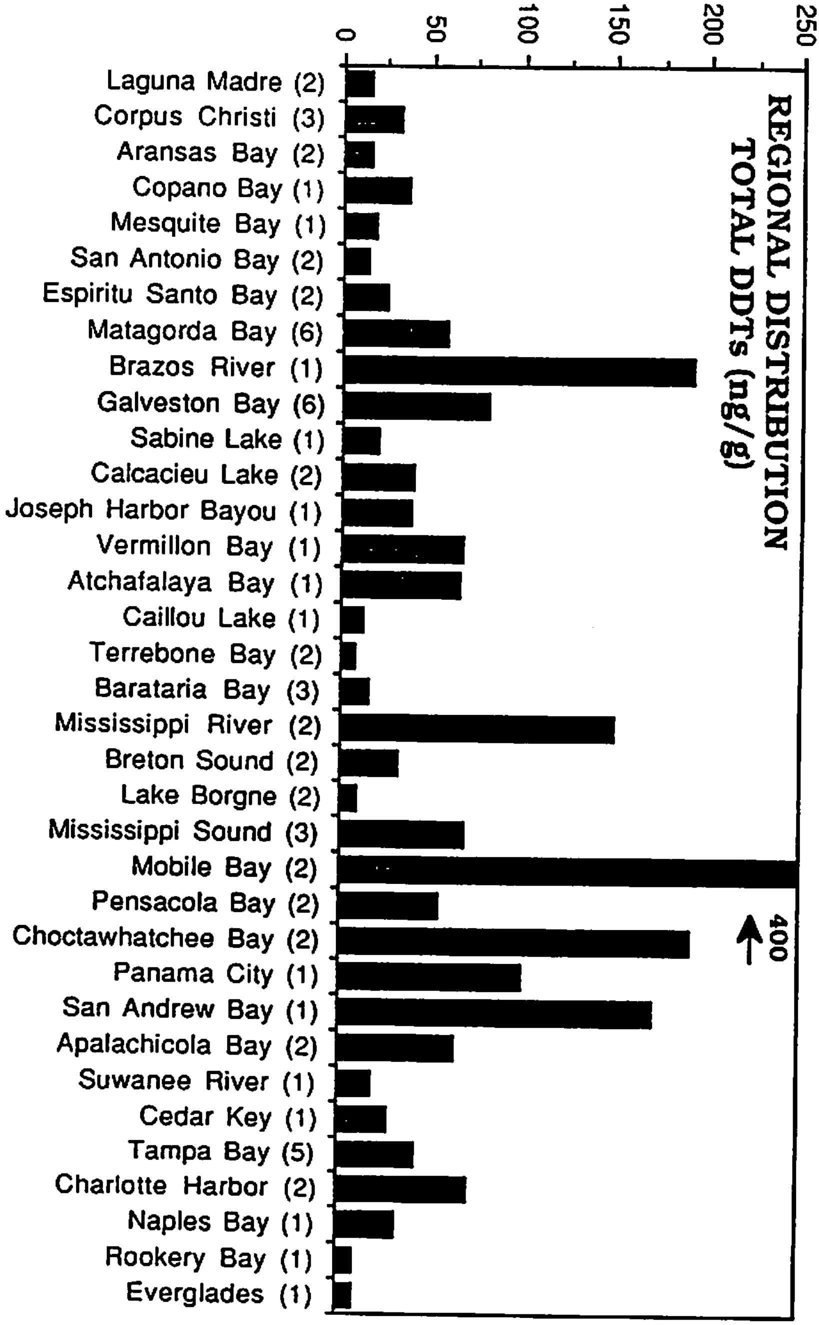
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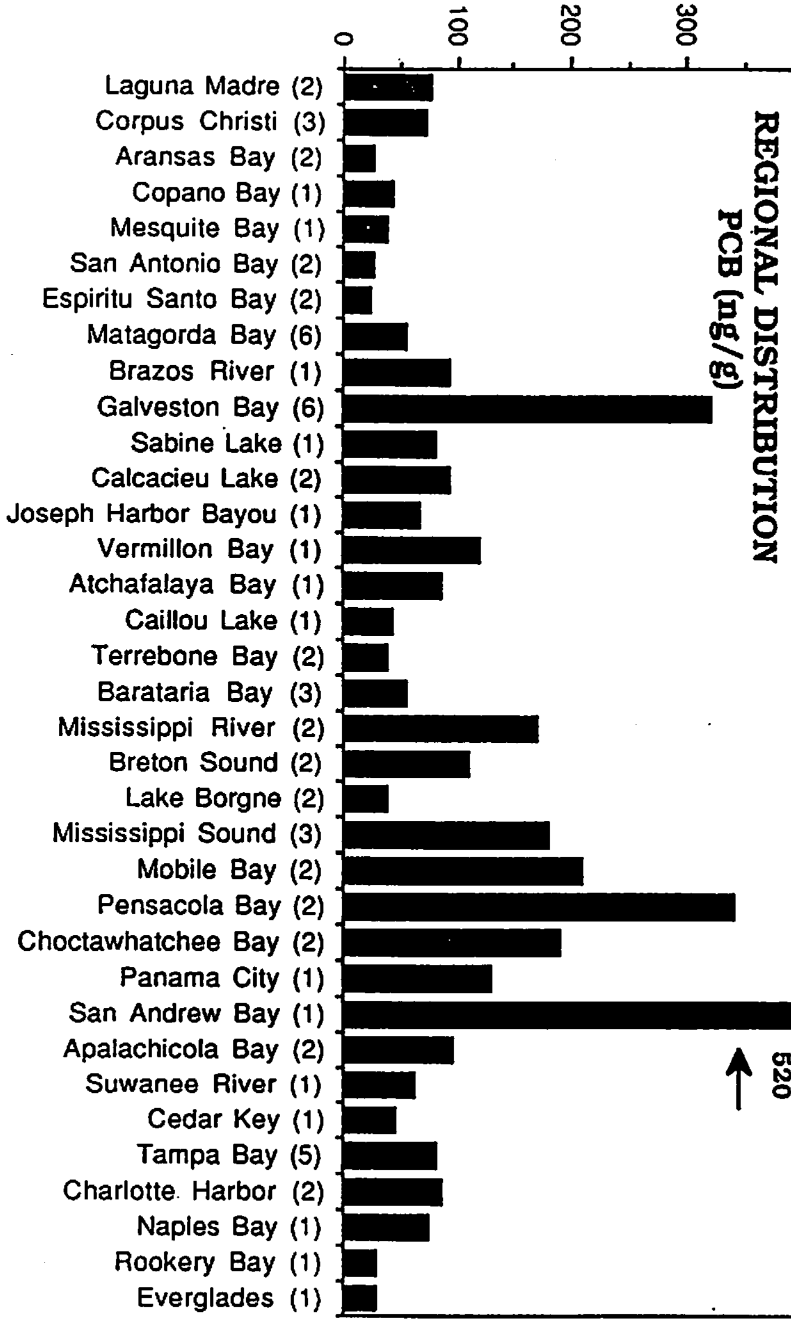
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Brazos River (1)
Galveston Bay (6)
Sabine Lake (1)
Calcacieu Lake (2)
Joseph Harbor Bayou (1)
Vermillon Bay (1)
Atchafalaya Bay (1)
Caillou Lake (1)
Terrebone Bay (2)
Barataria Bay (3)
Mississippi River (2)
Breton Sound (2)
Lake Borgne (2)
Mississippi Sound (3)
Mobile Bay (2)
Pensacola Bay (2)
Choctawhatchee Bay (2)
Panama City (1)
San Andrew Bay (1)
Apalachicola Bay (2)
Suwanee River (1)
Cedar Key (1)
Tampa Bay (5)
Charlotte Harbor (2)
Naples Bay (1)
Rookery Bay (1)
Everglades (1)

Buffer Zones: The Environment's Last Defense

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Massachusetts Audubon: North Shore

Abstract

More than 50% of our nation's 215 million acres of wetlands have been destroyed by development activities that have permanently altered the functions that are so valuable to the biological communities that depend on wetlands. The degradation of our nation's coastal waters continues to plague many states and communities that depend so heavily on this important resource. Within Massachusetts' North Shore region, 28,000 acres of shellfish beds remain closed to fishing due to bacterial contamination from the land. To prevent further coastal water contamination and wetland destruction, Massachusetts Audubon: North Shore recommends that specific resource management initiatives be adopted by municipalities prior to future development in areas of critical environmental concern such as the Essex Bay-Parker River Area of Critical Environmental Concern (ACEC). These policy recommendations include the identification of critical resource areas, the establishment of larger natural buffer zones between development and the critical resource areas, and the prioritization of critical resource areas for land acquisition and other conservation measures.

Introduction

As development pressure increases in the coastal regions of the United States, greater attention must be paid to the fringe areas surrounding coastal and freshwater wetlands. Studies show that development activities within these fringe areas cause changes that irreparably harm wetland habitats. Wetlands serve a tremendous biological value, particularly by providing habitat to a wide variety of plants and animals, and by serving as important sources for groundwater recharge, and by trapping nutrients and sediment. Vegetated buffer zones are an extremely valuable mechanism which protects wetland habitats by controlling non-point pollution, protecting wildlife and their habitats, and maintaining the aesthetic quality of the wetlands' natural features.

More than 50% of our nation's 215 million acres of wetlands have been destroyed. Wetland destruction can be attributed to activities such as filling and regrading, diverting the direction of water courses, and the loading of nutrients from septic systems, agriculture activities, and lawn treatments. A report published in October, 1987 by the National Wildlife Federation stated that 300,000 acres of wetlands are destroyed yearly in the United States. That rate is equivalent to 6 acres every 10 minutes. Despite national and local legislative initiatives, our Nation continues to lose wetlands at an alarming rate due to fragmented and inconsistent wetland policies. Recognizing this, environmental groups across the country are taking steps to:

* halt further destruction of wetlands
* restore degraded and destroyed wetlands
* increase our nation's wetland base

Purpose

The Massachusetts Wetlands Protection Regulations (301 CMR 10.01) include eight statutory interests that must be upheld by local conservation commissions to protect the integrity of wetlands. Buffer zones are vital to the protection of those interests. Presently, there is concern that the 100-foot buffer width designated in the regulations is not adequate to protect some (if not all) of those statutory interests. Massachusetts Audubon: North Shore proposes that buffer zone widths be increased, particularly around sensitive areas, to prevent further degradation of wetlands and the quality of water supplies and coastal waters.

This paper provides a summary of technical and scientific justification necessary to implement a policy to increase buffer zone widths, insuring the protection of the area's natural resources.

Present Regulations

The Massachusetts Wetlands Protection Act (MWPA) recognizes eight interests that local conservation commissions are mandated to protect when examining a project's impact on a wetland. They are:

* public and private water supply
* groundwater supply
* flood control
* storm damage prevention
* prevention of pollution
* protection of land containing shellfish
* protection of fisheries
* protection of wildlife habitat

In addition to protecting open water, wetland, and beach habitat (310 CMR 10:02), the MWPA also gives conservation commissions jurisdiction over the buffer zone around each wetland. Since it has long been recognized that activities adjacent to wetlands, such as construction, significantly alter the quality of the wetland through time, activities outside the designated 100-foot buffer zone may still be subject to the provisions of the MWPA if that activity alters any of the eight interests subject to protection (310 CMR 10:02 (2c)). The regulations state that there may be activities, particular sensitive regions, and/or interests that warrant more protection than a 100-foot buffer zone provides.

A 1987 amendment to the MWPA included wildlife habitat as one of the interests protected by the Act. Despite this amendment, wildlife still is not adequately protected by law. Animals that utilize a combination of upland and wetland areas are vulnerable in upland habitats even when the upland area lies within the 100-foot buffer zone. Herons, for example, often nest in trees adjacent to wetlands. A heron rookery is not protected by the MWPA, since it is not in a wetland habitat, even though herons are obviously aquatic birds that spend a good part of their lives foraging in wetlands.

Critical Resource Areas

Areas of Critical Environmental Concern (ACEC) are designated by the Commonwealth of Massachusetts to protect natural areas of regional and statewide significance. The Parker River-Essex Bay ACEC, designated in 1979, is one of the largest pristine salt marsh-estuarine ecosystems north of New York State. Over 300 species of birds have been recorded within this ecosystem, of which 75 species are considered rare by the Commonwealth. Waters of the ACEC contain vast amounts of shellfish that historically have supported an extremely valuable shellfishing industry (the world-renowned Ipswich and Essex Bay clams). Today, this valuable resource is threatened by bacterial contamination. The region also supports the largest runs of alewives and smelt on the North Shore (Masachusetts Coastal Zone Management, 1987).

The ACEC designations have not required the implementation of new permits or administrative programs. Instead, existing environmental programs are required to provide higher performance standards and thorough review for activities proposed within the boundaries of an ACEC (Massachusetts Coastal Zone Management, 1987). However, stricter guidelines need to be asserted at the community level with regard to setting buffer zone widths.

The Essex Bay marsh remains a particularly ideal habitat for wildlife species that depend on a mixture of salt marsh and vegetated uplands. By providing for continued protection of the wetlands and water quality, the shellfishing industry may be guaranteed a safe and clean resource for future generations.

Buffer Zone Features that Protect Wetlands

One method of guaranteeing the protection of environmentally sensitive regions is to provide vegetated areas or buffer zones between structures and the desired resource to be protected. Surface runoff from developed areas carries a variety of pollutants, including heavy metals (e.g.

lead, cadmium, copper, and zinc), hydrocarbons (e.g. gasoline and motor oil), pesticides/herbicides, bacteria, viruses, and sediments (Diamond and Nilson, 1988). These contaminants are often referred to as non-point pollutants because they do not generally discharge to waterways through a pipe. Table 1 describes the sources and environmental impacts of each pollutant.

A naturally vegetated buffer zone renovates or filters runoff prior to the runoff entering the receiving waters. The effectiveness of the renovation process is dependent on four factors:

* vegetation cover
* soil characteristics
* slope
* depth to ground water

An optimally functioning buffer zone is comprised of a well-established vegetation cover on moderately well-drained soils with slopes of less than 10%. If any of these three factors is impaired or altered, the renovation capability of the buffer zone is reduced. Scientific studies have determined buffer zone widths that will effectively remove or reduce the impacts of specific pollutants under very specific field conditions (Diamond and Nilson, 1988). Buffers 100-300 feet wide are recommended to protect surface water bodies from sedimentation and 300-1000 feet are recommended for 50 to 90% nutrient removal (Rhode Island Coastal Resources Management Program, 1984).

Some states in the United States have developed methods to determine buffer zone widths on a case by case basis. The most widely used and effective method is a scoring or ranking system (Diamond and Nilson, 1988). The ranking system allows a resource manager to calculate a buffer zone width based on the following criteria:

* soil conditions of the proposed site
* slope
* quantity and quality of the vegetation cover
* potential water quality impacts from the proposed development
* proximity of the proposed development to valuable resource areas (e.g. drinking water supplies, conservation areas, etc.)

Values are assigned to the various criteria. Following the site and proposal evaluation, the values are tabulated. If the values exceed a particular threshold, the project may proceed; if not, the proposal must be re-examined and altered to meet the community's goals.

Justification for Increased Buffer Zone Widths

Water Quality Maintenance and Public Health Protection.

The major water pollution problems throughout the United States are directly related to the density and distribution of development within watersheds (Yates, 1985). Several studies conducted in coastal communities throughout the United States suggest that the principal sources of fecal coliforms, viruses, and excess nutrients to groundwater and coastal waters are leachate from failed septic systems, direct discharges of improperly treated sewage, fecal material from domestic and farm animals carried by runoff, leaking sewers, and sanitary land fills (Rhode Island Coastal Resources Management Program, 1984; Heufelder, 1987).

Throughout the Essex Bay - Parker River ACEC, it is safe to assume that failing septic systems and contaminated runoff are the greatest contributors of contaminants to the region's coastal waters. In the City of Gloucester, densely populated areas along the Annisquam River with septic systems that predate Title V regulations were found to be the sources of bacterial contamination (Massachusetts Audubon Society, 1982). While steps are being taken to halt further contamination from the known sources, such as the sewering of North Gloucester, additional consideration must be given to reduce contaminated runoff or non-point pollution. Future development within areas of critical concern, such as the ACEC, must be designed and built in a manner that will not promote additional contamination of ground water and coastal waters above and beyond the currently recognized non-point sources.

Over half of the waterborne disease outbreaks in the United States are due to the consumption of contaminated groundwater; septic tanks are the most frequently reported cause of contamination (Yates, 1985). As an example, five cases of typhoid were reported in a residential area within the State of Washington. An epidemiological investigation revealed that the typhoid carrier lived in the vicinity. When the individual's septic system was dye-tested, the dye was detected 36 hours later in area wells 210 feet from the contaminated well. This demonstrates the seriousness of contaminant transport in groundwater supplies. Hagedorn (1984) summarized studies that examined the incorporation of various bacterial and viral organisms in soils. Migration distances of 2 to 2723 feet were reported for the different organisms, along with survival times of up to 27 weeks.

The viability and transport of viruses are causing greater concern since these organisms are often difficult to detect. Currently, there is no method used by federal and state agencies to monitor virus contamination in wastewater effluent or the waters receiving the effluent. Scientists have shown that viruses travel as far as 1300 feet horizontally in groundwater from sewage infiltration basins (Keswick and Gerba, 1980). Unfortunately, viruses cannot be considered permanently immobilized after adsorption onto a soil particle.

Some studies indicate that viruses may re-grow, desorb from soil particles, and migrate further in the soil (Rhode Island ISDS Task Force Report, 1988). Maximizing "contact time" in unsaturated soils improves the effectiveness of both the mechanical straining and adsorption processes of pathogens (Rhode Island ISDS Task Force Report, 1988). There is a possibility that viruses still travel great distances even from properly-sited septic systems which are in compliance with present Title V standards (Huefelder, 1987).

Nutrient enrichment of coastal waters has become a serious problem. Excess nitrogen leaches out of septic systems or may wash away following the application of lawn or agricultural fertilizers. Excess nitrogen causes massive algal growth, particularly in warmer months. This algal material eventually decomposes, robbing available oxygen. The result often leads to anoxic (i.e. no oxygen) conditions, rendering the waters uninhabitable for finfish and bottom dwelling organisms such as lobsters. Clean sand and gravel sediments often become covered with thick organic material which decreases the habitat suitability for commercial shellfish and finfish. By allowing for the natural filtering of nutrients through vegetated buffers, levels of nitrogen would be reduced through uptake by the plants within the buffer (Ehrenfeld, 1987; Valiela and Costa, 1988).

In a local review of the water quality impact of the proposed Essex Bay Estates development at Cole's Island, Gloucester, it was suggested that the likely route for wastewater from the development's septic systems would be laterally through the glacial till (Horsley et al., 1988). Typical of many sites throughout Cape Ann, Cole's Island has a shallow layer of glacial till overlaying bedrock, which is characteristically of low porosity. Therefore, the predicted course of wastewater contaminants would be downward through the glacial till then laterally across the surface of the bedrock and eventually out to the receiving waters. As expected, the direction and rate of flow would be dependent on the slope of the underlying bedrock, the porosity of the till, and the presence of standing ground water. Horsley et al. (1988) predicted that the flow rates in the area would be rapid.

If subsurface flow rates are rapid, a practical method for reducing the levels of contaminants is to require that naturally vegetated buffer zones be in place between development activities and the resource being protected. Coastal states throughout the United States are imposing minimum buffer zone widths that exceed the 100-foot buffer recommended in the MWPA (Table 2).

Habitat Protection and Wildlife.

Salt marsh ecosystems are extremely important habitats for wildlife. Many organisms depend on salt marshes for some aspect of their life cycle. For example, many species of commercially important ocean finfish utilize the tidal creeks and mud flats as nursery grounds to rear juveniles (e.g. flounder). These species, in turn, provide food for species higher on the food chain, such as herons. Several birds in Essex County are restricted almost entirely to salt marshes (e.g. sharp-tailed sparrows); however, many birds and mammals require a combination of salt marsh and upland habitat to carry out their daily activities of feeding and nesting. Many animals feed on the abundant organisms within the salt marsh, such as crabs, shrimp, and worms, but use upland habitats for nesting and roosting. For these animals, an adequate buffer zone around the marsh is essential because the uplands provide a refuge from the daily inundation of tides that would flood out any nests and burrows built too close to the tide line. Buffers are also an alternative site for foraging activities.

Habitat diversity leads to a greater diversity of wildlife. Presently, there is much concern among environmentalists and wildlife managers about the loss of biodiversity (i.e. extinction of species) on the global level. The greatest cause of this species loss is habitat destruction and fragmentation, i.e., reduction of the size of parcels of land such that the land no longer contains all the elements that many species require to survive. Although much media attention has focused on the dramatic loss of plants and animals that is presently occurring, we must also be concerned about losing species in Massachusetts. In 1986, for example, 600 acres of land in Massachusetts (equivalent to 12 Boston Commons) were lost to developers each week (Leahy, 1988). Gloucester, like many areas in Massachusetts, is under severe pressure to develop lands that were previously considered marginal. Since 1986, 800 acres of sensitive coastal land in West Gloucester have been transferred to Boston-based development companies.

A recent white paper by Massachusetts Audubon listed a number of reasons why we need to be concerned about the loss of wildlife (Leahy, 1988). These include:

1. intrinsic worth of wildlife species.

2. maintaining the health of ecosystems. As an example, if, by eliminating buffers, we destroy the ability of our wetland habitats to support hawks, we have lost one of the important controls on the populations of small rodents in the ecosystem.

3. our own best interests. Plants and animals in salt marshes provide us with food (shellfish, fish), fur (muskrats), mulch and fertilizer (salt marsh hay and peat), outdoor recreation (hunting ducks and geese, recreational shellfishing), a buffer against erosion from storms, and a filter of nutrients (salt marsh grasses).

The wildlife that lives in this region is part of our local heritage and enriches our lives. Part of the reason that Cape Ann is an attractive place to live and to visit is that it is still relatively unspoiled. A major reason why the wetlands of the Parker River/Essex Bay ACEC are so appreciated by humans for their scenic and wildlife values is that they have not been subject to intense development on their boundaries.

Wildlife is generally more abundant where there is a greater abundance of habitat types (such as wetlands, forests, fields, shrubby areas) in close proximity. In ecology, this principle is known as the "edge effect" because physical boundaries between two habitats are particularly attractive to wildlife. This is because many species require more than one type of habitat for their survival. For many wildlife species that use wetlands and surrounding uplands (see examples below), a 100-foot buffer zone is inadequate to provide the freedom from disturbance that the upland typically provides. By limiting a buffer zone to a narrow, 100-foot strip, the ability of the habitat to support a diversity of native wildlife is reduced.

A related danger of reducing the buffer zone around an Area of Critical Environmental Concern is the replacement of native species with urban species or those adapted to human habitation. Feeding of wildlife around wetlands has enabled certain species to survive or to remain in our area during winters. The presence of mallards, promoted by feeding by humans, is a threat to the survival of our native black duck. Domestic animals are also a threat to native wildlife. The Massachusetts Audubon Society will not permit dogs on its sanctuaries, even on leashes, because there is evidence that the native wildlife is repelled even by the odors dogs leave behind. In sum, to assure the survival of some wildlife species, we need to insure them sufficient separation from human habitation and activities.

Guidelines have been developed by many states that provide for a systematic way of calculating buffer zone widths on a case-by-case basis (Diamond and Nilson, 1988). A 300-foot buffer is presently provided around areas set aside by state and federal governments for the protection of wildlife (e.g. wildlife sanctuaries, refuges, conservation areas, and management areas). This is considered the minimum distance that will prevent disturbance of wildlife from development, noise, pollution, and other human activities on the boundary of the refuge. A buffer zone width of 300 feet is also necessary to maintain the buffer itself as a viable corridor for wildlife (Diamond and Nilson, 1988). A 300-foot buffer around wetlands will also provide a "high level of confidence" for the protection of habitat and prevention of disturbance to threatened and endangered species in the wetland (Diamond and Nilson, 1988). (According to the Harvard School of Design, a 200-foot buffer is the minimum that will protect the "scenic value" of a natural area.)

Essex County birds and mammals that depend on both the salt marsh and upland habitats are summarized below (DeGraaf and Rudis, 1986). We do not mean to imply that the species mentioned are the only ones that would be harmed by reduction in buffers around the marsh. Rather, we present a discussion of typical wetland species of Essex Bay for which there is data on the potential importance of buffer zones.

Waterfowl - The areas surrounding wetlands are important for providing the seclusion waterfowl need to nest and carry out their activities without predation and disturbance. "It has long been recognized that lands adjacent to areas managed for waterfowl play a major role in the entire management scheme" (Kirby, 1988). Black duck and Canada goose are two common species of waterfowl that feed and nest in and around the salt marshes of Essex Bay. Black ducks have been of concern to game managers since the 1950's because their numbers have steadily declined. They are listed as "declining" in Essex County (DeGraaf and Rudis, 1986). They nest along the edges of salt marshes; however, they are wary birds and are sensitive to disturbance by human activity. Black ducks nest either on islands in the marsh, in uplands up to 3/4 mile from the marsh, or in areas immediately adjacent to the marsh (Kirby, 1988). Favored nesting habitat of black ducks usually is heavily vegetated on at least one side to provide concealment from natural predators. A 250-foot buffer would provide them with adequate undisturbed habitat for nesting and feeding.

Birds of Prey - A number of species of birds of prey hunt for small animals over salt marshes while nesting and roosting in upland sites. These birds generally require large territories (greater than 1 mi^2) and a mixture of marsh and upland habitats. Red-tailed and rough-legged hawks and northern harriers are observed hunting over Essex Bay marshes. Red-tailed hawks and rough-legged hawks (in winter) use trees along the periphery of the salt marsh for perches where they can observe the movements of potential prey on the marsh. Great horned owls also perch along the salt marsh-upland edge when they hunt at night (W. Peterson, personal communication). Red-tailed hawks nest on uplands adjacent to the marshes of Essex Bay. Although there is no data on how large a home range they have in Essex County, DeGraaf and Rudis (1986) state that a typical home range of a red-tailed hawk is between 0.3 to 2.15 square miles. They are prone to disturbance by human activity and are likely to avoid areas where human activity encroaches to within 100 feet of the marsh (personal observations).

Herons and egrets - Snowy egrets, great egrets, great blue herons, green-backed herons, little blue herons, glossy ibis, and black-crowned night herons all use the marshes of Essex Bay for feeding. In a monograph on evaluating suitable habitat for great blue herons, Short and Cooper (1985) state that human disturbance and the resulting loss of nesting and foraging sites probably have been the most important factors contributing to declines in some great blue heron populations in recent years, as indicated by studies in New York State and British Columbia. Along the coast, typical feeding sites for great blue herons are salt marsh creeks and shallow ponds on marshes. These must be in sites with little human disturbance for several hours each day (Short and Cooper, 1985). In evaluating a suitable habitat, Short and Cooper (1985) say that potential foraging areas must be at least 330 feet from human activities and habitation.

Shorebirds - The marshes of Essex Bay are important stopovers for many species of migratory shorebirds, such as least sandpiper and greater yellowleg. Shallow ponds in the "high marsh" near the edge of uplands are important roosting and foraging areas for these birds. A 250-foot buffer would prevent disturbance of the birds when they are foraging in these high marsh "pannes."

Mink and otter - Mink and otter are weasel-like predatory mammals that occur in the Essex Bay marshes. They hunt in the tidal creeks and tide pools of the marsh and in upland areas immediately adjacent to the marsh (Allen, 1986). They also use the upland surrounding the marsh for their den sites. The interface between marsh and upland is very significant to these mammals. In a study in Alaska, 68% of all observations of mink were either in the wetland itself or within a 330-foot zone shoreward of the edge of a wetland (Dunstone and Birks, 1983 cited in Allen, 1986). Along the shore of Lake Ontario, rapid declines in mink populations were associated with small increases in human habitation of the shoreline (Racey and Euler, 1983 cited in Allen, 1986). In a monograph on evaluating the habitat requirements of mink in marshes with emergent vegetation, such as salt marshes, Allen (1986) assumes that a 330 foot buffer of woody vegetation along the marsh edge enhances the value of the marshes to mink. Otter typically breed in forested areas along the edge of waterways (DeGraaf and Rudis, 1986). They require a large home range (up to 30 miles along some rivers, [DeGraaf and Rudis, 1986]). It is the larger animals such as otters that are most vulnerable to encroachments of civilization on their habitat because they require relatively large territories.

<u>Conclusions and Recommendations:</u>

Massachusetts Audubon: North Shore strongly recommends that the following resource management policies be adopted by communities surrounding the Essex Bay/Parker River ACEC. These recommendations need to be adopted by: Conservation Commission (CC), Planning Board (PB) and Board of Health (BH) prior to the approval of future development projects proposed adjacent to or near areas of critical environmental concern. (Given that these recommendations span the jurisdiction of the three boards, each recommendation includes a notation on the board responsible for adopting a particular recommendation.)

* Municipal officials must begin to identify and map critical resource

areas such as ACEC's, valuable wildlife habitats (e.g. eelgrass beds), shellfish beds, areas with high scenic value, and flood-prone areas that need protection from future development initiatives. This process ought to include public participation. (CC, PB)

* A 300-foot wide natural, undisturbed buffer should be provided in those areas that directly abut critical resource areas. The landward edge of a wetland is recommended as the origin for the buffer measurement. Activities prohibited within the buffer zone are:

-permanent construction of buildings, bulkheads, riprap, surfaced roadways, and drainage systems;
-siting and construction of sewage disposal systems and/or leach beds;
-direct discharge from wastewater facilities, surfaced roadways, detention basins, drainage systems, and/or culverts; and
-the removal of natural vegetation for lawns.

Allowable activities may include:

-selective thinning of trees and vegetation;
-siting and maintenance of foot paths; and
-passive recreational activities (e.g. hiking).
(CC, BH)

* In addition, a 100-foot setback should be provided beyond the undisturbed 300-foot zone. Activities within the setback should be limited to landscaping and nonpermanent structures. (CC, BH)

* These critical resource areas must be set aside as priorities for additional measures to minimize pollution. These measures include land acquisition, conservation easements, tax relief, and watershed/aquifer protection ordinances. (PB, CC)

* Efforts must be taken by city officials to reduce the densities of developments that are proposed adjacent to critical resource areas and promote cluster designs that will allow developers a way to protect large open spaces while allowing for affordable housing. (PB, CC)

* In the event that variances to the above recommendations are sought, the developers must be responsible for providing scientific data to justify the proposed activities. (PB, CC, BH)

* A septic system maintenance regimen ought to be implemented by the City of Gloucester within housing developments currently serviced by on-site septic systems. Septic system inspections ought to be considered for properties located within 300 feet of a critical resource area prior to any real

estate transaction. In addition, it would be advisable to implement a public education program which summarizes the care and maintenance of septic systems. (CC, BH)

* Lawn treatments (e.g. herbicides, pesticides and fertilizers) ought to be prohibited from within 300 feet of a critical resource area.

References

Allen, A.W. 1986. Habitat suitability models: mink, revised. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.127)., 23 pp.

DeGraaf, R.M. and D.D. Rudis, 1986. New England Wildlife: Habitat, Natural History, and Distribution. Gen. Tech. Rep. NE- 108. U.S. Dep't. Agric., Forest Serv. Northeast Forest Exp. Sta. Broomall, PA. 491 p.

Diamond, R.S. and D.J. Nilson. 1988. Buffer delineation method for coastal wetlands in New Jersey. Symp. Coast. Water Res., Amer. Water Res. Assoc.

Dunstone, N. and J.D.S. Birks. 1983. Activity budget and habitat usage by coastal-living mink (Mustela vison Schreber). Anim. Behav. 27:1182-1194.

Ehrenfeld, J.G. 1987. The role of woody vegetation in preventing ground water pollution by nitrogen from septic tank leachate. Water Res. 21: 605-614.

Essex County Ornithol. Club of Mass., Inc. 1988. Field list of the birds of Essex County, Massachusetts, 6th edition. Peabody Mus., Salem, MA. 35p.

Hagedorn, C., E. McGoy, and T. Rahe. 1981. The potential for groundwater contamination from septic effluents. J. Environ. Qual. 10: 1-8.

Horsley, S., J. Witten & Hegemann. 1988. Water Quality Impact Review of Essex Bay Estates at Cole's Island, Gloucester, MA. Subdivision Plan. 7 November 1988. Prepared for the West Gloucester Association.

Heufelder, G. 1987. Bacteriological Monitoring in Buttermilk Bay. DRAFT Submitted to the US Environmental Protection Agency Region I.

Keswick, B. and C. Gerba. 1980. Viruses in groundwater. Environ. Science Technology. 14: 1290-1297.

Kirby, R.E. 1988. American black duck breeding habitat enhancement in the northeastern United States: a review and synthesis. U.S. Fish Wildl. Serv., Biol. Rep. 88(4). 50 p.

Leahy, C. 1988. Edens end: The case for ecological protection in Massachusetts. Mass. Audubon. Soc. 82 p.

Massachusetts Audubon Society: Resources for the North Shore. The Cost of Pollution. 35 p.

Massachusetts Coastal Zone Management 1987. Areas of Critical Concern Site Summaries and Regulations.

Racey, G.D. and D. L. Euler. 1983. Changes in mink habitat and food selection as influenced by cottage development in central Ontario. J. Appl. Ecol. 20: 387-402.

Rhode Island Coastal Resources Management Program 1984. A Special Area Management Plan for the Salt Pond Region. 113 p.

Rhode Island Individual Septic Disposal System Task Force Report to the Department of Environmental Management. Spring 1988.

Short, H.L. and R.J. Cooper. 1985 Habitat suitability index models: Great blue heron. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.99). 23 p.

Valiela, I. and J. Costa. 1988. N and P inputs into Buttermilk Bay and its watershed. Abstracts of the 1988 spring meeting of the New England Estuarine Research Society, April 21-23, 1988, Woods Hole, MA.

Yates, M. 1985. Septic tank density and groundwater contamination. Ground Water 23: 586-591.

Table 1: A Summary of Nonpoint Pollutants

POLLUTANT	CAUSE/SOURCE	IMPACT
Sediment	Excessive erosion as a result of vegetation removal and construction sites.	- Covers aquatic plants and spawning areas; - Pollutants adhere to sediment particles; - Increases water turbidity.
Nutrients	Fertilizers Failing septic systems Animal waste Natural decomposition Agriculture	- Increases algal growth which decomposes and therefore reduces available oxygen in receiving waters.
Heavy Metals	It is suspected that impervious surfaces such as roadways and the associated vehicle traffic are the sources.	- Toxic to aquatic organisms and accumulates in the food chain.
Petroleum Substances	Automobiles and illegal dumping	- Destroys aquatic organisms by adhering to them and cuts off the supply of oxygen. Also can alter life cycle processes.
Salt	Salts used to melt snow and ice on roadways	- Alters salinity of receiving waters and impacts biological activity.
Bacteria Viruses	Wildlife/waterfowl Failing septic systems Broken sewers Domestic Sewers Domestic animals and livestock	- Infects shellfish; - Contaminates potable water supplies and swimming areas.

Table 2. A summary of minimum buffer zone widths from six states. These are recommended minimum buffer zone widths for areas of critical environmental concern.

STATE	MINIMUM BUFFER ZONE WIDTH
Maine	150-300'
Maryland	300'*
New Jersey	300'
Rhode Island	200'
Washington	200'
Wisconsin	1000'

* Recommended for maximum nitrate removal.

Are Coastal Wetlands Better Off as a Result of Coastal Zone Management?

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Introduction

The importance of wetlands has been recognized for at least three decades. In 1972, the Clean Water Act was passed, providing for the protection of wetlands through the regulation of dredged or fill material in all waters of the United States under the Section 404 permit program. Also in 1972, the Coastal Zone Management Act (CZMA) was passed, providing for the protection of wetlands as part of the requirements for federal approval of state coastal zone management (CZM) programs. Despite these longstanding programs, wetlands loss and degradation continue to be at the forefront of current environmental problems. In light of these general wetland resource discussions, and those surrounding the current CZMA reauthorization debate, it is appropriate to consider the question: are coastal wetlands better off as a result of coastal zone management?

Regrettably, no complete national database exists that documents important trends in wetland status: state-by-state wetland losses from permitted and unpermitted activities; the number of projects approved under Section 404 which did not receive a state wetlands permit; the number of 404 permits found to be inconsistent by a state CZM program. In the absence of this information, it is impossible to specifically attribute wetlands losses, or the lack thereof, to one program or another. Thus, this paper will not compare the Section 404 program and the CZM Program to determine what effect each program has had on coastal wetlands. Rather, the paper will describe states' CZM legal authorities and implementation experience, which are indicators of the effect the CZM Program has had on coastal wetlands protection. The paper will also describe changes to the wetlands provisions of the CZMA resulting from reauthorization.

The Problem

The story of wetlands loss in the United States is dramatic; 482,000 acres of saltwater wetlands and 14,877,000 acres of freshwater wetlands were lost from the mid-1950's to the mid-1970's (Wetlands Policy Forum, 1988). In some individual states, the rate of wetland loss is even worse. For example, 75% of coastal wetlands in California were destroyed in less than 140 years (California State Coastal Conservancy, 1989). Wetlands regulation and management programs that have operated since the early 1970's have had an uphill battle against previous wetland losses and the long-standing public expectation that wetlands can be dredged or filled to accommodate development.

The Coastal Zone Management Program

Background

The CZMA established a voluntary program in which coastal states that developed an approvable coastal management program would receive federal implementation funds and would be able to review federal actions for consistency with the program. The protection of wetlands is a clearly-stated purpose of the CZMA; it is national policy to encourage and assist states to develop and implement management programs which provide for, "...the protection of natural resources, including wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone." The Office of Coastal Zone Management within the National Oceanic and Atmospheric Administration (NOAA) (later the Office of Ocean and Coastal Resource Management [OCRM]), is committed to the statutory mandate to protect wetlands. In the implementing regulations (15 CFR 923.21), NOAA requires states to inventory and designate areas of particular concern, including wetlands, and describe how the management program would address and resolve management concerns in these areas. Further, the NOAA regulations at 15 CFR 923.31 require the inland boundary of the coastal zone to include salt marshes and wetlands; i.e., those areas subject to regular inundation of tidal salt or Great Lakes waters, which also contain marsh flora typical of the region.

Through the federal CZM Program, states with approved programs have a number of tools available to protect coastal wetlands. First, states have enforceable authorities under state law, executive order, regulation, and/or local ordinance to control activities affecting wetlands. States receive federal CZMA Section 306 funds to implement these authorities. Second, states can use CZMA Section 307 federal consistency to ensure that direct federal activities, federal licenses and permits (including 404 permits), and federal financial assistance are consistent with a state's CZM program enforceable policies. Third, states can use federal CZMA Section 306A funds to acquire and restore wetlands within the coastal zone. Finally, states can use Section 306 funds to develop and conduct education programs to enhance public understanding of the importance of wetlands.

The Clean Water Act Section 404 permit program, administered by the U.S. Army Corps of Engineers, and the Section 404 responsibilities and other programs of the Office of Wetlands Protection of the Environmental Protection Agency (EPA), are the primary federal programs for the regulation of dredge or fill activities in wetlands. NOAA's National Marine Fisheries Service and the U.S. Fish and Wildlife Service have contributed significantly to wetlands protection through their habitat and wetlands programs and through permit reviews conducted under the Fish and Wildlife Coordination Act. State CZM program coordination with these federal programs has served to strengthen the success of each.

CZM Program Approval

In general, the current loss of coastal wetlands is less serious than the loss of inland wetlands. In a recent article, David Davis, Director of EPA's Office of Wetland Protection, stated that,

> "... we certainly haven't stopped all coastal wetland losses, but I think we have turned the corner. Many coastal states now have fairly strong laws protecting coastal wetlands ...The point here is that state, local, and federal governments became concerned about coastal wetlands long before they thought about inland wetlands. Some laws to protect coastal areas were enacted in the early 1970s, such as the Coastal Zone Management Act and the Marine Protection, Research and Sanctuaries Act" (Davis, 1989).

In some cases, the state coastal wetland laws referred to by Davis exist as a result of the CZM Program. During program approval, states that lacked adequate legal authority to protect coastal wetlands had to enact new or expanded wetlands legislation or regulations to meet CZMA requirements. For example, South Carolina, Alabama, Guam, Louisiana, and the Northern Mariana Islands enacted new wetland protection statutes or executive orders as a direct result of participation in the CZM Program (House of Representatives, 1980). Some states with pre-existing wetland laws had to adopt new or expanded regulations. For example, Massachusetts issued new regulations pursuant to the state's Wetlands Protection Act and Waterways Management Act within four months of CZM program approval (House of Representatives, 1980).

A summary of state CZM program wetland authorities and coastal zone boundaries is shown in Table 1. In seven states and territories, the coastal zone boundary is extensive and includes the entire jurisdiction. In eleven states, the coastal zone boundary follows a smaller, political boundary of coastal towns or counties. In the remaining eleven states, the coastal zone boundary is based on the location of important coastal resources.

Within the coastal zone, the authorities governing wetlands are different in every state; however, there are some similarities. All states have some form of statute, executive order, and/or regulation to control activities in tidal wetlands, because such authorities were required for program approval. In addition, 28 of the 29 approved CZM programs (except the San Francisco Bay segment of the California Coastal Management Program) now have some control over activities in freshwater wetlands within the coastal zone. Some of these laws were incorporated into the CZM programs subsequent to original program approval.

It is interesting to note that the wetland laws in states without federally-approved CZM programs are different from those in states with CZM programs. Based on information from the EPA Office of Wetlands Protection, of the six eligible states that do not (in 1990) have federally-approved CZM programs (Georgia, Texas, Ohio, Illinois, Indiana, Minnesota), only Georgia has a specific state coastal wetlands program. This contrasts with states having approved CZM programs, all of which have specific coastal wetlands programs.

CZM Program Implementation

Successes

As mentioned above, state CZM programs have several tools to accomplish wetlands protection. One of the most prominent tools is the federal funding provided for program implementation. Of the $35,322,000 total FY 1990 funds awarded to state CZM programs this year (1990), $8,949,500 or 25% is being expended on activities related to wetlands. These activities include: research and studies (2%); education (1.5%); conservation and restoration (0.5%); coordination and regulation (16.5%); mapping (3.4%); construction (0.5%); and acquisition (0.6%).

The largest expenditure of federal 306 funds for wetlands is in the area of coordination and regulation. These funds are used to operate state wetland or coastal regulatory programs, to conduct monitoring and enforcement activities, and to coordinate with other state and federal agencies. In general, regulatory activities have the greatest payoff. In the 1989 Annual Reports submitted to OCRM, state CZM programs described the status of wetland regulation programs. For example, the Rhode Island Coastal Resources Management Council did not permit any fill in coastal wetlands in 1989. The California Coastal Commission reported that in the past several years, almost no wetlands fill has been permitted except in port areas, and mitigation was required.

Other types of federally-funded projects include wetlands acquisition, studies, and public education. For example, the California State Coastal Conservancy used $277,500 in Section 306A federal funds and $1,230,000 in state funds to acquire 2,070 acres in Suisun Marsh adjacent to San Francisco Bay. The Washington CZM Program used $20,000 in Section 306 funds to investigate ecologically significant wetlands along the Greater Puget Sound shoreline. Nineteen sites were identified, nine of which were acquired by the state and one by a non-profit organization, totalling 1,000 acres of protected wetlands. The Washington CZM Program also used 306 funds to produce an educational video on the importance of wetlands for use in high school classrooms (Dept. of Commerce, 1988).

Another important wetlands protection tool for state CZM programs is federal consistency. For example, South Carolina regularly reviews activities in freshwater wetlands within the coastal zone by using federal consistency to review Corps 404 permits. The South Carolina CZM Program frequently objects to small projects, like a recent proposed excavation to extend an existing canal that would have destroyed .15 acres of freshwater wetlands.

Areas for Improvement

In the 1989 Annual Reports to OCRM, state CZM programs reported on the major wetlands protection problems and issues currently encountered. The most common problem reported was the continuing loss or degradation of wetlands due to indirect effects (stormwater runoff, adjacent urbanization, exotic species invasion) or natural causes (subsidence, erosion, sea level rise). In addition, many states reported wetland losses due to inadequate monitoring and enforcement of unpermitted activities and permit conditions. The impediments to adequate monitoring and enforcement were insufficient enforcement staff, due to the lack of funding, and inadequate interagency coordination at both the state and federal levels. Some states noted a lack of information and data on wetland losses and the associated causes, and inaccurate wetland maps. Finally, some state CZM programs described a lack of adequate statutory or regulatory authority. For example, Maine passed a Freshwater Wetlands Law in 1985; however, only freshwater wetlands larger than 10 acres are covered. Thirteen states noted a lack of specific legal authority to consider cumulative impacts and fifteen states reported a lack of state wetland mitigation policies. It appears that losses due to activities occurring directly in wetlands generally are minimal, and that now the challenge is to address wetland losses due to secondary or cumulative impacts.

CZMA Reauthorization

Some of the deficiencies in these coastal wetlands protection programs can be addressed through changes to the CZMA. There are currently two reauthorization bills that have the greatest likelihood of passing.

House bill

The House bill (H.R. 4450) passed the House Floor in late

September, 1990 and is currently attached to the House Budget Reconciliation Bill. H.R. 4450 adds a definition for "coastal wetlands" that is very general and appears to include both tidal and freshwater wetlands. The bill also requires that by 01 June 1991, the Under Secretary of Commerce will promulgate a rule defining coastal wetlands. The Under Secretary must hold at least four public meetings in conjunction with the rulemaking and must consult with other federal agencies to ensure that the CZM definition is consistent with other Federal definitions.

H.R. 4450 also creates a new Section 310, National Interest Improvements, which requires the Under Secretary to implement "an ongoing program to encourage each coastal State to make continual improvements in its management program in specified national interest areas," including coastal wetlands. To implement this National Interest Improvements Program (NIIP), the Under Secretary must assess each coastal state to determine the priority needs for improvement and negotiate a NIIP to cover a period of at least 3 years. At least 10%, but not more than 20%, of the funds appropriated under Sections 306 and 306A will be used to implement the NIIPs. Half of the funds will be awarded by formula and half competitively. Thus, states that choose to undertake real improvements to their wetlands protection programs will have access to additional federal funds.

Senate bill

The Senate bill (S. 2782) passed out of the Commerce Committee in June, 1990, but has not yet gone to the Floor. This bill also adds a definition of coastal wetland, which is identical to the 404 regulatory definition, with one exception. S. 2782 adds the phrase, "...coastal wetland means an area <u>or group of hydrologically related areas</u>." (emphasis added) Like H.R. 4450, S. 2782 adds a new Coastal Zone Enhancement Grants program. One of the objectives of this Enhancement Program is to ensure "that there is no net loss of coastal wetlands." Unlike the House bill, there is no requirement for an assessment by the Under Secretary. Also, the Senate bill phases the funding such that all of the funding goes toward program development in the first two years, and in the latter two years, 50% of the funds go toward program development and 50% toward implementation. All of the enhancement funds will be administered based on criteria established by the Secretary of Commerce, with a maximum of $10 million available.

<u>Conclusion</u>

Based on evidence such as the relative status of coastal wetlands versus inland wetlands, and anecdotal evidence of wetlands protection, acquisition, and public education by state CZM programs, it is possible to conclude that the Coastal Zone Management Program has had a positive effect on coastal wetlands. While these successes can be documented qualitatively, they cannot be fully documented quantitatively. The challenges for the next decade will be to develop better data on wetlands loss and its causes, to develop and implement improved coastal wetlands protection programs, and to address secondary and cumulative impacts to wetlands. If the CZMA reauthorization passes with provisions similar to those in the current bills, there will be additional resources for states to deal with some of these persistent and new wetland problems.

Post Script

Since this paper was written, the CZMA was reauthorized as part of the 1990 Budget Reconciliation Act. The CZMA amendments include a new Coastal Zone Enhancement Grants Program that provides funding for states to meet the objective of "protection, restoration, or enhancement of the existing coastal wetlands base, or creation of new coastal wetlands."

The views expressed in this paper are the author's and do not necessarily represent the views of the National Oceanic and Atmospheric Administration.

References

Davis, D. 1989. Wetlands: An Interview with David Davis. EPA Journal 15 (September/October 1989):19-22.

Marcus, L. 1989. The Coastal Wetlands of San Diego County. California State Coastal Conservancy, Oakland, CA.

National Wetlands Policy Forum. 1988. Protecting America's Wetlands: An Action Agenda. The Conservation Foundation, Washington, DC.

U.S. Department of Commerce. 1988. Coastal Management: Solutions to Our Nation's Coastal Problems. Office of Ocean and Coastal Resource Management, NOAA, Washington, DC. (Mimeographed.)

U.S. House of Representatives. 1980. Coastal Zone Management Act Oversight. Committee on Merchant Marine and Fisheries, Government Printing Office, Washington, DC.

State	Coastal Zone Boundary	Wetland Authorities at Program Approval	Freshwate r Wetlands Law*	New Wetlands Authorities Added Since Program Approval
ME	coastal towns	Alteration of Coastal Wetlands Act of 1975 Shoreland Zoning Law Alteration of Rivers & Streams Law	yes	Freshwater Wetlands Law (1985); Natural Resources Protection Law (1988)
NH	1000' from MHW & area of Wetlands Board jurisdiction	Fill & Dredge in Wetlands Law Coastal Wetlands Regulations	yes	no
MA	100' inland of major roads; coastal wetlands; Nantucket; Martha's Vineyard; & Cape Cod	Wetlands Restriction Act Wetlands Protection Act Waterways Management Act	yes	no
RI	coastal towns	RI Coastal Resource Management Act	yes	no
CT	1000' from MHW, inland extent of tidal wetlands, or inland limit of 100-yr. flood zone, whichever farthest	Tidal Wetlands Act Structure, Dredging & Filling Act	no	Structures, Dredging, & Filling Act Amendments (1990)
NY	1000' from shoreline; 500' in urban areas	Environmental Conservation Law Tidal Wetland Act Freshwater Wetland Act	yes	Tidal Wetland Act Amendments (1989)
NJ	from MHW to first road or property line; .5 to 24 mi. inland in south; Hackensack Meadowlands	Wetlands Act of 1970 Waterfront Development Law Flood Hazard Area Control Act	yes	Freshwater Wetlands Protection Act (1988)
DE	entire state	Delaware Coastal Zone Act Wetlands Act	no	no

MD	coastal counties	Natural Resources Article Sec.9 (tidal wetlands)	yes	Nontidal Wetlands Protection Act (1989); Critical Areas Law (1984)
VA	coastal counties	Wetlands Act of 1972	no	Chesapeake Bay Preservation Act (1988)
NC	coastal counties	Coastal Area Management Act Dredge & Fill Law Wetlands Protection Order	no	no
SC	coastal counties	SC Coastal Management Act	yes**	no
FL	entire state	FL Statutes Chaps. 253 & 403 (dredge & fill) Aquatic Preserves Act	yes	Warren Henderson Wetlands Protection Act (1984)
AL	10' contour above mean sea level	Alabama Coastal Area Act	yes	no
LA	approximately coastal parishes - inland 16 to 32 miles maximum	Louisiana State & Local Coastal Resources Management Act of 1978	yes	Wetlands Conservation and Restoration Act (1989); Mitigation of Coastal Wetlands Losses Act (1990)
MS	coastal counties	Coastal Wetlands Protection Law (1973)	no	no
VI	entire islands	VI Coastal Zone Management Act of 1978 Environmental Protection Act	yes	no
PR	1000 m from shoreline plus important resource areas & offshore islands	Water Pollution Control Act Earth Change Law DNR Regulations & Permit Administration Planning Board Land Use Plan Environ. Quality Board- Mangrove Resolution	yes	no

CA-CCC	1000 yds - 5 mi from MHW based on resources	California Coastal Act	yes	no
CA-BCDC	100' above highest tidal action plus Suisun Marsh	McAteer-Petris Act Suisun Marsh Preservation Act	no	no
OR	crest of coast range; approximately coastal counties	Comprehensive Land Use Planning Coordination Law & Statewide Planning Goals Fill & Removal Law	yes	Wetlands Management Act (1989)
WA	coastal counties	Shoreline Management Act of 1971 & wetlands regulations	yes	Exec. orders 89-10 & 90-04 (wetlands)
AK	biophysical boundary; approx. 1000' contour above mean sea level	Alaska Coastal Management Act of 1977 & regulations	yes	no
HI	entire islands, except State Forest Reserves	Hawaii Coastal Zone Management Act of 1977 Land Use Law	yes	no
AS	entire islands	Exec. Order 3-80 Environmental Quality Act	yes	Exec. order 7-88
GU	entire island	Exec. Order 78-21	yes	Exec. order 90-13 (1990)
CNMI	entire islands	Coastal Resources Management Act of 1983 & regulations	yes	no
MI	min. of 1000' from ordinary highwater plus critical areas	Shorelands Protection and Management Act Great Lakes Submerged Lands Act Inland Lakes and Streams Act	yes	Goemaere-Anderson Wetlands Protection Act (1979)

WI	coastal counties	Shorelands & Zoning Act WI Statutes Chap. 147 (water quality) WI Admin. Code NR 1.95 & 180.13 (wetlands)	yes	no
PA	variable boundary, 900' to 3.5 miles	Dam Safety and Encroachments Act	yes	no

* All federally approved coastal management programs have statutes, regulations, and/or executive orders for regulating tidal wetlands.

** South Carolina CZM uses state and federal consistency to review activities affecting freshwater wetlands, rather than having a separate freshwater wetlands law.

National Status and Trends Program: National Overview of Trace Metal Concentrations in Coastal Surficial Sediments

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Introduction

The National Oceanic and Atmospheric Administration (NOAA) initiated a coastal marine environmental quality monitoring program in 1984. This program, the National Status and Trends Program for Marine Environmental Quality (NS&T), was established with the overall goal of determining the current condition of U.S. marine coastal environments and detecting major changes in environmental quality in these areas. Because of the great national concern regarding the effects of anthropogenic inputs of toxic contaminants to our coastal and estuarine waters, the program has been focused primarily on measuring the status and trends in levels of these contaminants and of several indicators of their biological effects.

A major objective of the NS&T Program is to provide a national assessment as to which of our coastal areas are most likely to be experiencing environmental degradation due to inputs of toxic contaminants. To do this, the Program measures the contaminant levels in both biota (fish and bivalve molluscs) and sediments at a large number of sites around the coasts of the United States. The results from the different sites can then be compared to provide an asssessment as to which sites and regional groupings of sites have been experiencing the highest exposures to contaminants.

Unlike the concentrations in biota, which provide indications of average contaminant levels for a few weeks to months before the time of the collection, contaminant levels in surface sediments are especially useful for making comparisons concerning average conditions over a number of years. Depending on the thickness of sample obtained and the rate of sediment deposition at the sampling site, surficial sediment concentrations provide an indication of average conditions over a few years to decades. The NS&T Program measures contaminants in a thin layer of surface sediments and so obtains a measure of contaminant levels during the recent past, usually over the past several decades. This paper uses the results from these measurements to compare surficial sediment levels of eight trace metals from sites around the coasts of the United States. The purpose of this comparison is to provide a national overview of the distribution of these metals and to identify the areas with the highest concentrations of these contaminants.

Sampling Locations

The NS&T Program samples sites around the coasts of the United

States and includes locations in all our major coastal and estuarine areas. The sites included in the program were selected to be representative of ambient conditions in the general areas where they are located and were specifically chosen to avoid "hot spot" locations that were known or suspected of being strongly impacted by individual point sources of contaminants. The sites were selected, however, so that they are more concentrated in the general vicinity of large metropolitan and industrial centers because these were believed to be the areas with the greatest likelihood of experiencing substantial anthropogenic environmental degradation. Detailed information on site locations is available for most sites in NOAA (1988) and will be updated to include all sites in NOAA (in preparation).

Methods

The sampling and analytical methods used in the NS&T Program to determine trace metal levels in sediments are described in detail elsewhere (Battelle Ocean Sciences, 1987; Texas A&M University, Geochemical and Environmental Research Group, 1988; NOAA, 1988; and Shigenaka and Lauenstein, 1988) and are only briefly summarized here.

At each site, samples are collected at three stations. For the great majority of the sites, the three stations are within a radius 500 m of the site center, although, at a few Northeast sites sampled in 1984-87, the stations were as much as 5 km apart. The samples are collected with a specially designed box corer or with a Smith-MacIntyre or Van Veen grab sampler. Three separate samples are obtained at each of the three stations at a site, and a surface skim of the top 1 to 3 cm is taken from each sample. The skims from the three samples at each station are combined to provide one composite sample for that station. Thus, three samples are obtained from a site. Samples are stored in Teflon jars or ziplock bags and sent to the laboratory for analysis. An analogous procedure is employed to obtain samples for grain size determinations.

The concentrations of twelve trace metals (cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, antimony, arsenic, selenium, and tin) are determined for the NS&T sediment samples. The first eight of these are the metals generally present at the highest concentrations and are the ones considered in this paper. Usually, the surficial sediment samples are initially digested in concentrated hydrofluoric acid in preparation for trace metal analysis. The analyses for the eight metals considered here are carried out by graphite furnace, cold vapor, or flame atomic absorption spectrophotometry or by X-ray flourescence spectrophotometry (NOAA, in prep.). A thorough quality assurance/quality control program including analysis of intercomparison and reference materials is conducted to assure the accuracy and comparability of the measurements obtained.

In an attempt to minimize the effect that differences in sediment particle-size distribution have on sedimentary trace metal concentrations, the data are normalized before use. This normalization involves dividing the measured trace metal concentrations in each sample by the weight-fraction of the sediment particles in the sample that are less than 64 microns in diameter. Thus, the normalized data represent the concentrations based on the amounts of fine-grained sediment and ignore the greater than 64 microns (sand and larger) particles which, in general, have relatively little capability to absorb contaminants. This procedure is followed to help assure that observed differences among the concentrations at different sites are attributable to actual differences in levels of contaminants in the different areas and not to differences in sediment characteristics.

Normalizing the data in this manner can lead to misleading results when the sediments involved are composed primarily of sand or larger (greater than 64 microns diameter) particles, however. When such sediments contain detectable levels of a contaminant, the normalization procedure can lead to unreasonably high concentrations because the contaminant values are divided by small fine sediment fraction values. To avoid such distortions, contaminant data from sediments with less than 20% fine-grained material have been omitted from further consideration in this paper.

There are 261 sites around our coasts from which sediments have been collected and analyzed at least once by the NS&T Program. For 228 of these, trace metal data for at least one sample composed of 20% or more fine-grained sediments are available. In fact, most of these sites have been occupied in more than one year and have yielded three samples with 20% or more fine-grained sediment each time. Thus, as the values used in study are obtained by averaging all available data for each metal at each site, they are, in most cases, the averages of at least six individual concentration values.

Comparative National Assessment

The sites have been ranked in descending order of concentration for each metal, and these rankings have been used in two ways for identifying the areas that have the highest concentrations for each metal. First, the five sites with the highest average concentrations have been identified and are listed for each metal in Table 1. Additionally, the twenty sites with the highest average concentrations for each metal have been identified and related to the coastal states in which they occur. Table 2 lists the coastal states in clock-wise geographical order around the United States starting with Maine and includes for each state the total number of NS&T sediment sites and the number of sites in the top-20 list for each metal. Florida and California, because they have many sites and long coastlines, have been subdivided into two regions, peninsula and panhandle for Florida and southern and northern for California. Based on the information in these two tables, the following sections present, for each of the eight metals, a summary of the distributions around our coasts of the areas with the highest concentrations.

Mercury (Hg)

The sites with the highest average concentrations of mercury in sediments are all near major industrial and urban centers. As Table 2 shows, they are mostly the Northeast or in Southern California. The five sites with the highest average concentrations are all in the Hudson-Raritan Estuary near New York City (Table 1) and 13 of the top-20 sites are in the Northeast in the vicinity of either New York or Boston. Four of the top-20 sites are in Southern California, 3 of these being in San Diego Bay and the fourth near Los Angeles. Two of the top-20 sites are in Puget Sound, in the vicinity of Seattle, and one is in Chesapeake Bay in the Elizabeth River at Norfolk, Virginia.

Silver (Ag)

The highest average concentration for silver was found at a site in Southern California's Santa Monica Bay, with the second and third highest levels detected at sites in Boston Harbor (Table 1). As with mercury, the sites with the highest concentrations for silver were almost all found near large urban centers in the Northeast and Southern California. This is indicated in Table 2 with 6 of the top-20 sites located in Massacusetts (all but one of these near Boston), 8 in the New York-New Jersey area (near New York City in the Hudson-Raritan Estuary or western Long Island Sound), and 4 in Southern California (3 near Los Angeles and 1 in San Diego Harbor). The only top-20 sites that were outside these three areas are one site in Choctawhatchee Bay in the Florida panhandle and one in Northern California in Monterey Bay.

Copper (Cu)

As with the preceding two metals, the NS&T sites with the highest copper concentrations are strongly concentrated near major urban centers in the Northeast and Southern California. Thirteen of the top-20 sites are in the Northeast, with 4 sites in Massacusetts, all in Boston Harbor, and 9 in the New York/New Jersey area, all near New York City in the Hudson/Raritan Estuary or western Long Island Sound. Four sites are in Southern California, two in San Diego Bay and two off Los Angeles. The remaining three top-20 sites are also all near urban centers, with one in Baltimore Harbor (MD), one in the Elizabeth River at Norfolk (VA), and one in Elliott Bay off Seattle, Washington.

Cadmium (Cd)

Two of the three sites with the highest cadmium concentrations are in Southern California near the Los Angeles urban area; the third is in Salem Harbor, Massacusetts (Table 1). More generally, 14 of the top-20 sites are concentrated in just two areas, New York-New Jersey and Southern California (Table 2). These concentrations are associated primarily with the two largest metropolitan centers in the country, with all 9 sites in the New York-New Jersey area being near New York City and four of the five in Southern California occurring near Los Angeles. The rest of the top-20 sites are scattered around the country, but also almost always near major urban and industrial centers, with 2 sites in the Salem-Boston area (MA), one in Baltimore Harbor (MD), one in the Elizabeth River at Norfolk (VA), and one in Tampa Bay (FL). One site is in a more rural area in Oregon at the mouth of the Columbia River.

Lead (Pb)

Again, the sites with the highest levels of lead in sediments tend to be concentrated near large urban centers in the Northeast and Southern California. Four of the 5 sites with the highest concentrations are near New York City in New York or New Jersey. Thirteen of the top-20 sites are in either Boston/Salem Harbors or near New York in western Long Island Sound or the Hudson/Raritan Estuary area. Two sites are in Southern California, one off Long Beach near Los Angeles and the other in San Diego Bay. Lead does have more top-20 sites outside the Northeast and Southern California than the preceding metals. However, these sites are still mostly near large urban areas, with one of the top-20 sites being found in estuarine or bays near the cities of Baltimore, Norfolk, Tampa, and Seattle. One site, in Choctawhatchee Bay on the Florida panhandle, was in a relatively rural area.

Zinc (Zn)

The sites with the highest concentrations for sedimentary zinc are not as concentrated in the Northeast and Southern California as was found for the preceding metals, although the sites with the highest concentrations still show an association with urban areas. The two sites with the highest concentrations are near urban areas on Chesapeake Bay, one in Baltimore Harbor and the other in the Elizabeth River at Norfolk (VA). Three other of the top-20 sites are in Chesapeake Bay, but in areas farther removed from cities. Six of the top-20 sites are in New York or New Jersey area, with 5 of these being near New York City and the sixth along the New Jersey shore of Delaware Bay. Six of the top-20 sites are in Southern California, 3 in San Diego Bay and 2 near the Los Angeles area. The remaining top-20 sites are quite dispersed, with one in Boston Harbor, one near Panama City, Florida, one at the mouth of the Columbia River in Oregon, and one in Puget Sound near Seattle.

Chromium (Cr)

The sites with high levels for chromium show quite a different pattern that found for the preceding six metals. The site with the highest level is still in a major urban area at Salem Harbor, Massachusetts, and 5 of the other top-20 sites are in Massachusetts, all in Boston Harbor. However, with the exception of one site in Baltimore Harbor, the rest of the top-20 sites are on the West Coast and only two of these, both off Los Angeles, are in Southern California. The remaining 11 sites are located from Monterey Bay north and many of these are located in rather rural areas, for example the site with the second highest level is in Humboldt Bay in northern California. The fact that the sites with the highest chromium levels are not so strongly linked to urban areas as with the preceding six metals suggests that anthropogenic influences may not play as important a role in determining the sites with the highest levels of chromium as they do for those metals. Available evidence at hand suggests that chromium levels in marine sediments may well be naturally higher along the Pacific Coast north of Point Conception than elsewhere around the United States. Only in a few other areas, such as Boston Harbor, is there evidence that human influences have resulted in levels of chromium that match those that naturally occur in this region of the Pacific Coast.

Nickel (Ni)

The distribution of sites with high levels of nickel is somewhat similar to that found for chromium, but is very different from that found for all the other metals considered in this paper. For nickel, all the top-20 sites are on the West Coast and, except for one site in Hawaii, all are in Northern California, Oregon, or Washington. Many of the top-20 sites are in relatively rural areas, although 8 of them are in San Francisco Bay. As with chromium, the distribution of top-20 sites for nickel found in the NS&T Program suggests that the concentrations of this metal in marine sediments are naturally higher on the Pacific Coast north of Point Conception than elsewhere around the United States. The distribution also observed suggests that anthropogenic inputs are of relatively minor importance in determining the areas with the highest levels of this metal around our coasts.

Conclusions

For six of the eight metals examined in this paper, the distributions of the NS&T sites with the highest sedimentary concentrations seem to be strongly influenced by anthropogenic inputs. For these metals , cadmium, copper, lead, mercury, silver, and zinc, there is a strong tendency for the sites with the highest concentrations to be found near major urban areas, especially in the Northeast near Boston and New York City and in Southern California off Los Angeles and, to a lesser extent, near San Diego. Two of the metals, chromium and nickel, show much less of a tendency for sites with the highest levels to be determined by anthropogenic inputs. Sites with the highest levels of these metals tend to be in Northern California and the Pacific Northwest in both urban and rural areas, although Boston Harbor also has relatively high levels for chromium.

References

Battelle Ocean Sciences. 1987. Phase 2: Work/quality assurance project plan for project plan for Contract No. 50-DGNC-5-0263, collection of bivalve molluscs and surficial sediments and performance of analyses for organic chemicals and toxic trace elements. Battelle Ocean Sciences, Duxbury, MA. 111 pp. + Appendices A-O.

NOAA. 1988. National Status and Trends Program for Marine Environmental Quality. Progress report: A summary of selected data on chemical contaminants in sediments collected during 1984, 1985, 1986, and 1987. National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. NOAA Tech. Memo. NOS OMA 44, 15 pp. + Appendices A-D.

Shigenaka, G. and G. G. Lauenstein. 1988. National Status and Trends Program for Marine Environmental Quality: Benthic Surveillance and Mussel Watch projects sampling protocols. National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. NOS OMA 44, 12 pp.

Texas A&M University, Geochemical and Environmental Research Group. 1988. Second annual report, analyses of bivalves and sediments for organic chemicals and trace elements. Texas A&M Research Foundation, College Station, TX.

Table 1. The top five sites for sediment concentrations of eight trace metals.

Metal	Ranking				
	1	2	3	4	5
Ag	Santa Monica Bay, CA	Boston Harbor, MA	Quincey Bay, Boston Harbor, MA	Raritan Bay, Hudson/Raritan Esturary, NJ	South Raritan Bay, NJ
Cd	Royal Palms, Palos Verdes, CA	Salem Harbor, MA	San Pedro Canyon, CA	Hillsborough Bay, Tampa, FL	South Raritan Bay, NJ
Cr	Salem Harbor, MA	Humboldt Bay, CA	San Pablo Bay, CA	Hood Canal, Puget Sound, WA	Baltimore Hrb, Chesapeake Bay, MD
Cu	South Bay, San Diego Hrb, CA	Elliott Bay, Puget Sound, WA	Baltimore Hrb, Chesapeake Bay, MD	Boston Harbor, MA	South Raritan Bay, NJ
Hg	Upper Bay, Hudson/Raritan Estuary, NY	Raritan Bay, Hudson/Raritan Estuary, NJ	South Raritan Bay, NJ	Lower Bay, Hudson/Raritan Estaury, NY	Sandy Hook, New York Bight, NJ
Ni	Humboldt Bay, CA	Semple Point, San Pablo Bay, CA	Hood Canal, Puget Sound, WA	San Pablo Bay, CA	Spanger's Restaurant, Tomales Bay, CA
Pb	Raritan Bay, Hudson/Raritan Estuary, NJ	Upper Bay, Hudson/Raritan Estuary, NY	Shirk Point, Choctawhatchee Bay, FL	Lower Bay, Hudson/Raritan Estuary, NY	Sandy Hook, New York Bight, NJ
Zn	Baltimore Hrb, Chesapeake Bay, MD	Elizabeth River, Chesapeake Bay, VA	South Raritan Bay, NJ	Raritan Bay, Hudson/Raritan Estuary, NY	Elliott Bay, Puget Sound, WA

Table 2. The distribution of top 20 sites by coastal state in the sedimentary concentrations of eight trace metals (Florida and California subdivided into two regions).

State	Total Sites in State	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn
ME	3	0	0	0	0	0	0	0	0
MA	13	2	6	4	5	6	0	6	1
RI	5	0	0	0	0	0	0	0	0
CT	2	0	0	0	0	0	0	0	0
NY	9	6	0	6	5	4	0	5	2
NJ	8	3	0	3	3	3	0	3	4
DE	4	0	0	0	0	0	0	0	0
MD	8	1	1	1	1	0	0	0	4
VA	10	1	0	1	1	1	0	0	1
NC	4	0	0	0	0	0	0	0	0
SC	4	0	0	0	0	0	0	0	0
GA	2	0	0	0	0	0	0	0	0
FL (Pen)	16	1	0	0	1	0	0	0	0
FL (Pan)	10	0	0	0	1	0	0	1	1
AL	3	0	0	0	0	0	0	0	0
MS	4	0	0	0	0	0	0	0	0
LA	20	0	0	0	0	0	0	0	0
TX	32	0	0	0	0	0	0	0	0
CA (S)	20	5	2	4	2	4	0	4	5
CA (N)	13	0	6	0	0	0	11	1	0
OR	9	1	4	0	0	0	3	0	1
WA	13	0	1	1	1	2	5	0	1
AK	11	0	0	0	0	0	0	0	0
HI	2	0	0	0	0	0	1	0	0

A Mixing Zone Model for Use with Virginia's Toxics Management Program

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Abstract

The Virginia State Water Control Law mandates the protection of water quality conditions within the Commonwealth. Management regulations are established to control the levels of toxic pollutants in surface waters discharged from all sources holding Virginia Pollution Discharge Elimination Systems (VPDES) permits. These regulations provide for the existence of zones for mixing wastes with receiving waters. Mixing zones must be identified where pollution concentrations in discharge effluents may be monitored. They include the zone of initial dilution (ZID) as well as near- and far-field mixing zones. Toxin concentrations within these zones may be considered as criteria based on acute and/or chronic toxicity tests. Water quality criteria and standards must be achieved at the edges of mixing zones. Therefore, permit writers need to determine zonal boundaries for setting effluent limits. To meet this goal, a mathematical computer model was developed. Virginia's Mixing Program (VAMP) is a user-friendly computer program to perform screening-level calculations of dilution ratios in estuarine systems. It consists of a set of screening tools which address dilution and the spatial extent of mixing zones. The purpose of this paper is to discuss the model's development and its applications to toxics management in Virginia.

Introduction

Virginia's water quality programs have focused on the control of conventional pollutants, primarily oxygen-demanding materials and suspended solids. Having addressed many of the problems associated with conventional pollutants, attention has shifted to other causes of water quality impairment, notably nutrients and toxics. Although nutrient enrichment has been identified as the major cause of deteriorating water quality in Chesapeake Bay, toxic compounds also threaten the Bay's living resources. Research and monitoring programs in Virginia have found elevated concentrations of metals and organic compounds in portions of the Bay, most notably in highly industrialized areas such as the Elizabeth River (Butt and Alden, 1986; Alden and Butt, 1987). Studies have demonstrated the relationship between levels of toxic compounds found in the sediments, the survival of individual organisms, and the resulting health of the ecosystem (Alden and Butt, 1988; Alden et al., 1988). Therefore, better understanding of toxics and their impacts is sought.

Virginia's Water Control Board currently maintains active files on over 2800 permits for surface water discharges. Unfortunately, mixing zones have not been utilized to characterize the control of nutrients or potential toxins from these discharges. This is because permits previously limited only conventional pollutants where the primary reaction lowers dissolved oxygen in the receiving waters. In actuality, the maximum impact of these reactions is further downstream from the source of the pollutants. As a result, the mixing dynamics at the point of discharge were not considered overly important and mathematical solutions of conventional pollutants normally assumed instantaneous and complete mixing at the discharge point. However, toxic materials have their maximum impact at the point of maximum concentration; that occurs at the outfall structure before significant mixing occurs. Therefore, the mixing process and the physical location of the process is much more important than previously assumed.

If discharge effluent contains pollutant concentrations higher than those allowable under Virginia's water quality standards, the mixing zone or parts of it will exhibit concentrations exceeding the criteria. The result is a plume of partially-mixed effluent that extends from the discharge structure to some point downstream where it is completely mixed. Characterization of this mixing process is important when establishing permit limits and wasteload allocations.

The Virginia State Water Control regulations (VWCB, 1990) mandate the protection of water quality conditions within the Commonwealth. Regulations for toxic management are established to control the levels of toxic pollutants in surface waters discharged from all sources holding Virginia Pollution Discharge Elimination Systems (VPDES) permits. These regulations provide for the existence of zones for mixing wastes with receiving waters. Therefore, a mixing zone model was proposed as a management tool capable of analyzing water quality impacts using data inputs available to permit writers. The purpose of this paper is to discuss the development of Virginia's Mixing Zone Model, VAMP, and its potential applications to toxics management in Virginia.

Virginia's Toxics Management Program

The Toxics Management Regulation for Virginia (VWCB, 1988) is designed to address the discharge of toxic pollutants to surface waters from facilities holding VPDES permits. It requires facilities which discharge potentially toxic substances to perform biological and chemical tests to determine the toxic characteristics of their effluents. Both acute and chronic toxicity testing may be required using approved organisms. Data from these toxicity screening tests aid in establishing water quality-based effluent limitations and assessing the possible extent of effluent toxicity. Instream mix values (assuming instantaneous complete mixing) are compared to criteria values for the parameter(s) of interest. A partial list of the published values for such substances in Virginia is presented in Table 1.

For free flowing streams in Virginia, the 7Q10 and maximum effluent flow conditions are compared with the critical value to see if the numerical result exceeds the published value. Published values for total maximum daily loads are based on mass balance calculations using state water quality standards applied to each specific waterbody. If the results are positive, the facility is included in the Toxics Monitoring Program. Further toxin management activities, including a toxicity reduction evaluation, are required in the permit whenever the results of a monitoring assessment indicate that toxicity exists. If complete mixing does not occur near the discharge point, as in estuarine and tidally-influenced systems, and an effluent plume is discernible downstream, techniques are needed to simulate and predict mixing conditions.

In order to better evaluate waste load allocations (WLA) for a particular waterbody, a reliable method is needed to estimate the distance from the outfall to the point at which the effluent mixes completely with the receiving waters. The boundary is defined by a location where the pollutant concentration gradient across a transect of the waterbody is sufficiently small (EPA, 1989). This boundary can be determined using a mixing zone model.

VAMP Model Development

WLA provides a quantitative relationship between the waste load discharged and the receiving water concentrations of a pollutant. Unfortunately, this type of screening analysis in estuaries is complex. Estuarine transport processes are not controlled by the advective systems which typify many rivers. The driving forces of transport and circulation in an estuary are riverflow coupled with local turbulences that include tidal action.

The basis for development of the present VAMP mixing zone model is to ensure that water quality conditions which protect designated uses are achieved through proper WLAs. Appropriate numerical solutions must be developed characterizing the waterbody, followed by model calibration and verification. This is supported by actual field data or results from previous studies, as described below. A flow chart for model development is presented in Figure 1.

Mixing Processes

In order to develop a mixing model, it is important to understand the basic principles associated with the mixing process. When an effluent is discharged continuously to a receiving body of water, mixing and dilution are determined by the initial momentum and buoyancy of the discharge. This zone of initial dilution, or ZID, is typically of limited spatial extent and a number of models have been developed to quantify the process (c.f. Muellenhoff et al., 1985). The remaining mixing occurs over a more extensive area, where waste is mixed primarily by ambient turbulence. Dispersion within the near-field region occurs in both vertical and lateral directions, accounting for the cross-sectional mixing. Additional mixing due to tidal oscillations takes place in the downstream or longitudinal direction. This final mixing process continues to smooth out differences downstream, but occurs by the patterns of flood and ebb flows over tidal cycles.

Model Design/Requirements

Design of the mixing model was guided by the principal thesis that it must be able to simulate the complex transport processes outlined above. However, it was not practical to expect permit writers to have the technical background to perform this type of analysis. In addition, it was very desirable to establish uniformity among users and to standardize permit evaluations within the state. The program needed to be user-friendly and operate on IBM-compatible personal computers. This latter requirement resulted in basic hardware and software constraints associated with program system configurations.

Model Identification

Much of the theoretical and experimental work in this type of mixing zone model development was accomplished by Fischer et al. (1979). With the establishment of model design requirements, the next step was model identification and selection. A number of conceptual models were previewed such as QUAL2E, WASP4, TOXI4, EUTRO4, and others for a discussion of model classification by transport complexity (refer to Ambrose et al., 1990). However, due to the special agency requirements, a customized mixing model was developed by HydroQual. The model is a steady-state, finite-difference model with a longitudinal component for tidal action. The current version of VAMP uses the USEPA models DKHDN and UMERGE to perform the initial mixing computations and the HydroQual model SPAM to develop near- and far-field dilution computations.

Computations for estimating both near- and far-field concentrations outside the ZID required the assignment of dispersion coefficients. A literature review was performed to identify alternative estimation procedures for relatively simple yet technically correct methods of evaluating dispersion coefficients for use in the preliminary screening evaluations. Additional analyses were performed for model calibration and verification to demonstrate the applicability of the methods developed for projecting model results. The final stage of model development was computation of dilution ratios for graphical output.

VAMP attempts to predict the dispersion and dilution of the effluent plume. In this capacity, it does not attempt to predict any removal or transformation of non-conservative pollutants. Post-audit evaluations are emphasized when and where necessary. Site-specific evaluations employing dye studies and current measurements may be necessary to evaluate the dispersion coefficients in some instances and should be given priority over the estimation procedures used in the current version of the model.

Discussion

VAMP is a mathematical model specifically designed as a user-friendly system to ensure uniformity among district permit writers. Virginia's Water Quality Standards specify that calculating permit limits for mixing zones will be done on a case-by-case basis. Since it is capable of predicting the size and location of a mixing zone in tidally-influenced waters based on rudimentary field data, VAMP offers permit writers a management tool to use in preliminary screening evaluations for any permitted facility which discharges into tidal waters. This "first cut" approximation defines a mixing zone for both unstratified and stratified systems.

Effluents discharged to the saline portions of estuaries can occur as either surface discharges or submerged discharges. These two classes have distinctly different mixing characteristics. Submerged discharges offer more flexibility in meeting the design goals for toxic management, particularly in estuarine systems. Surface discharge of freshwater effluent into saline waters results in limited mixing since less dense, freshwater remains on the surface. On the other hand, submerged discharges usually result in a well-defined plume of effluent that tends to rise toward the surface due to density differences. In addition, the rising plume provides initial mixing and further distributes the material over the depth of the system, enhancing tidal mixing.

Of course, there is the issue of mixing zones in free-flowing streams, lakes, and stagnant wetlands within Virginia. Mathematical models to predict the size and location of a mixing zone for each type of aquatic system are not currently available but would be easy to produce. Permit writers could then calculate appropriate permit limits for discharges in each of these separate environmental types. However, since standard specifications for mixing zones in these systems do not yet exist, any model work in this area may be hampered by inadequate definitions and restrictions in the current standards.

A final note is that most models represent an idealized simulation based on field conditions. VAMP is no exception; it must be used with caution to ensure that the underlying model assumptions hold for each site-specific situation under study. The most immediate application of VAMP is its ability to provide uniformity of the permit process in estuarine and tidally-influenced waters of Virginia.

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References

Alden, R.W. and A.J. Butt. 1987. Statistical classification of the toxicity and polynuclear aromatic hydrocarbon contamination of sediments from a highly industrial seaport. Environmental Toxicology and Chemistry, 6:673-684.

_____ and _____. 1988. Toxicity testing of dredged materials using multiple-species microcosms. American Society of Testing and Materials (ASTM), Special Technical Publication, 976:418-437.

_____, _____, and R.J. Young. 1988. Toxicity testing of sublethal effects of dredged materials. Archives of Environmental Contamination and Toxicology, 17:381-389.

Ambrose, R.B., J.L. Martin, and J.F. Paul. 1990. Technical Guidance Manual for Performing Waste Load Allocations. Book III: Estuaries. Part 1: Estuaries and Waste Load Allocation Models, U.S. EPA, Office of Water, Washington, D.C.

Butt, A.J. and R.W. Alden. 1986. Organic sediment toxicity in Lower Chesapeake Bay. Chesapeake Bay Research Conference Proceedings, Williamsburg, VA, pp:189-199.

Doneker, R.L. and G.H. Jirka. 1989. CORMIX1: An expert system for mixing zone analysis of conventional and toxic single port aquatic discharges, Volume I: System Description, ID No. CR813093-01-0. US Environmental Protection Agency, Environmental Research Laboratory, Washington, D.C.

Fischer, H.B., E.J. List, R.C.Y. Koh, J. Imberger, and N.H. Brooks. 1979. Mixing in Inland and Coastal Waters. Academic Press, New York.

Muellenhoff, W.P., et al.. 1985. Initial Mixing Characteristics of Municipal Ocean Discharges (Vol. 1 & 2), USEPA, Environmental Research Laboratory, Narragansett, RI.

U.S. Environmental Protection Agency. 1989. Draft Technical Support Document for Water Quality-based Toxics Control, Office of Water, Washington, D.C.

Virginia Water Control Board Regulations, 1988, Toxics Management Regulations, Virginia Regulation 680-14-01.

Virginia Water Control Board Regulations, August, 1990, Surface Water Standards with General, Statewide Applications, Virginia Regulation 680-21-01.

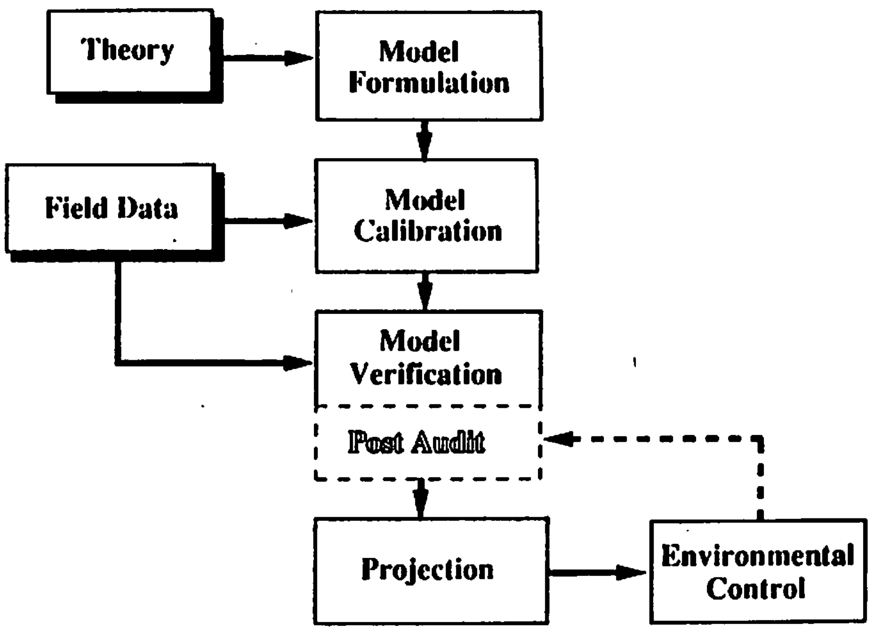
Table 1. Numeric water quality standards for some specific parameters in Virginia's surface waters (VWCB, 1990).

SUBSTANCE	MAXIMUM SALTWATER ACUTE (1) ug/l	CONCENTRATION CHRONIC (2) ug/l
Inorganic		
Arsenic III	69.0	36.0
Cadmium	43.0	9.3
Copper	2.9	2.9
Lead	220.0	8.5
Mercury	2.1	0.025
Nickel	75.0	8.3
Selenium	300.0	71.0
Organic		
Aldrin c	1.3	0.13
Chlordane c	0.09	0.004
Dieldrin c	0.71	0.0019
Heptachlor c	0.053	0.0036
Lindane	0.16	0.01
Pentachlorophenol	13.00	7.90
Toxaphene c	0.21	0.0002

(1) The acute maximum concentration is a one-hour average that is not to be exceeded once every three years.
(2) The chronic maximum comcentration is a four-day average that is not to be exceeded once every three years.

Definitions: **Acute toxicity** is any adverse effect that usually occurs shortly after the introduction of a pollutant. Lethality to an organism is the usual measure of acute toxicity; however, where death is not easily detected, immobilization is considered equivalent to death. **Chronic toxicity** is any adverse effect that is irreversible or progressive or occurs because the rate of injury is greater than the rate of repair during prolonged exposure to a pollutant. This includes low-level, long-term effects such as reduction in growth or reproduction.

Model Development



The Prescription for Saving Our Coastal Waters

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Abstract

Coastal and open ocean waters are productive systems that provide economic, environmental, cultural, and aesthetic benefits across the globe. Overdevelopment, inappropriate land uses, and pollution from a variety of sources have resulted in degradation or loss of marine resources in many regions. The challenge to our society is to restore lost coastal resources and to prevent additional perturbations to the coastal environment. Key needs fall into three areas: information needs; improvements in current structural water pollution control programs; and full implementation of nonstructural water pollution control programs. Marine research linked to government decision-making, and a combined structural/nonstructural approach to water pollution control are urgently needed in the United States if we are to successfully abate or prevent coastal water pollution and maintain coastal water quality.

Introduction

Human activities have imposed great changes on the earth's ecosystems. Ever-expanding populations and settlements have produced visible signs of environmental degradation and loss of natural resources. Forests, fields, wetlands, mountainsides, and valley floors have been plowed, filled, harvested, and developed. Incrementally, civilizations have re-shaped most of the earth's land mass.

Against this backdrop of land degradation, our society has looked reassuringly to the oceans as a limitless, unspoiled frontier. The vastness of the global seas has masked the reality that marine waters also have their limits of use and abuse. In our lifetime, the assimilative capacity of the oceans as repositories of the world's waste is being reached. Much of what we have dumped and discharged in coastal waters -- "out of sight, out of mind" -- is now coming back to us. Sewage, an abundance of plastic debris, insidious but measurable quantities of toxic chemicals, and even medical wastes despoil coastal waters and beaches.

Estuaries and coastal waters, the most productive of marine systems, are showing obvious signs of impact. Pollution has altered the basic chemical and physical composition of near-shore waters, including modifications in pH, salinity, turbidity, temperature, and dissolved oxygen content. These environmental perturbations are caused by point source and non-point source discharges of nutrients, suspended solids, and chemicals. Heavy metals and organic chemicals are the principal toxicants discharged. Introduction of bacteria, viruses, fungi, and other pathogens via wastewater and runoff also stress coastal and estuarine systems (Ketchum, 1972).

The fate of these pollutants in coastal and estuarine waters is just beginning to be understood. We know that organic matter, metals, and organic chemicals concentrate in the plankton-rich thermocline and pycnocline (temperature and density interfaces) of marine waters, in the surface microlayer, and in the sediments. The thermocline, pycnocline, and surface microlayer are critical habitats for the embryonic life stages of many marine organisms, and the sediments are habitat for numerous commercially important finfish and shellfish (Office of Technology Assessment, 1987). Because the federal Clean Water Act (33 U.S.C.A. sec. 1251 et seq., 1972, as amended) regulates concentrations of pollutants in the water column based on a vertical average, there may be local exceedences of pollutant limits in the ecologically-sensitive thermocline, pycnocline, and surface microlayer. This poses a danger to sensitive organisms living there, and, therefore, to the maintenance of sustainable populations of many marine species. Moreover, the Clean Water Act is silent on the regulation of contaminants in sediments (Save the Bay, 1987).

The impacts of marine pollution are manifold. Benthic organisms and associated food webs show changes in species abundance and distribution, and increased incidence of disease. Species inhabiting Boston Harbor, Long Island Sound, San Francisco Bay, the Southern California Bight, and Puget Sound have been severely impacted. Fin erosion, shell disease, liver lesions, and skeletal anomalies are common in winter flounder, lobster, striped bass, starry flounder, and English sole (Sindermann, 1979). Physiological effects have been observed in littoral species as well, including inhibited growth and reproduction and lowered resistance to infection (Anderson et al., 1979; Bertine et al., 1979). Mass mortalities of finfish occur most frequently along the Gulf Coast, but are also quite common in the northeastern United States, coastal California, and Puget Sound (Wastler and Wastler, 1972).

The nation's $3 billion commercial fishery is at stake. Large portions of many of the nation's urban harbors are off limits to finfishing (Toufexis, 1988). In 1985, 42% of the Nation's commercially productive shellfish areas were subject to restriction due to high levels of fecal coliform bacteria (Office of Technology Assessment, 1987). The number of closures and restrictions is estimated to be higher now. Many estuaries and coastal embayments have experienced partial and even total loss of submerged aquatic vegetation, the primary food and shelter of numerous fish and shellfish (ibid., 1987). Wildlife populations have suffered lethal and sublethal impacts from both acute and chronic exposure to pollutants. For example, the population of canvasback ducks in Chesapeake Bay has declined precipitously due a to pollution-caused die-back of wild celery, this species's principal food source. The high mortality of brown pelicans in southern California has been linked to ingestion of DDT which, though banned since the early 1970's, persists in marine environments. Pollution has been implicated in the impaired reproduction of California sea lions (Young and Mearns, 1978).

Pollutants originating from onshore point source and non-point source discharges have been detected at distant points in the open ocean. The immediate and long-term effects of these pollutants on populations of pelagic organisms are unknown.

The 1987 mass mortalities of humpback whales and Atlantic bottlenose dolphins along the Atlantic coast may be an indication of the susceptibility of the entire ocean system to near-shore environmental perturbations. Biotoxins were implicated as the direct cause of the mortalities in both species. In the case of the dolphins, there is a strong possibility that pollution stressed the animals enough to lower their resistance to disease (Geraci, 1987). Circumstances surrounding the humpback whale deaths are similarly complex, possibly the result of several human-induced factors.

Breakdown of the Coastal Pollution Problem

Much of the debate surrounding use of the oceans for waste disposal has focused on offshore dumping of sewage sludge, industrial wastes, and low-level radioactive wastes. Yet near-shore discharges of wastes from point sources and non-point sources present an immediate and arguably far greater threat to marine environments (Ketchum, 1972). Estuaries and coastal waters receive most of the wastewater, dredge material, and sewage sludge disposed in marine waters. Nationwide, over 1300 major industrial facilities and 600 municipal facilities (an estimated two trillion gallons per year) discharge directly to estuaries and coastal waters. Add to these discharges minor industrial inputs, non-point sources, and upstream discharges into rivers tributary to coastal waters, and the result is thousands of tons of pollutants entering our estuaries, bays, and sounds (Office of Technology Assessment, 1987).

A comparison of total inputs from industrial discharges, municipal point sources, and non-point runoff reveals, generally, the relative contributions of certain types of pollutants. In all regions but the northeastern coastline, non-point sources are considered more important than point sources in terms of total volume of contaminants and impacts to coastal ecosystems. Non-point urban and agricultural runoff dominate as sources of suspended solids, oxygen-demanding organic matter, fecal coliform bacteria, total phosphorous, pesticides, chromium, copper, lead, iron, and zinc. Industrial point sources discharge most of the near-shore inputs of organic chemicals (e.g., chlorinated hydrocarbons) and certain metals such as cadmium and mercury. Conventional pollutants, such as total nitrogen, oil and grease, and those that cause an increase in biochemical oxygen demand, originate largely from municipal point sources (Anderson et al., 1979; Bertine et al., 1979).

Upstream sources have long been viewed as insignificant compared to direct discharges. In recent years, however, it has become apparent that 50% or more of pollutants enter coastal waters via rivers and streams. This is especially true along the Gulf of Mexico and in the Northeast (Ibid., 1979). For example, Boston Harbor daily receives 500 million gallons of wastewater from two sewage treatment plants in the harbor and another 500 million gallons of highly polluted freshwater from three major rivers (Massachusetts Water Resources Authority, 1988). The dilution factor reduces the initial impact of some riverborne pollutants; however, the long-term, cumulative effects of total loadings have been highly significant to the degradation of harbor water and sediment quality.

Some "new" non-point sources are getting the attention of coastal biologists. Atmospheric deposition, acid rain, transport of wastes through groundwater,onshore and near-shore dumping of trash, and leaching of pollutants from landfills, septic systems, and ship hulls are increasingly recognized as significant sources of contaminants to coastal waters (Toufexis, 1988). The nitrogen oxide component of acid rain has recently been shown to contribute nitrogen to marine environments, causing eutrophication of these nitrogen-limited systems (Fisher et al., 1988). Trash is wreaking havoc with marine mammals and seabirds that ingest or become entangled in nondegradable plastic debris (Pruter, 1987). Tributyltin, an antifouling agent applied to boat and ship hulls, is released to the waters, and ultimately, the sediments of harbors and bays, inflicting damage to nontarget organisms at extremely low levels (Lawler and Aldrich, 1987). Some of these nontarget animals have commercial value or are important in estuarine food webs.

At the same time we are doing battle with coastal water quality -- bombarding bays and estuaries with a steady stream of pollutants -- we are compounding the problem by destroying these system's defenses. America's wetlands perform a vital pollution control function for coastal waters, and yet they are being destroyed at an alarming rate. More than 50% of wetlands in the continental United States have been irretrievably lost to development, dredge and filling activities, and pollution, most of them coastal wetlands or wetlands bordering major river systems tributary to coastal waters (Tiner, 1984).

Approximately 75% of the U.S. population lives within 50 miles of the coast. This clearly illustrates the enormous development pressures destined to compound and exacerbate existing pollution problems in coastal zones. Residential, commercial, and industrial construction, and physical alterations of water bodies, wetlands, and watersheds can be expected to severely stress the natural resources of coastal communities (Ketchum, 1972). The problem here is three-fold: overdevelopment; inappropriate land uses; and mismanagement of wastes.

Beyond Observing Symptoms: Toward a Cure for Coastal Pollution

We have had ample warning; indeed, our coasts are dying. It is time to heed the warnings, time to take action to reverse the dismal trend. The key needs fall into three categories: information needs; improvements in current structural water pollution control programs; and full implementation of nonstructural water pollution control programs.

Information needs

Critical questions face marine scientists in their quest to assist government decision-makers in establishing effective pollution controls:

* what are the origins and fates of the thousands of pollutants discharged to estuaries and coastal waters?

* what are the principal pathways of pollutants to humans, and the health effects of these pollutants?

* what levels of exposure produce which physiological and behavioral effects in marine organisms?

* precisely how much pollution can the various species tolerate?

* can cumulative toxicity be assessed for the many contaminants to which organisms are exposed?

* what is the assimilative capacity of our near-shore waters, and their ability to recover from degradation? The removal or reduction of which pollutants would enable systems to recover? Is there a "point-of-no-return," a level of contamination from which estuaries and coastal waters cannot recover?

While thousands of pollutants are discharged to near-shore waters, information programs and resources are generally focused on the 126 EPA-regulated "Priority Pollutants". Unregulated pollutants, namely pathogens and many organic chemicals, could be significant in terms of volume and impact in marine waters (Office of Technology Assessment, 1987). Just how significant (i.e., what pollutants exist in individual waterbodies and the impacts of these pollutants) needs to be assessed.

There are a multitude of data gaps precluding effective management and regulatory responses by federal and state agencies. Presently, data that is gathered on the origin, quantity, composition, fate, and effects of different wastes is often not available, or is gathered and analyzed using different methodologies and assumptions (Goldberg, 1979). In simple terms, we don't know where all the various pollutants come from, or where they end up! Understanding pollutant pathways is essential if pollutant loadings to marine ecosystems are to be halted and appropriate management solutions applied to restore fish and shellfish populations (Ketchum, 1972).

The charge to marine scientists is to facilitate the establishment of coastwide monitoring and research programs, and to cooperatively engage in these programs. Monitoring and basic research programs should target all harbors, embayments, and coastal waters which receive significant inputs from non-point sources. Programs should be aimed at assessing the presence of metals, organic chemicals, and pathogens in wastewater, their precise origins, the pathways of these pollutants in marine environments, and their ultimate fate and effects on marine organisms.

Monitoring studies must identify the various sources, pathways, and fates of contaminants in sediments, in the water column and in the tissues of marine organisms (Goldberg et al., 1971; Winchester et al., 1971; Hood et al., 1971). Basic research should attempt to quantify and characterize non-point sources of contamination, such as resuspension from sediments, examine acute and sublethal effects of toxics on marine organisms (including impacts on reproductive rates and susceptibility to disease), and involve studies on the effects of consumption of contaminated fish and shellfish on human health (Barber et al., 1971).

Specifically, marine scientists should consider participation in the following research areas:

1) Monitoring of conventional and toxic pollutants in harbors and bays.

2) Determining the speciation of metals in the water column and sediments as a means of assessing their toxicity or bioavailability.

3) Basic research aimed at assessing the bioaccumulation potential of metals and organic chemicals.

4) Development of culturing methods for pathogen screening.

5) Studying depuration of organic chemicals and metals by marine organisms.

6) Research into mobilization of pollutants from sediments.

7) Performance of whole-effluent toxicity tests in determining the overall toxicity of wastestreams or the cumulative impacts of all pollutants in a waterbody.

8) Fisheries studies--life histories, population biology, ecological dynamics, fish diseases.

Monitoring and basic research objectives should be coupled to government decision-making needs. Information acquired can assist federal and state agencies in the development of additional contaminant standards for regulated pollutants and in revision of old standards as toxicity studies indicate necessary (Save the Bay, 1987). For unregulated pollutants, monitoring data and basic research information can assist in the development of new standards. Most importantly, data can be used in assessments of the diversity, distribution, and abundance of species to be maintained or restored in coastal waters, and therefore in the establishment of long-term conservation objectives.

The ideal research and monitoring programs should be made concurrently "pro-active," assisting in development and implementation of management techniques that will prevent resource decline; and reactive in a way that fosters quick recovery of damaged marine systems.

Participation in coastwide research and monitoring programs is the most important response scientists can make to reverse the downward trends in fish and shellfish populations and in overall coastal resource quality. Without these programs, our coastal waters will continue to be stressed by potentially cataclysmic environmental threats, about which we know very little and for which planning and implementation of effective controls will become increasingly difficult.

Funding for coastal monitoring and research programs should be sought through government and private sources. Currently, government resources for augmenting monitoring and research efforts are limited (Robinson, pers. comm., 1988). Scientists must press for priority placement of monitoring and basic research programs on government environmental agendas. Federal and state interest and support for these programs is growing; however, a strong push from the scientific community is urgently needed.

In an ideal world, no chemicals would be developed, used, and disposed of unless or until: 1) extensive evaluation of their toxicity, fate, and effects in the marine environment produced conclusive evidence of their benign nature and 2) regulations (including outright bans, if necessary) were promulgated for those chemicals found to be harmful. Since the post-World War II dawn of the chemical era, the approach has the contrary. Thousands of chemicals have been sanctioned for unregulated use and disposal in the United States alone (Office of Technology Assessment, 1987). Hundreds of new chemicals are produced each year. With tighter restrictions being applied to land-based disposal of toxic wastes (42 U.S.C.A., sec. 6901 et seq., as amended), the volume of pollutants disposed of in wastewater and discharged to marine environments can be expected to increase.

It is hoped that pressure will mount from a variety of organizations and institutions to amend the federal Toxic Substances Control Act (15 U.S.C.A., sec. 2601 et seq., as amended). The burden of proof should be placed on manufacturers to demonstrate the environmental acceptability of compounds before they are licensed for production and use (Save the Bay, 1987). Scientific research into the bioavailability and toxicity of various pollutants can lend credence and support to this much-needed amendment.

Improvements in existing structural programs

Numerous federal laws regulate waste disposal in marine waters: The Clean Water Act; the Marine Protection, Research and Sanctuaries Act (MPRSA); the Coastal Zone Management Act; the Endangered Species Act; the federal "Superfund" (hazardous waste clean-up) law; the Resources Conservation and Recovery Act (on hazardous waste management); and the Toxic Substances Control Act. MPRSA (33 U.S.C.A., sec. 1401 et seq., as amended, governing ocean dumping of solid wastes, incinerator residues, sewage sludge, industrial wastes, dredged materials, and low-level radioactive waste); and the Clean Water Act (setting forth regulatory requirements for industrial and municipal discharges of sludge and liquid effluent) are the principal marine water quality laws (Ketchum, 1972).

Overall, MPRSA has been effective in its intended purpose to protect waters of the territorial sea, contiguous zone, and the open ocean from the impacts of unregulated ocean dumping. Regulation of ocean discharges under the Clean Water Act has posed considerably more problems. The Clean Water Act has made great strides in cleaning up the Nation's inland waters. Unfortunately, similar progress has not been made for coastal waters. The quality of coastal waters has regressed in recent years, in part owing to failure of the Act to keep pace with growth and water pollution control needs.

The Clean Water Act applies technology-based effluent limitations to both direct discharges to marine waters (through the National Pollutant Discharge Elimination System [NPDES] program) and indirect discharges to municipal sewer systems that ultimately discharge to the ocean (the National Pretreatment Program). Direct dischargers are required to meet secondary levels of treatment for conventional pollutants (for municipal POTW's) or Best Practicable Technology(BPT)/Best Available Technology (BAT) (for industrial dischargers). BPT is designed to control conventional pollutants;

BAT controls toxic and nonconventional pollutants. Indirect dischargers are required to meet Pretreatment Standards (33 U.S.C.A., sec. 1251 et seq., as amended).

While the Clean Water Act originally intended that industrial sources achieve BPT level of treatment and compliance with BPT (technology-based) standards by 1977, and BAT by 1984, compliance dates for many of these standards have been extended and have not been reached. Regulations for some major industrial categories have not yet been promulgated. Moreover, water quality- or "use"-based effluent limitations--standards incorporated into the discharge permit (to be met in the effluent) to ensure achievement of technology-based standards and receiving water quality standards--have been developed and promulgated by only a few states with approved NPDES programs. Municipal treatment plants have been slow to develop Pretreatment Programs, so that numerous indirect industrial dischargers of toxics remain unregulated (Office of Technology Assessment, 1987). Thus, some of the most basic water quality goals of the Clean Water Act have not been achieved for many industrial point sources.

Similar shortcomings exist for municipal dischargers required to meet secondary level of treatment. For years, municipalities have sought waivers to the secondary requirement, proposing instead to extend primary outfalls further offshore. Most waiver petitions made by municipalities on the east coast, where the continental shelf is shallow and extends miles from shore, have been denied (Rolbein, 1987). During the decade of court battles leading up to final denial of waiver petitions, what would have been avoidable pollution of harbors and bays, notably Boston Harbor, continued unabated.

Even with secondary level of treatment, technologies have not been developed to deal effectively with nutrients and pathogens, pollutants which are becoming more significant in marine waters (Ketchum, 1972).

"Sidestepping" and insufficient enforcement and funding of structural mandates and water pollution control regulations have slowed progress toward improving coastal water quality (Millemann, 1986). But, even if structural goals (i.e. BPT, BAT, secondary treatment) and compliance with technology-based standards and water quality-based standards were at once achieved by point-source dischargers across the board, they would not be sufficient to maintain or improve coastal water quality, because:

1) Current pollution control programs do not address all pollutants. Standards are set by the federal government and states for <u>conventional pollutants</u> (dissolved oxygen, total suspended solids, etc.). But for <u>toxics</u>, in the absence of federal or state standards, federal Water Quality Criteria serve merely as guidelines in the writing of NPDES permits. Not all 126 federally-listed Priority Pollutants have Water Quality Criteria; instead, the

EPA has developed "advisories" based on less scientific data. Thousands of chemicals that are not listed but may be present in wastestreams in harmful quantities are completely unregulated. EPA has failed to add to the list. There is insufficient or no monitoring for listed and unlisted toxics.

2) Current pollution control programs do not address all sources of pollution. For example, textile mills, commercial laundries, combined sewer overflows (CSO's), stormwater outfalls, and non-point sources are not yet regulated.

3) Discharge permitting programs do not consider all inputs to a waterbody and the cumulative effects of these inputs.

4) Contamination of sediments with persistent toxic pollutants is not addressed. Criteria and standards have not been developed for sediments.

5) There are no standards for sludge. Sludge dumped in coastal waters, like effluent, should comply with prescribed standards, or such dumping should be prohibited.

6) The Clean Water Act requires that all direct discharges to the territorial seas, the contiguous zone, or the open ocean comply with Ocean Discharge Criteria, so as to "...not unreasonably degrade the marine environment." Intended to provide additional protection over those afforded inland waters, these criteria presently do not apply to estuaries.

7) Pipeline discharges and non-point source pollution (particularly urban runoff) will increase as populations and developments expand in coastal areas. (Office of Technology Assessment, 1987)

Pretreatment and NPDES programs should be expanded by developing standards for additional pollutants, sources of pollutants, and receiving waters/sediments:

1) Using federal Water Quality Criteria as guidelines, states should establish specific, empirically verifiable numerical Water Quality Standards (standards to be met in receiving waters) for listed toxics (Save the Bay, 1987). Pollutants not on the CWA list, but which can impact estuaries and coastal waters, must be identified and Water Quality Criteria and Standards developed for them.

2) Pollution control programs must be expanded to point sources and non-point sources not adequately regulated. (e.g., CSO's and stormwater discharges should be treated according to numerical standards) (Office of Technology Assessment, 1987).

3) Discharge permits should increasingly assign Waste Load Allocations that consider all inputs and total loadings to a waterbody, and the cumulative effects of these inputs/loadings (Save the Bay, 1987).

4) The EPA should develop Sediment Quality Criteria, so that numerical state Sediment Quality Standards could be linked to improving the health of benthic communities (ibid., 1987).

5) Standards for sludge should be established. Sludge Quality Standards will increase the ability of municipal treatment plants to require source reduction of toxics by industrial dischargers, and the higher quality sludge can be disposed of through land application. (ibid., 1987).

6) Given the severely degraded condition of coastal estuaries and embayments, consideration should be given to applying Ocean Discharge Criteria to these waters. Issuance of an NPDES permit for discharge into estuaries should be made contingent on: (1) compliance with Ocean Discharge Criteria; (2) development of an acceptable monitoring protocol; (3) specification and acceptance of conditions under which the discharge may be terminated or modified; and (4) demonstration of need to discharge into estuarine waters, after source reduction, recycling, re-use, pretreatment, and other disposal options have been exhausted (Office of Technology Assessment, 1987).

Coastwide monitoring and research efforts could then use the above parameters to measure progress toward attainment of prescribed goals for use of the waterbody (fishing, swimming, etc.). If monitoring indicates insufficient progress toward specific goals, agencies should respond by shifting planning or control efforts.

But how do we deal with increases in the number of pipeline discharges and additional amounts of non-point source pollution, as populations and developments expand in coastal areas? One thing is clear: the present system of water pollution control in the United States is inadequate to meet these needs.

Implementation of nonstructural water pollution controls

The present strategy for addressing water pollution problems solely by structural means, exclusive of non-structural means, is the most serious failure of current water pollution control programs. Nationally, the traditional response to water pollution problems has been implementation of capital-intensive, purely structural solutions, for example, construction of new infrastructure and wastewater treatment facilities to convey and treat additional sewage flows. Since 1972, the federal government has spent over $44 billion to build municipal treatment plants (ibid., 1987).

In contrast, only limited resources have been dedicated to non-structural programs. Examples of such controls are:

* site-specific waterbody management;

* application of non-point source pollution controls, source reduction of toxics, and recycling strategies;

* basin-wide watershed management;

* comprehensive land use planning, wastewater treatment planning, and integration of these two planning processes;

* no net loss of wetlands.

The Clean Water Act clearly establishes non-structural approaches as a goal: Sections 208 and 303e of the Act set in motion ambitious state and regional water quality management efforts, completed in the 1970's, to plan and implement structural and non-structural water pollution controls in urban-industrial centers and over entire river basins. But the Act failed to put "teeth" into the non-structural portions of these Plans (Save the Bay, 1987). Regional and local waterbody management plans, land use goals, growth management plans, and environmental bylaws proposed in the 208 and 303e Plans--essential to maintaining coastal water quality--stand as unenforceable, underfunded, and unmet objectives.

Coastal water pollution problems persist, in part, because much of the pollution is non-point source in nature, and states and municipalities have made little progress with non-structural water pollution controls (Millemann, 1986). This is most unfortunate, in view of what lies ahead: by the end of this year, EPA will have phased out its annual contribution of Construction Grant monies and replaced it with a limited loan program. The phase-out of federal funds is forcing a shift to state and local funding of structural water pollution control projects. States and locals are hard-pressed to meet this financial responsibility. They must double their efforts to implement non-structural water pollution controls to supplement costly structural measures. Non-structural remedies are preventive, less costly and, together with structural measures, can produce long-term improvements in water quality.

The Congressional Office of Technology Assessment (1987) has warned of problems inherent in structural pollution control. They have stated that full implementation/enforcement of structural goals of the Clean Water Act is unlikely, as long as structural initiatives fail to keep pace with growth. Non-structural approaches must be fully implemented and enforced to supplement structural approaches.

Water body management.

Application of non-structural water pollution control methods has at its foundation the goal of site-specific water body management. Estuaries and coastal waters have site-specific characteristics and can encompass multiple political, legal, and statutory jurisdictions (ibid., 1987). Therefore, there should be greater coordination among agencies in identification of site-specific problems, allocation of resources, and in the application of effective non-structural water pollution controls to supplement structural controls (Ketchum, 1972).

The characteristic/jurisdictional argument isn't the only impetus to water body management. In light of the impending phase-out of federal construction grant monies, state limitations in filling this void, and municipalities themselves constrained by limited staff and funds, communities must begin to evaluate non-structural measures for application to local circumstances and conditions. Non-structural water quality management approaches can best be applied to specific water bodies.

Site-specific, water body management involves a water quality-based approach to compliment the present system of uniform, technology-based controls. For each water body, this additional layer of water pollution control would require:

1) determination of whether water quality goals are being met; is additional management of the waterbody needed?

2) inventory and assessment of pollution sources (both point sources and non-point sources);

3) identification of monitoring and basic research needs, establishment of data bases;

4) establishment of measurable goals, target dates, and regular evaluation of progress in attaining these goals; goals should include restoration and maintenance programs for water quality, fish and shellfish, wetlands, and wildlife habitat;

5) development and implementation of a waterbody management plan that integrates basin-wide efforts, incorporates the aforementioned goals of restoration and maintenance of resources, and incorporates or updates the existing 208 and 303e Plans; and

6) development and implementation of regional compacts, local bylaws and regulations which would manage land use so as to prevent, abate, and control water pollution. (Office of Technology

Assessment, 1987)

Government grants should be made contingent on development and implementation of adequate water body management plans by municipalities and regions. The "adequacy" of plans would be based on their potential, when implemented, to attain and maintain water quality, sediment quality, and natural resource goals established for the water body. Emphasis should be on prevention of pollution problems through full implementation of waterbody management plans.

Watershed management.

Water body management programs should be expanded upstream to include management of the entire watershed. Physical alterations and pollutant inputs occurring anywhere within the watershed of a water body can seriously effect the quality of that water body. For example, upstream development, channelization, water withdrawal, diversions, point source discharges, and non-point runoff all contribute to diminished water quality downstream. Upstream projects and discharges should be scrutinized for their potential to adversely impact downstream estuaries and coastal waters, and should be required to minimize or avoid such impacts (Save the Bay, 1987). Further, shoreline development should be evaluated for impacts that may be carried "downshore" with the currents and tides.

As mentioned above, CWA Section 208 and Section 303e programs planned land use and wastewater treatment over entire watersheds, including those of estuaries and coastal waters (33 U.S.C.A., sec. 1251 et seq., as amended). If updated and implemented, 208 and 303e plans can be a critical extension of water body management plans in any quest to improve coastal water quality.

The Chesapeake Bay Program, Great Lakes National Program, and the Puget Sound Water Quality Authority are model water body management initiatives whose jurisdictions extend over entire watersheds. Much of Puget Sound's success can be attributed to the establishment of a lead agency with clear authority, whose recommendations are binding on other state and local agencies (Office of Technology Assessment, 1987). The EPA's National Estuary Program, modeled after these programs, is highly successful with similar initiatives in many coastal regions (Morganthau, 1988).

Non-point source pollution control, source reduction of toxics, household hazardous waste collections, and recycling.

Important to include in water body management plans and watershed management programs are non-point source pollution control, source reduction of toxics through application of user fees, household hazardous waste collections, and recycling programs.

Fifty percent or more (variable by region) of pollutant loadings to coastal waters comes from urban and agricultural non-point runoff. "Best Management Practices" (BMP's) must be instituted for these sources, including percentage requirements for permeable surface area, reduced area for pesticide-intensive lawns, and integrated pest management techniques (Save the Bay, 1987).

Effluent discharge fees based on the number of toxics, total loadings, and relative toxicities (essentially "true-cost" pricing of wastewater discharges) eliminates the subsidizing of industrial pollution (ibid., 1987). Progressive fees encourage waste reduction and compliance with discharge permits. The incentive is to follow a waste hierarchy: source reduction first; otherwise, recycling and re-use. As a last resort, the choices are waste treatment and destruction, and finally disposal.

As much as 20% of the toxic chemicals discharged to coastal waters originate in households (Office of Technology Assessment, 1987). Public education programs must encourage reduced use of toxics in the home and substitution of natural products (lemon juice, baking soda, vinegar) for chemical products. States and local communities must commit to funding local household hazardous waste collections for chemical wastes that are still produced.

Much of the trash that finds its way to beaches and appears as flotsam in coastal waters can be recycled; other trash--plastics and styrofoam--should be reduced in coastal locations through the use of substitute, degradable materials (O'Conner and O'Dell, 1988).

Comprehensive land use planning and wastewater treatment planning. The all-important issue that must be addressed in waterbody management and watershed management programs is land use. High-density or inappropriate land uses, and/or rapid development have given rise to water quality problems in coastal zones. Unbridled growth in coastal states portends additional stresses on the quality of marine waters.

Poor planning, zoning, and land use regulation can predispose coastal communities to development/resource conflicts. Water pollution can be extensive and severe as growth begins to exceed the capacity of wastewater treatment systems to convey and treat wastes. Therefore, development which stresses or overloads present infrastructure should be restricted or prohibited altogether. Firstly, communities must revisit their land use plans, bylaws, and regulations, revising them as necessary to more effectively manage growth and protect water quality. The importance of developing and implementing carefully-drawn local master plans, open space plans, strict zoning bylaws, non-zoning bylaws, and regulations to accomplish coastal water quality goals (and overall environmental protection) cannot be overemphasized.

Second, growth management must be integrated with wastewater management. The Mayo Peninsula, Maryland Water Reclamation Project is one example of where this integration has proven highly successful in the correction of long-standing wastewater disposal problems. Previously proposed centralized wastewater treatment plans were rejected as growth-inducing. Growth management has been integrated with wastewater management on the Mayo Peninsula by:

1) projecting prospective growth on the peninsula (on a lot-by-lot basis). Environmental restrictions were incorporated in the future growth potential determinations. Also, growth restrictions were developed during the wastewater management planning phase;

2) adherence to infrastructure facilities requirements;

3) adoption of a user charge system that ensures the financial integrity and self-sufficiency of the wastewater systems. The user charge system includes contribution to a repair/replacement fund that will ensure that wastewater facilities are required/replaced in the future, when necessary. Fees are revised regularly to reflect true costs; and

4) growth cannot occur unless wastewater facilities are financed and built to support the growth. New development and wastewater treatment facilities are added at a specific rate (phased growth).

The Mayo Peninsula Water Reclamation Project is a prototype for integrated growth and wastewater management. The project has effectively eliminated growth stimulants and "subsidized" growth: excessive capacity in wastewater collection systems has been eliminated and all users pay their fair share of wastewater services. The fear of uncontrolled growth has been dispelled.

Wastewater treatment planning on the Mayo Peninsula is based on "buildout" in the region. Any resource conflicts that may still result would indicate the need to revise zoning and subdivision control regulations to limit density (Lombardo, 1988).

No net loss of wetlands

Each of the components of properly functioning wetlands--those which provide flood control, prevent storm damage, control pollution, provide clean recharge to groundwater and public and private drinking water supplies, and those which sustain fish, shellfish, and wildlife--must be protected, through aggressive implementation and enforcement of federal, state, and local wetlands protection regulations. Most important, a "no net loss/net gain of wetlands" policy must be implemented nationally and by the individual states. For the protection of coastal water quality, "no net loss" of wetland quantity and quality must be assured. Recognizing that wetlands are the "lifeblood" of coastal ecosystems, the commonwealth of Massachusetts is working to accomplish both quantity and quality objectives for coastal wetlands, through its "no net loss of wetlands" policy.

Conclusion

The future health of coastal waters and all of their dependent organisms depends upon a major change in thinking about basic approaches to the reduction of human impacts on the environment. The post-hoc, structural "quick fix" must be complemented by anticipatory, non-structural approaches. Structural water pollution controls instituted in the absence of non-structural measures become obsolete before they see a day of service. If routinely combined with non-structural controls and an overall management plan for a body of water, however, the cycle of reactive, end-of-the-pipe pollution control can be broken, and an end will come to the procession of "technical fixes" responsible for the gross pollution of our coastal waters. A combined structural/non-structural approach is urgently needed in the United States and abroad, if we are to once and for all abate and prevent coastal water pollution and maintain coastal water quality.

In accordance with this change in attitude, the scale of consideration for environmental management must also shift. In the past twenty years, we have seen a highly case-specific approach to impact mitigation: e.g., does this power plant or that housing development impact this or that square foot of habitat. In view of the simple and obvious facts that water is a fluid, that aquatic systems are structured by currents and flow, that most aquatic organisms rely upon pelagic dispersal of young, it is essential that the case-specific approach be replaced by one that is water body specific: i.e., that there be an overarching plan for the nondisruptive management of each watershed, bay, or ocean basin on an ecosystem level. The result will be a hierarchy of environmental plans based principally on non-structural approaches to water pollution control, including non-point source pollution control, the elimination of toxic inputs, resource recycling, integrated land use planning/wastewater treatment planning, and watershed and wetlands protection.

Scientists must play an essential part in bringing about the fundamental changes in philosophy and environmental hygiene that will take us beyond this era of case-specific management, the quick-fix, and the mop-up. Certainly there is the obvious need for basic research on the dynamics of coastal ecosystems. Some will think this the only proper involvement in conservation activity by academic ecologists. This attitude, however well advised in a climate of "gentler, kinder" environmental politics, is inappropriate for these times. Ecologists who choose to distance themselves from coastal and other environmental issues contribute to the growing membership in a "Silent Authority". This is dangerous. If scientists cannot find voice in the public sector about the issues they best understand, then environmental decision-making will be left to a half-informed coalition of politicians and special interest groups. Besides merely aiding such groups, scientists must speak out on their own on environmental issues--it is their voices that society needs and wants to hear.

Other important roles for scientists are equally threatening to the notion of a life totally devoted to basic research. Scientists' efforts are needed to foster the establishment of monitoring and research programs that will begin to answer the critical questions presented in this paper. By and large, such programs are not of theoretical interest. This does not make them any less important from a conservation standpoint. Scientists must work to develop ongoing communication with federal and state environmental agencies, so that data, but more importantly, judgements, informed opinion, and syntheses of scientific information can be regularly incorporated into government decision-making on coastal planning, regulation, conservation, and management.

Ecologists are being called upon to function in important ways that are outside their immediate academic interests. Coastal environmental quality is just one of several issues that are ripe for the constructive and influential participation by scholars. Without a modicum of activism on the part of full-time academicians, however, this vital influence is squandered and the seeds of coastal degradation are sown once more.

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References

Anderson, A.R., T.W. Anderson, W.M. Dunstan, L.L. Falk, J.E. Kerrigan, L.R. Rose, and R. Tollefson. 1979. Sources of pollutants. In: Goldberg, E.D. (ed.). Assimilative Capacity of U.S. Coastal Waters for Pollutants. Crystal Mountain Press, Washington. 284 p.

Barber, R.T. 1971. The effects on marine organisms. In: National Academy of Sciences/National Research Council, Ocean Science Committee. Marine Environmental Quality: Suggested Research Programs for Understanding Man's Effect On the Oceans. Washington, D.C.. 107 p.

Bertine, K., J.K. Cochran, L.E. Cronin, W.P. Davis, C.S. Martens, L.R. Pomeroy, J. Schubel, J.L. Tast, J. Teal, and R. Wilson. 1979. Pollutants in estuaries. In: Goldberg, E.D. (ed.). Assimilative Capacity of U.S. Coastal Waters for Pollutants. Crystal Mountain Press, Washington. 284 p.

Duedall, I.W. et al. (Eds.). 1983. Wastes in the Ocean, Volume I: Industrial and Sewage Wastes in the Ocean. John Wiley and Sons, Inc.. 413 p.

Fisher, D., J. Cerraso, T. Mathew, and M. Oppenheimer. 1988. Coastal Waters: The Role of Acid Rain. Environmental Defense Fund. New York, NY 90 p.

Geraci, J.R. 1987. Report on the continuing investigation of the bottlenose dolphin die-off along the mid-Atlantic coast. In: Coastal Pollution in the New York Bight and Mid-Atlantic, Hearing Before the House Subcommittee on Oceanography, Committee on Merchant Marine and Fisheries, September 8, 1987. U.S. Government Printing Office No. 80-649. 405 p.

Goldberg, E.D. 1971. Fluxes of materials to the marine environment. In: National Academy of Sciences/National Research Council, Ocean Science Committee. Marine Environmental Quality: Suggested Research Programs for Understanding Man's Effect On the Oceans. 1971. Washington, D.C.. 107 p.

_______ (ed.) .1979. Assimilative Capacity of U.S. Coastal Waters for Pollutants. Crystal Mountain Press, Washington. 284 p.

Hood, D.W. 1971. The ultimate fate of substances that relate to the quality of the marine environment. In: National Academy of Sciences/National Research Council, Ocean Science Committee. Marine Environmental Quality: Suggested Research Programs for Understanding Man's Effect On the Oceans. 1971. Washington, D.C.. 107 p.

Ketchum, B.H. 1972. The Waters Edge: Critical Problems of the Coastal

Zone. MIT Press. 367 p.

Lawler, I.F. and J.C. Aldrich. 1987. Sublethal effects of Bis (Tri-N-Butyltin) oxide on Crassostrea gigas. Marine Pollution Bulletin. 18(6):274-278.

Lombardo, P.S. 1988. Integration of Growth and Wastewater Management, the Mayo Peninsula, Maryland Water Reclamation Project. In: Dean, S.E. (ed.). The Emerging State/Regional/Local Challenge to Abate and Prevent Coastal Water Pollution and Restore Coastal Water Quality. Workshop Proceedings, New England Environmental Conference, March, 1988.

Massachusetts Water Resources Authority. 1988. Secondary Treatment Facilities Plan, Volume I: Executive Summary. pp. 2- 15 -- 2-17.

Millemann, B. 1986. And Two If By Sea: Fighting the Attack on America's Coasts. Coast Alliance, Inc., Washington, D.C.. 109 p.

Morganthau, T. et al. 1988. Don't go near the water. Newsweek. August 1, 1988. pp. 42-48.

O'Conner, D.K. and R.O'Dell. 1988. The tightening net of marine plastics pollution. Environment 30(1):16-36.

Office of Technology Assessment. 1987. Wastes in Marine Environments. U. S. Government Printing Office, Washington, D.C.. 312 p.

Pruter, A.T. 1987. Sources, quantities and distribution of persistent plastics in the marine environment. Marine Pollution Bulletin. 18(6B):305.

Robinson, W.E. New England Aquarium. Personal communication. August 10, 1988.

Rolbein, S. 1987. The Harbor, Boston's Floating Crap Game. Boston Magazine. May, 1987:150-211.

Save the Bay, Inc. 1987. Saving Our Bays, Sounds, and the Great Lakes: The National Agenda. Conference Proceedings, October 19-23, 1987. 83 p.

Sindermann, C.J. 1979. Pollution-associated diseases and abnormalities of fish and shellfish: a review. Fishery Bull. 76(4):717-749.

Tiner, R.W., Jr. 1984. Wetlands of the United States: Current Status and Recent Trends. U.S. Fish and Wildlife Service. 59 p.

Toufexis, A. 1988. The Dirty Seas. Time Magazine. 132(5):44- 50.

Wastler, T.A. and L.C. Wastler. 1972. Marine Pollution in the World Today: Estuarine and Coastal Pollution in the U.S. Pages 40-54. In: Marine Pollution and Sea Life. Food and Agriculture Organization of the United Nations. Fishing News (Books), Ltd. 624 p.

Winchester, J.W. 1971. Dispersal and transport of pollutants in the marine environment. In: National Academy of Sciences/National Research Council, Ocean Science Committee. Marine Environmental Quality: Suggested Research Programs for Understanding Man's Effect On the Oceans. 1971. Washington, D.C.. 107 p.

Young, D.R. and A.J. Mearns. 1978. Pollutant flow through food webs. Pages 105-200. In: Southern California Coastal Water Research Project Annual Report.

The Impact Of Beach Sand Mining in Montserrat and the Islands of the Eastern Caribbean

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Abstract

Coastal changes in Montserrat, a small volcanic island 400km southeast of Puerto Rico, were measured during the period 1966 - 1990. The data showed that all the west coast beaches had experienced erosion over this period. Among the causes of this erosion were natural causes (hurricanes and winter swells), sea defense structures, and beach sand mining. Analysis of the data showed that beach sand mining had doubled the natural rate of erosion. The paper analyzes the legislation dealing with sand mining. At present there is no charge for beach sand, and while alternatives to beach sand are available, these obviously have a higher cost. In developing countries, natural resources management does not play a lead role in the development plan, and while a country's progress is measured by economic indicators alone such as the GDP, this will continue to be the case. Beach sand mining is a major problem in Montserrat and the Eastern Caribbean Islands; its management and control requires extensive education of all population sectors, the provision of alternatives and proof of their suitability, and, perhaps most importantly, a strong political motivation.

Introduction

Coastal zone management (CZM) is a relatively new concept in the Eastern Caribbean Islands, yet the need for effective CZM is readily apparent in these developing countries as they move towards their goal of sustainable development. The coastal zones of these islands are intensively used. Coastal problems are widespread and include erosion, pollution, and mining of beach sand for construction purposes. Some islands have set up coastal zone management agencies, in particular Barbados and the British Virgin Islands, while other islands such as St. Kitts are moving towards this end. However, there are islands where the need for such CZM agencies has not yet been perceived by the present government.

One of the major problems facing all the Eastern Caribbean Islands is the supply of construction sand. Traditionally, this material has been taken from the beaches. In the past, when the level of construction was very low and there was a predominance of wooden buildings, this did not cause major problems. With the growth of tourism, especially in the last two decades, and the move towards concrete buildings for residential, commercial, and industrial construction, the volumes of sand being removed from the beaches has caused considerable beach erosion in many islands. Ironically, construction of the hotels and related infrastructure has contributed to the erosion of the beaches the tourists come to enjoy.

This paper discusses the issue of beach sand mining in one island, Montserrat, and describes and attempts to quantify the physical effects of large-scale beach sand mining. Political, economic, and institutional aspects of the problem are discussed within the context of Montserrat and the entire region. Finally, solutions are proposed and discussed.

Geography and Geology of Montserrat

Montserrat lies north of Guadeloupe and south of Antigua in the inner volcanic chain of the Caribbean Island arc, 16°45' N and 62° 10' W. Montserrat is a small island, 104 km^2, had a population of 12,000 in 1980. Montserrat is a dependent territory of Britain and has a Governor appointed by the Crown. General control and direction of Government affairs is performed by an elected Legislative and Executive Council (Oldfield, 1987).

Over the past 25 years, Montserrat made the transition from a plantation-based agricultural economy to a service economy driven by tourism, and to a lesser extent, manufacturing (Von Rabenau, 1987). Steady economic growth is evidenced by the per capita GDP, which increased 2.9% annually between 1975-1985. It is estimated that high income tourism may have been the most important contributor to the growth pattern of the economy. The most important segments of the tourism sector are the resident tourists and the holiday tourists. Resident tourism started in the 1960's when foreign developers and domestic estate owners developed large areas of land on the west coast and sold them to developers. These resident tourists spend a significant portion of the year in Montserrat contributing to the Island's economy; during the rest of the year their houses are rented to holiday tourists. Von Rabenau (1987) argues that Montserrat now has one of the highest development standards in the region.

Montserrat is a volcanic island built up of an andesitic suite of volcanics erupted from seven major centres. The material is mainly coarsely pyroclastic, but lavas and intrusions occur. The chief rock types are agglomerates, breccias, and tufts (Martin-Kaye, 1959). Volcanic activity occurred from the late Miocene to the Pleistocene; no eruption has been recorded in historic times. There are seven active soufrieres which give rise to warm sulphur emissions.

The coastline is rugged and cliffed, although there are some small embayments where beaches have developed. There are eleven sand beaches along the west coast and two sand beaches on the east coast. All the beaches are composed of black volcanic sand with essentially a magnetite-pyroxene assemblage, with the exception of Rendezvous Bay on the west coast, which is composed mainly of coral sand. Most of the beaches are small, bayhead beaches. The west coast beaches exhibit the characteristic Caribbean leeward coast form, with a narrow intertidal zone, on average 10 m wide and with 8 degrees of slope, and a flat back-beach segment averaging 12 m wide and 2 degrees of slope. Small patches of coral reef exist along the north, west, and south coasts but are not present on the more exposed east coast (Wells, 1988).

Montserrat lies within the Trade Wind Belt. Winds approach with great constancy from directions between northeast and east and, hence, the east coast is the windward, high energy coast and the west coast is the leeward or low energy coast. The most important type of storm is the tropical storm or hurricane, which occurs from June to November. The last hurricane to affect Montserrat was Hurricane Hugo in 1989, the centre of which passed directly over the island with wind speeds of 265 km/h (Markham and Fergus, 1989). Damage was severe. Previous to Hugo, Hurricane Klaus in 1985 and Hurricanes David and Frederick in 1979 passed close to Montserrat and inflicted severe coastal damage, particularly to the port of Plymouth in 1979. The frequency with which hurricanes affect Montserrat is one in five years (Admiralty Pilot, 1969; De Souza, 1966). The recent pattern would tend to confirm this statistical average.

The east, north, and west coasts of the Island are also affected by wave swells which originate from extra-regional disturbances in the North Atlantic Ocean during the winter months, October to March. Swell events cause serious erosion, especially on the west coast. The frequency of swell events varies from year to year. For example, in the nearby island of Grenada, six swell events were recorded in the 1985/86 winter season, while in the 1986/87 winter season, eleven swell events were recorded, one of which lasted for 15 days (Cambers, 1990a).

Institutional and Legislative Background to Beach Management

The Ministry of Agriculture, Trade, Lands and Housing (MATLH) is responsible for most aspects of coastal zone management in Montserrat, in particular conservation, fisheries, land and sea usage, and national parks. Existing legislation related to the coastal zone deals with beach protection, fisheries regulation, and oil pollution control (Lausche, 1987). All beaches on Montserrat are public and have a public access.

The Beach Protection Ordinance (No.9, 1970) regulates removal of sand, stones, or gravel from any beach, seashore, or foreshore. The removal of such material by motor vehicle is prohibited except with a permit issued by the Ministry of Communications and Works (MCW). Fouling the seashore with garbage, litter, or other offensive matter is also prohibited. Penalties for offences under the ordinance may be charged up to US $758. The terms "beach", "foreshore", and "seashore" are not defined under the ordinance, and interpretation follows common law usage.

However, the Beach Protection Ordinance is not implemented or enforced in Montserrat, despite Government's awareness of the problems caused by beach sand mining. To give but one example, following serious beach erosion caused by Hurricanes David and Frederick in 1979, the MATHL commissioned a study of the erosion and possible alternatives to beach sand mining (Cambers, 1981). This study reviewed several long-term alternatives and made recommendations. In addition, the study recommended that a short-term control measure be to implement the Beach Protection Ordinance and start a licensing system whereby users pay a minimal cost for the quantities of sand mined. It was felt that this would condition users to the idea of paying for a valuable resource.

However, the recommendations of this study were never implemented. Throughout most of the 1980's, the beaches were mined for sand and the only measure of control was action by the Ministry of Communications & Works to rotate the beaches which were mined. However, with only minimum enforcement, this measure was largely ineffective.

Von Rabenau (1987) discussed Montserrat's policies affecting resource use and depletion and found a lack of Government follow-thru on resource and environmental issues. He found that with sand mining, as well as other areas of environmental management, problems had been identified and studies undertaken, but recommended policies had not been implemented. This may reflect a lack of political will to implement what may be viewed as harsh and restrictive environmental management options, a possibility discussed later in this paper.

Coastal Beach Changes in Montserrat 1966-1990

Methodology

The surveying of beach profiles as a quantitative indicator of coastal change is a relatively new form of monitoring to the Eastern Caribbean Islands. No regular surveying of beach profiles is conducted in most islands. Coastal monitoring has only recently (1980's) been adopted in the more advanced islands such as Barbados and Trinidad. In Montserrat, this type of monitoring was established in March, 1990 (Cambers, 1990a).

Against this background, the following methodology was adopted to obtain quantitative estimates of coastal change. The 1970 Department of Overseas Surveys 1:2500 maps, based on aerial photography of 1966, were used to measure from buildings or other landmarks to the vegetation edge/cliff edge and to continue the measurement to the high water mark. The same buildings/landmarks were located in the field in March, 1981 and in February, 1990 and the measurements repeated. The three measurements were compared to compute coastal change. While there is a sizeable margin of error in this technique, in the absence of other data the results may be used to infer the direction and relative magnitude of beach change, if not the absolute magnitude. In addition, while the position of the high tide mark changes daily, the tidal range in the Eastern Caribbean Islands is small (0.3-0.5m) and seasonal effects have been largely eliminated since all measurements were made in February or March.

Results

Table 1 shows the annual rate of coastal beach change for each of the two measurement periods (1966-1981) and (1981-1990), as well as for the entire period (1966-1990) for eight beach sites on the west coast of Montserrat. (Unfortunately the two east coast sites could not be included since there were no convenient landmarks/buildings from which to conduct the measurements).

At Sugar Bay, just south of the main town of Plymouth, the rate of erosion was fairly low. This may reflect the fact that the measurement site is south of a groin structure. The net drift of sand at this point is from south to north and it is most likely that accretion around this groin has influenced the beach change at this point. At Sturge Park, located just north of Plymouth, there has been severe beach erosion. The average rate of change for this beach is -1.92 m per year -- a very high erosion rate for a Caribbean coast. It is most likely that reclamation and jetty construction at Plymouth in the early 1970's reduced the supply of sand to this beach. In addition, Sturge Park has traditionally been one of the major sources of construction sand for the island. Foxes Bay has also shown a high erosion rate, -0.8 m per year. Prior to the 1979 hurricanes, this beach was a major source of construction sand, although since 1979 this has not been a permitted beach. However, illegal extraction has taken place. At Iles Bay, Woodlands Bay, and Bunkum Bay, the average rate of erosion has been similar, -0.41 m per year. However, at Carrs Bay, a known sand mining beach, the rate of change has been higher, -0.82 m per year.

Using the data from Table 1, an attempt was made to estimate the relative importance of the various causes of the beach erosion. There are three major causes:

(1) natural causes, eg. hurricanes and winter swells
(2) sea defence structures
(3) sand mining.

Table 2 lists the importance of these causes at each site. The first column represents the average erosion rate at each beach for the period 1966 - 1990, (some extrapolation was necessary for Lime Kiln Bay). The second column lists whether sea defence structures have played a major part in the recorded coastal change; eg. the Plymouth port reclamation obviously influenced the rate of change at Sturge Park. The third column lists whether or not sand mining has been a major factor at that beach. It has been assumed that hurricanes and winter swells affect all beaches to a similar extent. This is an obvious over-simplification, but it may be assumed for this analysis.

Having assumed that natural causes affect all beaches similarly, Table 2 shows that there are three beaches with no sea defence structures and where the unavailability of vehicular access means that there has been no significant beach sand mining. These beaches are Lime Kiln Bay, Woodlands Bay, and Bunkum Bay. All three beaches have a similar rate of erosion of -0.38 m per year. Two other beaches, Foxes Bay and Carrs Bay, have no sea defence structures but have experienced extensive sand mining during the 24-year period. Both these beaches show an erosion rate of -0.80 m per year. Based on this very limited data, it appears that sand mining has resulted in a doubling of the natural rate of erosion. It is impossible to comment on Sturge Park and Sugar Bay in this analysis because sea defence structures have also played a role in beach changes here.

To take another comparison, the beaches on the west coast of Barbados have also been eroding in recent times. An analysis of the erosion rate along these beaches using aerial photographs has been completed for the period 1954 - 1983 (Cambers et al., 1985). These data show an average erosion rate of -0.2 to -0.3 m per year. It has been suggested that this erosion is due to natural causes and coral reef deterioration (Proctor and Redfern International Ltd., 1984). This recession rate, which is based on more detailed survey data than is available for Montserrat, is of the same order of magnitude as the three beaches on Montserrat where no sand mining has taken place and where there are no sea defence structures. This provides some additional justification for the use of these three beaches as a baseline against which the effects of sand mining can be estimated. (Barbados has inland sources of construction sand and beach sand mining is not a major factor there).

In summary, it may be stated that the rate of beach erosion in Montserrat is high in the context of the Eastern Caribbean. While it appears likely that natural causes such as hurricanes and winter swells play a significant causal role, the mining of beaches for construction sand also influences beach erosion such that natural erosion rates may be doubled.

Discussion

As has been shown in the previous section, it appears likely that the rate of coastal erosion in Montserrat has doubled as a result of beach sand mining. Sand is an essential component for the construction industry which, in turn, contributes to the development process.

The question must be asked whether the sand is more valuable in the buildings and related infrastructure or on the beaches? As shown earlier, Montserrat's tourism is based on resident tourism, rather than the more typical Caribbean Islands where short-term stayover visitors are the norm and where most of the tourism infrastructure is centred around the beaches. Nevertheless, the Tourism Board of Montserrat views the beaches as an important part of the tourism product and residents, both local and overseas, view the beaches as an important recreational resource.

To date, Montserrat has been fortunate in that most of the land behind the beaches is undeveloped. As the beaches erode, they have repositioned themselves further inland with the actual beach form remaining seemingly unchanged. However, this state of affairs is not likely to continue. For instance, at Sturge Park beach the Fisheries building and the oil storage tanks may become endangered as the beach retreat continues; existing and potential development at Carrs Bay may be similarly threatened.

In an attempt to value the land lost at Sturge Park over the 24-year period, the length of the beach and the width of the land lost was calculated. The area of land lost was 66,700 m^2. Beachfront property has a high value in the Caribbean Islands. Assuming a value of US $50 per m^2, this lost area represents a value of US $3,335,000. Since beach sand is free in Montserrat, it appears that a small number of property owners have subsidised the island's construction industry over the past two decades.

As the coastline becomes more developed and as existing properties are endangered by erosion, efforts will have to be made to provide alternatives to beach sand and to control beach sand mining. There are alternatives, such as offshore sand sources (Cambers, 1981), quarry dust, and possibly, inland materials such as tarris (pumice). It should be noted that the inland alternatives have not yet been fully evaluated. However, alternatives will be costly when compared with beach sand, which is at present a "free" resource. To date, the political support has not been sufficient to place any price on beach sand. Obviously this has to be a first step, even if it is only a minimal price. However, such a step would require a very strong political party which was also deeply committed to sound environmental management. And when a country's growth and progress is measured by its GDP, of which construction is an important component, natural resource management plays a minor role in the overall development process.

However, there are signs that Montserrat is moving to manage its natural coastal resources. In 1990, a beach monitoring programme was set up and technical assistance has been sought to develop a plan of operations to manage sand resources. Studies have been carried out before and not implemented; hopefully, this time the effort will be sustained and a sound beach management programme put in place.

Implications for The Region

Sand mining is a problem throughout most of the Eastern Caribbean Islands. Montserrat is at one end of a scale where there is no permitting process and no charge for the sand resource. Other islands, eg. Grenada, have a permitting process whereby certain beaches are open to mining, but no charge is levied. Still other islands, such as St. Lucia, have a permitting process and a minimimal charge for sand (US $2 per yd^3) (Cambers, 1990b). However, in all these islands, inadequate surveillance, an absence of beach monitoring, and illegal mining make sand mining one of the region's major coastal problems. In general, the nature and effects of beach sand mining are recognized, but there is a lack of political will to manage and regulate what has always been regarded as a free resource.

There are feasible alternatives to beach sand mining, on regional and national scales. A recent study (Cambers, 1988) recommended a regional approach to deep water dredging to stockpile sand for the individual islands. In Guyana, there are extensive deposits of river sand suitable for construction. Some islands, such as St. Lucia, have extensive deposits of pumice; pilot projects have shown its suitability for various types of construction. Again, some islands, eg. the British Virgin Islands, have resorted to nearshore dredging to supply sand.

Alternatives exist for the region. It remains for the individual islands to select the most appropriate alternatives and to implement them. This is no easy task, requiring extensive education of all sectors of the population, the provision of alternatives and proof of their suitability, and a strong political motivation. The control of beach sand mining is one of the major coastal zone problems facing the islands of the Eastern Caribbean.

References

Admiralty Pilot. 1969. West Indies Pilot No. 71, Vol.2, Publ. London Hydrographer of the Navy.

Cambers, G. 1981. Sand Resources in Montserrat. Unpublished report prepared for the Government of Montserrat.

______, T. Holder, and W. Ross. 1985. Analysis of Beach Changes between March 1983 and March 1985. Technical Report 2, Barbados Coastal Conservation Project.

______. 1988. Regional Survey of Coastal Conservation. Vol III of Regional Sewage Disposal and Coastal Conservation Studies, report prepared for U.N. Economic Commission for Latin America & the Caribbean.

______. 1990a. Montserrat Coastal Monitoring Programme. Report prepared for the Organisation of Eastern Caribbean States - Natural Resources Management Unit.

______. 1990b. Beach Sand Mining in St. Lucia : An Environmental, Economic and Geotechnical Assessment. Report Prepared for the Organization of American States.

De Souza, M. 1966. Report on all Caribbean Hurricane Insurance. Report prepared for the Ministry of Public Utilities, Trinidad & Tobago.

Lausche, B. 1987. Inventory of National Legislation for Natural Resources Management and Environmental Protection. Report prepared for the Organization of Eastern Caribbean States - Natural Resources Management Project.

Markham, E.A. and H.A. Fergus. 1989. Hugo versus Montserrat. New Beacon Books Ltd.

Martin-Kaye, P.H.A. 1959. Reports on the Geology of the Leeward and British Virgin Islands. Voice Publishing Co. (1953) Ltd., St. Lucia.

Oldfield, S. 1987. Fragments of Paradise. Pisces Publications.

Proctor and Redfern International Ltd. 1984. Coastal Conservation Study. Report prepared for the Ministry of Housing & Lands, Government of Barbados.

Von Rabenau, B. 1987. Montserrat Resource Economy. Report prepared for the Organisation of Eastern Caribbean States Natural Resources Management Unit.

Table 1 Coastal Beach Change in Montserrat Between (1966-90).

Site	Coastal Change, metres per year		
	1966 - 1981	1981 - 1990	1966 - 1990
Sugar Bay	*	*	- 0.24
Sturge Park 1	*	*	- 2.73
Sturge Park 2	- 1.65	- 2.07	- 1.81
Sturge Park 3	- 1.78	- 1.15	- 1.55
Sturge Park 4	- 2.07	- 0.70	- 1.58
Foxes Bay	*	*	- 0.79
Iles Bay	*	*	- 0.48
Lime Kiln Bay	- 0.37	*	*
Woodlands Bay	- 0.40	- 0.39	- 0.40
Bunkum Bay	- 0.53	- 0.11	- 0.38
Carrs Bay 1	- 2.04	- 0.26	- 1.37
Carrs Bay 2	*	*	- 0.26

* no available data
exact site description from Cambers 1990.

Table 2 Relative Importance of Sea Defence Structures and Sand Mining on the Beach Erosion Rate in Montserrat

Site	Average Erosion Rate 1966-1990 (m per year)	Influence of Sea Defence Structures	Influence of Sand Mining
Sugar Bay	- 0.24	yes	?
Sturge Park	- 1.92	yes	yes
Foxes Bay	- 0.79	no	yes
Iles Bay	- 0.48	no	?
Lime Kiln Bay	- 0.37	no	no
Woodlands Bay	- 0.40	no	no
Bunkum Bay	- 0.38	no	no
Carrs Bay	- 0.82	no	yes

The Usefulness of Transplanted Oysters in Biomonitoring Studies

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Abstract

This study was designed to examine the uptake and depuration of selected organic contaminants of environmental concern, i.e., polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), by transplanted oysters (Crassostrea' virginica) in Galveston Bay, Texas and to establish the feasibility of using transplanted oysters for biomonitoring the contamination status in areas were no indigenous bivalves are present. Transplanted oysters bioaccumulated individual PAHs and low molecular weight PCBs to concentrations that were not statistically differentiable from the levels encountered in native oysters within 30 to 48 days. In contrast, high molecular weight PCBs did not reach equilibrium in transplanted oysters; whose high molecular weight PCB concentrations were lower than those measured in indigenous oysters during the seven-week uptake period. During the depuration phase of this study, originally uncontaminated oysters depurated PAHs and low molecular wight PCBs at a faster rate than chronically contaminated oysters. Clearance of high molecular weight PCBs was limited in both oyster populations.

Introduction

Contamination of the coastal marine environment by a number of organic compounds of synthetic or natural origin has received increasing attention over the last several years. Biomonitoring of these compounds in the aquatic environment has been well established and bivalves are generally preferred for this purpose. The rationale for the "Mussel Watch" approach using different bivalves, e.g. mussel, oysters and/or clams, has been summarized by different authors (Goldberg et al., 1978; Farrington et al., 1980; Phillips, 1980; Risebrough et al., 1983) and its concept has been applied to many monitoring programs during the last decade (Farrington et al., 1983; Martin, 1985; Tavares et al., 1988; Wade et al., 1988; Sericano et al., 1990).

The National Oceanic and Atmospheric Administration's National Status and Trends Program (NOAA's NS&T) is designed to monitor the current status and long-term effects of selected organic and inorganic contaminants of environmental concern, e.g. polynuclear aromatic hydrocarbons (PAHs), chlorinated pesticides, polychlorinated biphenyls (PCBs), and trace metals, along the coasts of the U.S. by measuring their concentrations in bivalves over a number of years. During the first five years of this program (1986-1990), the intent was to sample all the locations prescribed by NOAA. However, locations depleted or devoid of living oysters caused by virtue of diseases, predators, excessive freshwater runoff, harvesting, or dredge material burying entire reefs compromised this goal. Therefore, in some instances, it was not possible to obtain samples. After the first five years of the NS&T, nearly 20% of the original locations presented some of the above-mentioned sampling problems that left the database with missing values. Transplantation of bivalves to areas where indigenous individuals were not originally present or have been lost because of natural or man-induced actions could be a potentially useful tool in monitoring environmental pollution.

The present study was designed to examine the uptake and depuration of selected organic contaminants, i.e. polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), in oysters (Crassostrea virginica) through transplantation experiments in two locations in Galveston Bay, Texas.

Materials and Methods

Experimental design

Approximately 250 oysters of similar dimensions were collected from a relatively uncontaminated area in Galveston Bay, Hanna Reef, and transplanted in 24x70 cm net bags, containing 25-30 individuals per bag, to a new location near the Houston Ship Channel in the upper part of the Bay (Figure 1). Composite samples of 20 transplanted and 15 indigenous oysters were collected at 0, 3, 7, 17, 30, and 48 days during the first phase of the transplantation experiment. The remaining Hanna Reef oysters were then back-transplanted to their original location in Galveston Bay. At the same time, approximately 150 indigenous oysters from the Ship Channel site were also transplanted to the Hanna Reef area. Composite samples of 20 oysters from each population were collected at 3, 6, 18, 30, and 50 days after transplantation.

Analytical method

The analytical procedures used during this study are modifications of previously reported methods (MacLeod et al., 1985) and are fully described elsewhere (Wade et al., 1988; Sericano et al., 1990).

Results and Discussion

The concentrations of some of the organic contaminants increased dramatically during the seven-week exposure period. Comparatively, concentrations of individual PAHs and PCBs in indigenous oysters during the first phase of this experiment were fairly constant. The analyte concentrations in native oysters represent the time-integrated contaminant concentrations available to the oysters in solution, adsorbed onto particles, and incorporated into food.

Initial concentrations of total PAHs in transplanted oysters increased from 290 ng/g to a final value of 4360 ng/g. Two- and three-ring PAHs were detected in low concentrations in transplanted and indigenous oysters. Four- and five-ring compounds were accumulated to the highest concentrations in Hanna Reef oysters. By the end of the first 48 days, transplanted oysters accumulated these PAHs to levels that were not statistically differentiable from the concentrations measured in native individuals (Figure 2a). The PAHs accumulated to the highest concentrations by transplanted oysters were: pyrene> fluoranthene> chrysene> benzo(e) pyrene> benzo(b)-anthracene (Figure 2b). Clams and mussels exposed to sediments contaminated with high PAH concentrations accumulated pyrene> benzo(e) pyrene> benzo(b) fluoranthene> benz(a) anthracene (Obana et al., 1983) and chrysene> benzo(b) fluoranthene> fluoranthene> benzo(e)pyrene> benz(a)anthracene (Pruell et al., 1986), respectively.

Hanna Reef and Ship Channel oysters showed statistically significant depuration ($p<0.05$) of four- and five-ring PAHs after relocation to the Hanna Reef area (Figures 2c and 2d). Depuration of these aromatic compounds by both groups of oysters was approximately exponential. This is indicated in Figure 3, where the concentration of selected PAHs plotted on a semi-log plot approximate straight lines.

Kinetics parameters describing uptake and release of PAHs can be calculated assuming the first-order equation

$$(1)\quad dC_t/dt = k_u C_w - k_d C_t$$

where C_t is the PAH concentration in the transplanted oyster at time=t, C_w is the PAH concentration in the seawater, and k_u and k_d are the uptake and depuration rate constant, respectively. If the C_w at Hanna Reef is regarded as zero, i.e., $C_w=0$, which is considerably reasonable because of the very low PAH concentrations measured in indigenous oysters, then equation (1) reduces to

$$(2)\quad dC_t/dt = -k_d C_t$$

or, after integration,

$$(3)\quad \log C_t = \log C_o - (k_d/2.301)t$$

where C_o is the PAH concentration in oysters at the time of their relocation to the Hanna Reef area. Using this equation and the PAH concentrations corresponding to both oyster populations during the depuration period, values of k_d can be calculated. Statistical analyses, at the a=0.05 level, of the regression lines of the logarithm of the concentrations versus sampling time for the depuration period showed significant differences between the slopes, i.e., depuration rates, measured for Hanna Reef and Ship Channel oysters.

The biological half-life, $t_{1/2}$, can be derived from equation (3)

(4) $t_{1/2} = 0.693/k_d$

The half-lives are reported in Table I. They ranged from 10.4 and 12.4 days for pyrene to 25.6 and 38.5 days for fluoranthene in Hanna Reef and Ship Channel oysters, respectively. Most of the values were, however, between 10 and 16 days.

Recently, Pruell et al. (1986) reported the half-lives for selected PAHs in mussels (Mytilus edulis) exposed to environmentally contaminated sediments. The calculated half-lives compared well with the values measured in this study (Table I).

PCB concentrations in transplanted oysters increased from 30 ng/g to 850 ng/g after the 48-day exposure period. Pentachlorobiphenyls were the compounds accumulated to the highest concentrations in transplanted and native oysters (Figures 4a and 4b). In comparison, practically no octa-, nona-, or decachlorobiphenyls were detected in either oyster group. Contrasting with PAHs, not all the PCB homologs measured in transplanted oysters reached the concentration encountered in indigenous individuals by the end of the first phase of this experiment. While there were no statistically significant differences in the tri- and tetrachlorobiphenyl concentrations measured in transplanted and native oysters, significant differences were observed in the total concentrations of penta- and hexachlorobiphenyls. It seems evident that a longer exposure period is needed for the higher molecular weight PCBs to reach an steady state concentration (Figure 5).

Hanna Reef and Ship Channel oysters showed statistically significant depuration ($p<0.05$) of low molecular weight PCBs when relocated to the Hanna Reef area (Figures 4c and 4d). Originally uncontaminated oysters depurated PCBs at a faster rate than chronically contaminated oysters. The depuration rates of high molecular weight PCBs were significantly slower in both oyster populations. This differential PCB depuration can be observed in Figures 4b and 4d showing the concentrations of selected PCBs at the end of the uptake and depuration periods. Biological half-lives for these PCBs in Hanna Reef and Ship Channel oysters ranged from 21 to 129 days and from 20 days to >year, respectively (Table 1). Pruell et al. (1986) reported half-lives for tri- to hexachlorobiphenyls in mussels exposed to resuspended contaminated sediments ranging from 16.3 to 45.6 days. Similar to the present study, the biological half-lives of PCBs increased with the number of chlorine atoms in the biphenyl rings. Langston (1978) also reported that the less chlorinated PCB congeners were depurated more rapidly by bivalves (Cerastoderma edule and Macoma balthica) with half-lives from 5 to 21 days for di- to tetrachlorobiphenyls. In contrast, hexachlorobiphenyls, and some of the pentachlorobiphenyls, did not decrease in concentration during the 21-day study. Courtney and Denton (1976) reported that environmentally contaminated clams and clams exposed to Aroclor 1254 in the laboratory did not depurated PCBs during three months in control seawater.

In summary, PAHs and low molecular weight PCBs were rapidly accumulated by transplanted oysters. Apparent steady-state concentrations were reached after 30 to 48 days. In contrast, high molecular weight PCBs did not reached an equilibrium plateau within the seven-week exposure to high PCB concentrations. However, the still-increasing concentrations measured for these PCBs by the end of the exposure period seems to indicate that, given enough time, equilibrium concentrations will eventually be reached. When back-transplanted to the Hanna Reef area, originally uncontaminated and chronically exposed oysters depurated PAHs with half-lives ranging from 10.4 to 23.6 days and from 12.4 to 38.5 days, respectively. These rates were similar to those calculated for tri- and tetrachlorobiphenyls but faster than those estimated for heavier molecular weight PCBs. Despite the limitations discussed in the text, transplanted oysters are considered valuable bioindicators of environmental contamination by PAHs and PCBs in areas lacking indigenous bivalves.

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References

Courtney, W.A.M. and G.R.W. Denton. 1976. Environ. Pollut. 10: 55-64.

Farrington, J. W., J. Albaiges, K.A. Burns, B.P. Dunn, P. Eaton, J.L. Laseter, P.L. Parker, and S. Wise. 1980. In: The International Mussel Watch: Report of a workshop sponsored by the Environmental Studies Board Commission on Natural Resources. National Research Council, pp. 7-77.

_______, E.D. Goldberg, R.W. Riserbrough, J.H. Martin, and V.T. Bowen. 1983. Environ. Sci. Technol. 17: 490-496.

Goldberg, E.D., V.T. Bowen, J.W. Farrington, G. Harvey, J.H. Martin, P.L. Parker, W. Risebrough, E. Schneider, and E. Gamble. 1978. Envir. Conserv. 5: 1-25.

Langston, W.J. 1978. Mar. Biol., 46: 35-40.

MacLeod, W.D., D.W. Brown, A.J. Friedman, D.G. Burrows, O. Maynes, R.W. Pearce, C.A. Wigren, and R.G. Bogar. 1985 In: Standard Analytical Procedure of the NOAA National Analytical Facility, 1985-1986. Extractable Toxic Organic Compounds. (2nd Ed.), U.S. Department of Commerce, NOAA/NMFS. NOAA Tech. Memo. NMFS F/NWC- 92.

Martin, M. 1985. Mar. Poll. Bull. 16: 140-146.

Obana, H., S. Hori, A. Nakamura, and T. Kashimoto. 1983. Water Res., 17: 1183-1187.

Phillips, D.J.H. 1980. "Quantitative Biological Indicators, Their Use to Monitor Trace Metals and Organochlorine Pollution"; Applied Science: London.

Pruell, R.J., J.L. Lake, W.R. Davis, and J.G. Quinn. 1986. Mar. Biol., 91: 497-507.

Risebrough, R.W., B.W. de Lappe, W. Walker II, B.R.T. Simoneit, J. Grimalt, J. Albaiges, J.A. Garcia Regueiro, I. Ballester A. Nolla, and M.G. Marino Fernandez. 1983. Mar. Poll. Bull., 14: 181-187.

Tavares, T.M., V.C. Rocha, C. Porte, D. Barcelo, and J. Albaiges. 1988. Mar. Poll. Bull., 19: 575-578.

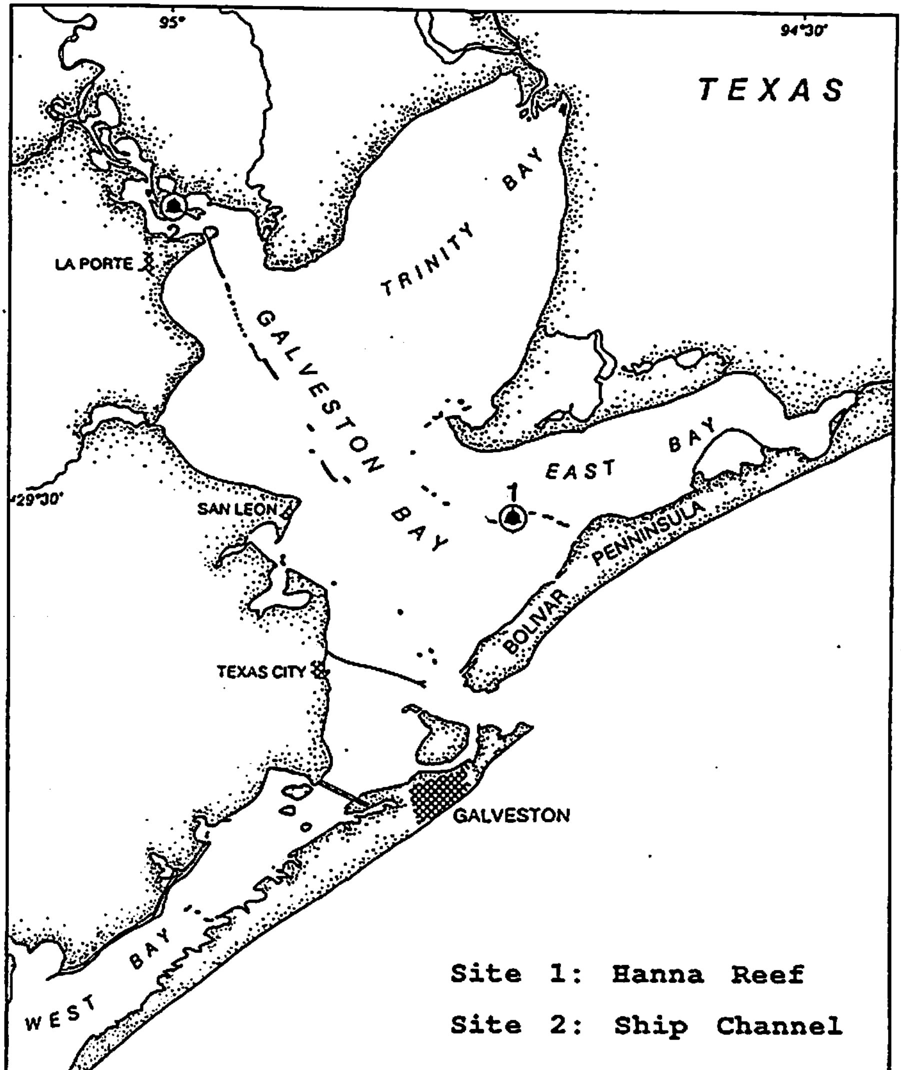
Sericano, J.L., E.L. Atlas, T.L. Wade, J.M. Brooks. 1990. Mar. Environ. Res. 29: 161-203.

Wade, T.L., E.L.Atlas, J.M. Brooks, M.C. Kennicutt II, R.G. Fox, J.L. Sericano, B. Garcia-Romero, D. DeFreitas. 1988. Estuaries, 11: 171-179.

TABLE I. Biological half-lives of selected PAHs and PCBs in transplanted and indigenous oysters

COMPOUND	OYSTERS		MUSSELS[1]
	HANNA REEF	SHIP CHANNEL	
Phenanthrene	-	-	-
Fluoranthene	25.6	38.5	29.8
Pyrene	10.4	12.4	-
Benzo(a)anthracene	13.2	15.3	17.8
Chrysene	12.3	15.8	14.2
Benzo(e)pyrene	11.5	16.1	14.4
PCB#26	21	20	-
PCB#52	28	47	-
PCB#110	45	147	-
PCB#118	75	>year	-
PCB#149	129	>year	-
PCB#22	-	-	16.3
PCB#101	-	-	27.9
PCB#128	-	-	36.5
PCB#153	-	-	45.6

1 Pruell *et al.*, 1986



<u>Figure 1</u>: Galveston Bay transplantation sites.

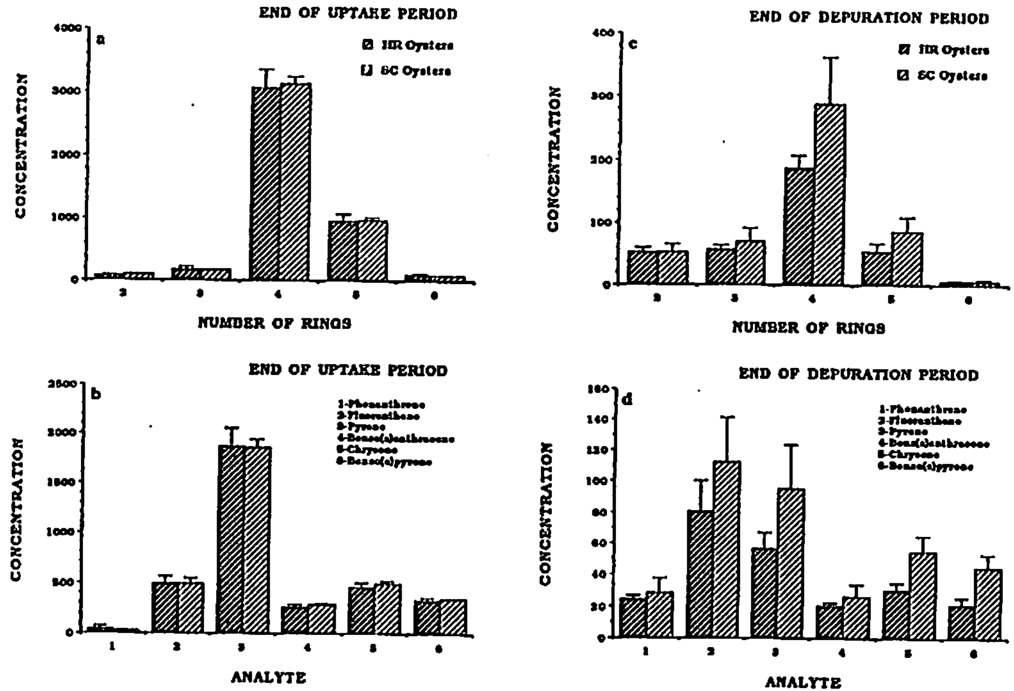


Figure 2: Total and selected individual polynuclear aromatic hydrocarbon concentrations (ng/g, dry weight) in Hanna Reef and Ship Channel oysters after the uptake and depuration periods. The error bars represent one standard deviation from the mean (n=4).

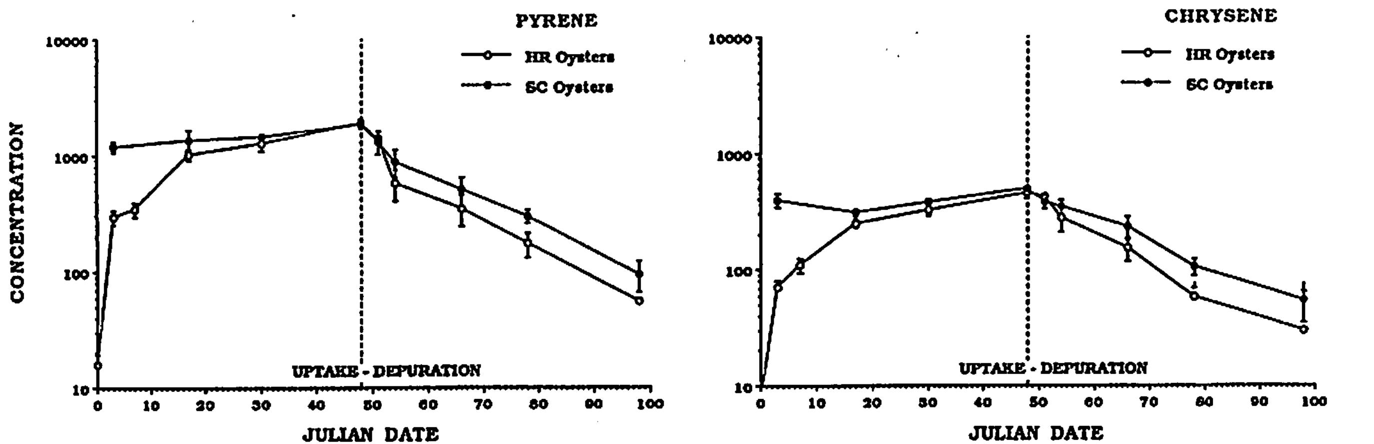


Figure 3: Selected PAH concentrations (ng/g, dry weight) in Hanna Reef and Ship Channel oysters during the uptake and depuration phases of the experiment.

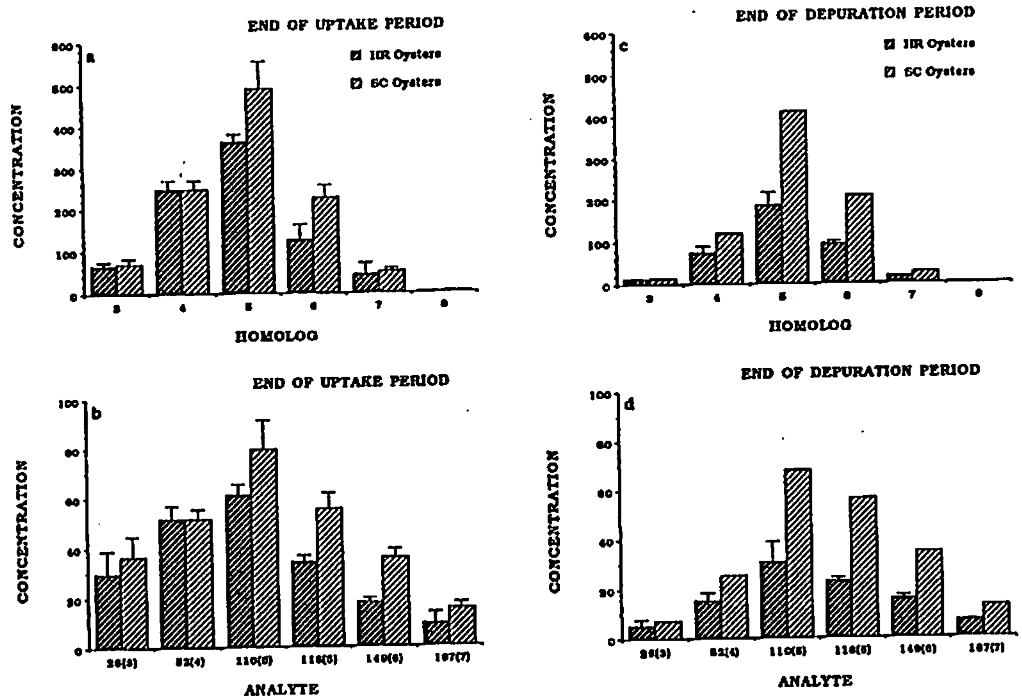


Figure 4: Homolog and selected individual polychlorinated biphenyl concentrations (ng/g, dry weight) in Hanna Reef and Ship Channel oysters after the uptake and depuration periods. The error bars represent one standard deviation from the mean (n=4).

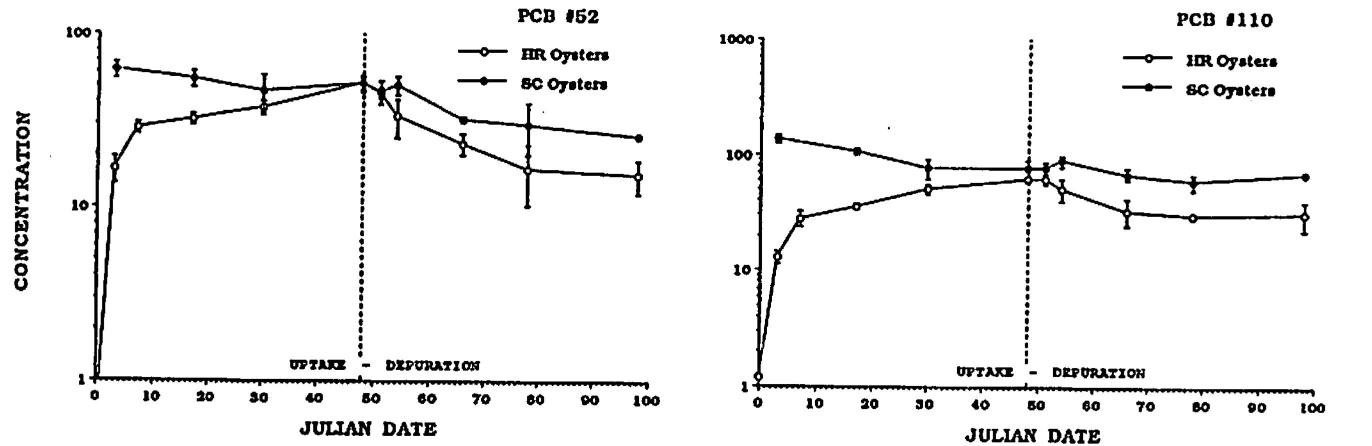


Figure 5: Selected PCB concentrations (ng/g, dry weight)in Hanna Reef and Ship Channel oysters during the uptake and depuration phases of the experiment.

The Environmental Monitoring and Assessment Program (EMAP): Plans for Gulf of Mexico Monitoring in 1991

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Introduction

Environmental regulatory programs in the United States have been estimated to cost more than $70 billion annually. Most of these programs address specific local pollution problems. For the specific purposes for which they were designed, these programs appear to be effective; however, the means to assess the effectiveness of these programs in protecting the environment at national and regional scales and over the long-term do not exist. The U.S. Environmental Protection Agency (EPA) considers it critical to establish monitoring and assessment programs to confirm the effectiveness of pollution control programs and to corroborate, at regional and national scales, the science upon which they are based.

The Environmental Monitoring and Assessment Program (EMAP) is a nationwide program being implemented by EPA's Office of Research and Development (ORD). It was developed in response to the demand for information on the condition of the nation's ecological resources. Although EMAP is funded by ORD, it is designed to be an integrated federal program. During the planning of EMAP, ORD has worked with other federal agencies including the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (USFWS), the U.S. Forest Service, and the U.S. Geological Survey (USGS), as well as other offices within EPA (e.g., the Office of Marine and Estuarine Protection [OMEP]). These other agencies and offices will participate in the collection and use of EMAP data.

The goal of EMAP is to assess and document the status and trends in the condition of the nation's forests, wetlands, estuaries, coastal waters, inland surface waters, Great Lakes, agricultural lands, and arid lands on an integrated and continuing basis. It is designed to answer the following questions on regional and national scales over a time period of decades: What is the status, extent, and geographical distribution of our ecological resources? What proportion of these resources is declining or improving. Where? At what rate? What are the factors likely to be contributing to this declining condition? Are pollution control, reduction, and mitigation programs achieving overall improvement in ecological conditions?

EMAP-NC (EMAP Near-Coastal) uses a regionalization scheme to divide the nation's estuarine resources into a series of biogeographical provinces (Figure 1). In 1990, field activities were implemented in the Virginian Province and, in 1991, will be implemented in the Louisianian Province. By 1995, all provinces in the continental U.S. should be included in the sampling program. This paper describes the plans for implementating EMAP in the Gulf of Mexico (Louisianian Province) in 1991.

EMAP-NC does not have the resources to monitor all parameters of concern. Rather, EMAP-NC will identify, evaluate, and use indicators of environmental quality for each near-coastal ecosystem type that collectively characterize the overall condition of ecosystems and are applicable on regional and national scales.

Sampling Design

The initial sampling design to be used by EMAP-NC combines the strengths of systematic and random sampling designs with an understanding of estuarine systems, to collect data that provide unbiased estimates of the status of the nation's estuarine resources with a known level of confidence. The classification scheme is used to divide estuaries into classes that have similar physical features and are likely to respond to stressors in a similar manner. The sampling classes defined include: (1) 28 large, continuously distributed estuaries covering 23,773 km^2 (e.g., Galveston Bay, Mississippi Sound); (2) a single, large, continuously distributed tidal river covering 307 km^2 (i.e., Mississippi River); and (3) 156 small, discretely distributed estuaries, bays, inlets, tidal creeks, and rivers covering 6,066 km^2 (e.g., Crystal Bay, Perdido Bay, Biloxi Bay, Atchafalaya River). In addition, a fourth estuarine class will be implemented, experimentally, to address its importance in the overall assessment of estuarine condition in the Louisianian Province. This class represents small bayous (i.e., with surface areas < 2.5 km^2) including 418 bayou systems in the delta region of Louisiana covering 878 km^2.

EMAP-NC does not have the resources to characterize natural variability or to assess status in all seasons. Therefore, sampling will be limited to a confined portion of the year (i.e., an index period), when measured parameters are expected to show the greatest response to pollution stress and within season variability is expected to be small. EMAP-NC has selected summer as the appropriate index period. For most near coastal ecosystems in the Northern Hemisphere, mid-summer (July-August) is a period when dissolved oxygen concentrations are most likely to approach stressful low values (Holland et al., 1977; EPA, 1984; Officer et al., 1984), and the cycling and adverse effects of contaminant exposure are greatest because of low dilution flows and high temperatures (Connell and Miller, 1984;

Sprague 1985, Mayer et al., 1989). In addition, fauna and flora are usually abundant during summer, increasing the probability of collecting the organisms required to complete assessments.

Within each estuarine class, elements of systematic, random, and fixed location sampling based on scientific judgement will be used. Large, continuously distributed estuaries will be sampled using a randomly placed, systematic grid. Grid points will be about 18 km apart, and the large estuarine class will include 55 sample sites. The Mississippi River will be sampled within systematically-spaced segments, with their boundaries located about 15 km apart. Two sampling points are located within each segment; one is randomly selected and one is an index sample totaling 20 sample sites. The purpose of the index sample is to use scientific judgement to identify sampling locations that can be used to determine if degraded conditions occur in a system without having to conduct intensive surveys. The index sample site will be located in a depositional, muddy environment where sediments are accumulating and the potential for exposure to low dissolved oxygen concentration and/or contaminants is high.

Small, relatively discrete estuaries will be sampled using a population approach. First, a list of all small estuaries is defined and placed in order according to latitude and/or longitude. Then, the estuaries are placed into continguous groups of four and one estuary from each group is randomly selected without replacement to be sampled in 1991 (N=47 estuaries). Two samples are located in each small estuary that is sampled; one is randomly selected and one is an index sample for a total of 94 samples from the small estuarine class. Regional-scale information from index sites will be combined with similar information from randomly selected locations. To complete the total of 222 sample sites, 24 samples will be collected from small bayous, 13 spatial supplementary samples from Mobile Bay (to evaluate the effect of grid scale on parameter estimation), and 16 judgemental sites selected to represent specific environmental conditions in order to test the reliability of selected indicators.

Index samples will be used to estimate the proportion of small estuaries and tidal river segments that have unacceptable (or acceptable) indicator values. However, the index samples are biased and cannot be used alone to estimate the extent of degradation. When regional-scale information from index sites is combined with similar information from randomly selected locations, robust statements can be made about the proportion of systems that have pollution problems in highly vulnerable sites as well as about the extent and magnitude (i.e., areal extent) of degradation for the population of small estuaries and tidal river segments.

A critical issue that must be addressed by EMAP-NC is how best to represent the ecological condition of near-coastal environments with limited resources and relatively few samples. It is obvious that one or two samples, from one or two locations, at one time of the day, in a specific season of a particular year cannot characterize the ecological condition of even a small estuary. Such a sampling program is justified only if it can be demonstrated that parameters that are indicative of the overall ecological condition of estuaries can be identified and a population approach to sampling can be used to characterize estuarine resources. That is, resources and locations that are sampled can be used to make inferences about unsampled resources and locations. One of the major goals of EMAP-NC 1990-1991 field efforts is to make this demonstration.

Ecological Indicators

EMAP-NC does not have the resources to monitor all ecological parameters of concern to the public, Congress, scientists, and decision makers. Therefore, a defined set of parameters that serve as indicators of environmental quality will be measured. EMAP-NC indicators will be selected that are related to ecological condition in a way that can be quantified and interpreted, can be applied across a range of habitats and biogeographical provinces, are of value and concern to society, and are quantifiable in a standardized manner with a high degree of repeatability.

The selection of indicators that will be used by EMAP-NC is an ongoing process. It is anticipated that a number of years will be required before a relatively complete list of indicators will be developed. Categories of indicators that were identified and will be sampled by EMAP-NC include the following:

Response Indicators

Measurements that quantify the integrated response of ecological resources to individual or multiple stressors. Examples include measures of the condition of individuals (e.g., frequency of tumors or other pathological disorders in fish), populations (e.g., abundance, biomass), and communities (e.g., species composition, diversity).

Exposure Indicators

Physical, chemical, and biological measurements that quantify pollutant exposure, habitat degradation, or other causes of degraded ecological condition. Examples include contaminant concentrations in the water, sediments, and biological tissues; the acute toxicity of sediments to endemic or sensitive biota; and dissolved oxygen concentration.

Habitat Indicators

Physical, chemical, and biological measurements that provide basic information about the natural environmental setting. Examples include water depth, salinity, sediment characteristics, and temperature. Habitat indicators will be used to normalize values for exposure and response indicators across environmental gradients. Habitat indicators may also be used as a basis for defining subpopulations of interest for assessments.

Stressor Indicators

Stressor indicators are economic, social, or engineering measures that can be used to identify the sources of environmental problems and poor ecological condition. Examples include human demographics, land use patterns, discharge records from manufacturing and sewage treatment facilities, freshwater inflows, and pesticide usage in the watershed. Stressor data will be gathered primarily from existing federal and state programs (e.g., NOAA's National Coastal Pollution Discharge Inventory-NCPDI; wetland acreage and extent from FWS's National Wetland Inventory, NOAA, and state wetland inventories and maps), from other EMAP task groups (e.g., the extent and distribution of forests) as well as from local permitting/planning agencies.

The relationships among indicator categories are summarized in Figure 2. Information on exposure, habitat, and stressor indicators will be used to identify potential factors contributing to the status and trends of response indicators. A list of indicators that will be used in the first year of the program is provided in Table 1. In this first year, EMAP-NC will oversample indicators and use the data collected to develop a reduced list of indicators that can be applied in future years to accurately characterize overall estuarine condition. The additional sampling is necessary because indicators of estuarine condition that are acceptable to the public and scientists and that have been demonstrated to be appropriate to apply at regional scales are not well developed.

Near-Coastal EMAP Reporting

EMAP-NC will produce three types of reports to meet the objectives of the program: (1) Annual Statistical Summaries; (2) Interpretive Assessment Reports; and (3) Special Scientific Reports. Annual Statistical Summaries will be prepared approximately 9 months after data are collected and will provide tabular and graphical summaries of each year's collections. They will be analogous to the annual reports prepared by the Department of Commerce for leading economic indicators. Interpretive Assessment Reports will be prepared every 4 years for the public, Congress, interested scientists, and decision-makers (e.g., the EPA Administrator). These reports will assess status of ecological resources on regional scales, measure trends in ecological resources, identify likely causes of poor, deteriorating, or improving conditions, assess the extent and magnitude of pollution impacts, identify emerging problems and their likely causes before they reach crisis proportions, and assess the effectiveness of regulatory/control programs. Special Scientific Reports will be produced periodically to address specific concerns raised about the program (e.g., appropriateness of design) and topical areas of general interest (e.g., results of the indicator testing and evaluation program).

References

Connell, D.W. and G.J. Miller. 1984. Chemistry and Ecotoxicology of Pollution. New York: John Wiley and Sons.

Holland, A.F., N.K. Mountford, and J.A. Mihursky. 1977. Temporal variation in upper bay mesohaline benthic communities: I. the 9-m mud habitat. Ches. Sci. 18:370-378.

Mayer, F.L., Jr., L.L. Marking, L.E. Pedigo, and J.A. Brecken. 1989. Physiochemical factors toxicity: pH, salinity, and temperature, Part I. Literature review. U.S. Environmental Protection Agency, Gulf Breeze, FL.

Officer, C.B., R.B. Biggs, J.L. Taft, L.E. Cronin, M.A. Tyler, and W.R. Boynton. 1984. Chesapeake Bay anoxia: origin, development, and significance. Science 223:22-27.

Sprague, J.B. 1985. Factors that modify toxicity. In: G.M. Rand and S.R. Petrocelli (eds.).Fundamentals of Aquatic Toxicology: Hemisphere Publication Corporation. New York.

United States Environmental Protection Agency. 1984. Chesapeake Bay: A framework for action. Prepared for the U.S. Congress by the Environmental Protection Agency, Region 3, Philadelphia, PA.

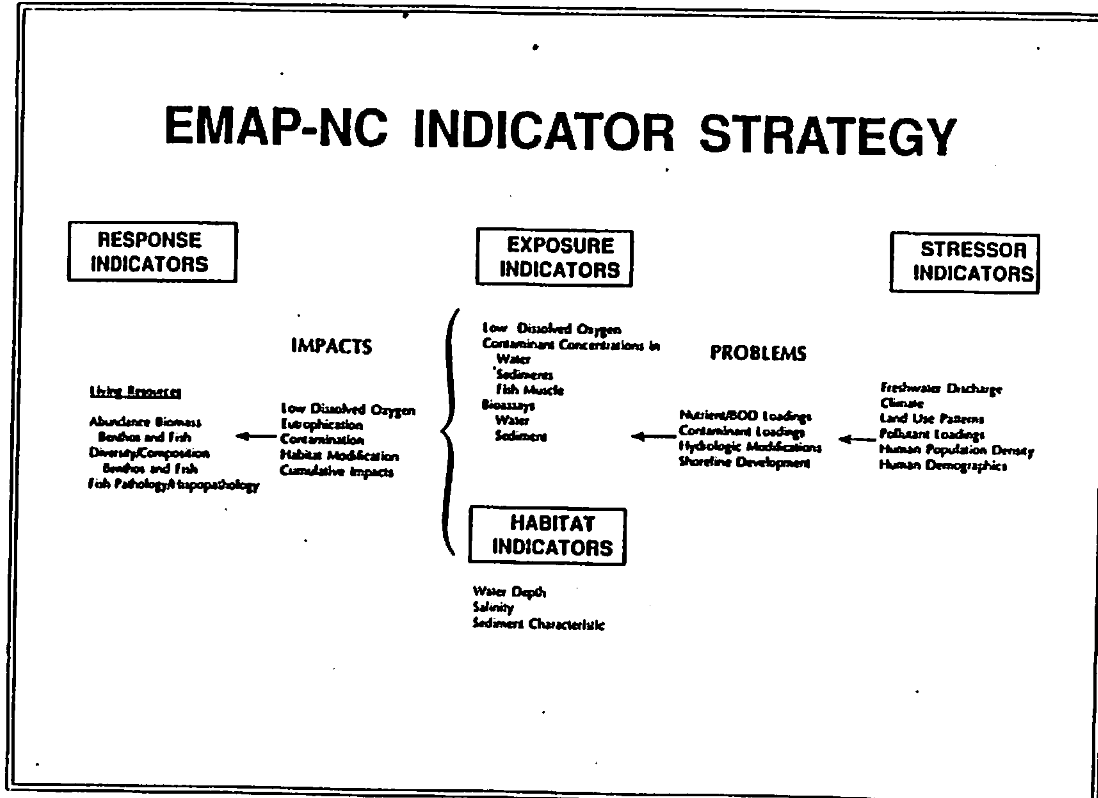

Figure 1. Environmental Monitoring and Assessment Program-Near Coastal biogeographical provinces.

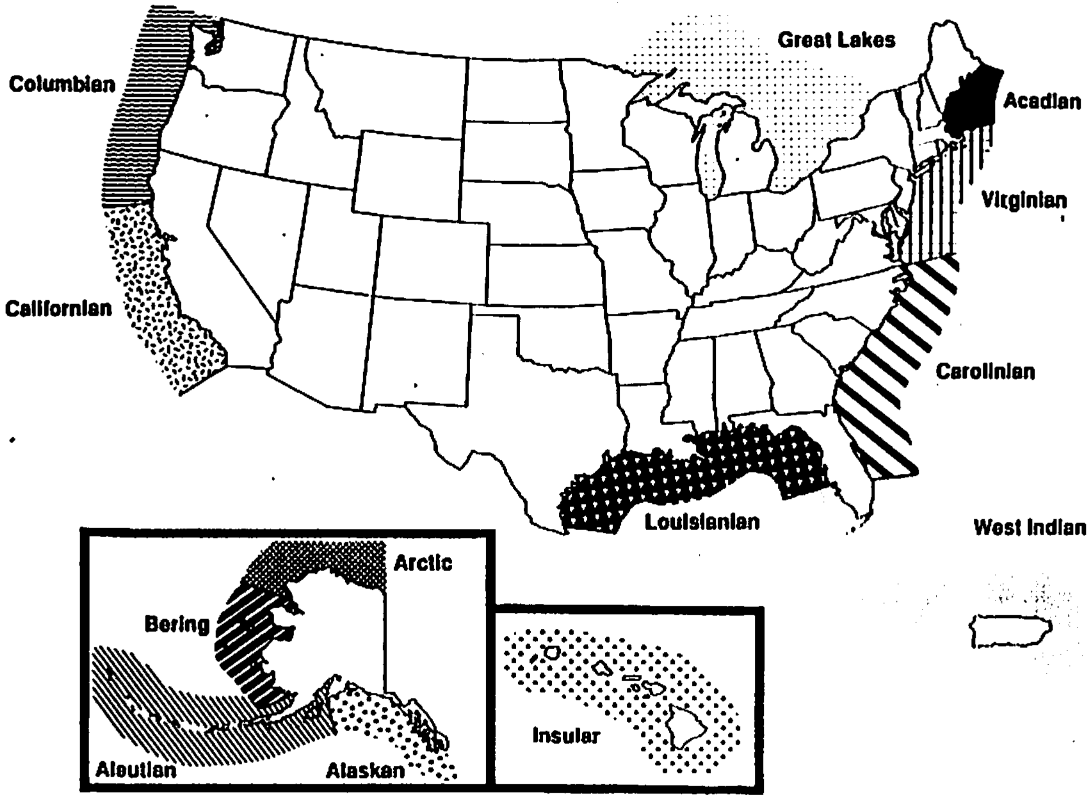

Figure 2. Overview of the indicator stategy for the selection of indicators for the 1991 Louisianian Province Monitoring showing the relationships among indicator types.

Table 1. Indicators to be used in the 1991 Louisianian Province Monitoring Program

Category	Proposed Indicator
Response	Benthic species composition and biomass Gross pathology of finfish/shellfish Fish community composition Relative abundance of large shellfish Histopathology of fish/shellfish Apparent RPD
Exposure	Sediment contaminant concentration Sediment toxicity Contaminants in fish/shellfish tissues Contaminants in colonial nesting birds Contaminants in large bivalves Selected biomarkers (e.g., cytochrome P-450, blood chemistry) Continuous and point measurements of dissolved oxygen concentration
Habitat	Salinity Temperature Sediment Characteristics (e.g., organic content, grain size) Water Depth
Stressor	Freshwater discharge Climatic fluctuations Atmospheric deposition Point-source pollutant loadings Nonpoint-source pollutant loadings Land use patterns Human population density Fisheries landings Shellfish bed classifications

IV. SCIENCE AND LOUISIANA'S CHANGING COASTAL LANDSCAPE

Effects of Sea Level Rise on Coastal Land Loss

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Louisiana Geological Survey

Abstract

Louisiana's billion dollar fur, fish, seafood, and waterfowl industry is in jeopardy from increased coastal land loss and erosion. Physical marsh deterioration, subsidence, and deficiency of vertical accretion are resulting in the breakup of the valuable wetlands and the growth of estuarine bay systems, producing high rates of annual wetland loss. These fragile estuaries and wetlands, along with the protective barrier islands, have been diminishing at alarming rates. Researchers predict that, in some areas, barrier islands will become submerged shoals by the Year 2007, and wetlands will be transformed into open bays and water bodies in 50-60 years. Sea-level rise and subsidence are two of the main driving forces behind coastal land loss in Louisiana. This paper explains the reasons for the severe land loss problems faced in Louisiana and the role relative sea-level rise plays in this losing battle.

Nine tide gauge stations maintained in coastal Louisiana by NOAA's National Ocean Survey, and twenty tidal stations maintained by the Army Corps of Engineers, have been analyzed to determine the relationship of sea-level rise and subsidence in Louisiana compared to neighboring states in the northern Gulf of Mexico. Eustatic sea-level rise in the Gulf of Mexico has been estimated at approximately 0.23 cm/yr. Louisiana's relative sea-level rise rates range from 0.5 cm/yr in the Chenier Plain and Pontchartrain Basin to 1.0 cm/yr in the Terrebonne delta region, where the Holocene deltaic sediments thicken. The term relative sea-level refers to the combined effects of eustatic sea-level and subsidence. Eighty percent of the sea level rise rates in Louisiana are due to subsidence.

The Environmental Protection Agency and the National Research Council are predicting increased rates of sea-level rise to occur due to global warming. Present mean rates of sea-level rise in Louisiana fall within the low to middle of the predicted future range, which is more than five times the current average for the entire Gulf of Mexico (EPA, 1988; NRC, 1989). With these increased rates, coastal erosion and land loss will far exceed current conditions, and other coastal environments could experience Louisiana's crucial land loss problem.

Introduction

Louisiana has the distinction of being the only Gulf coastal state formed by the Mississippi River delta switching. Due to the delta and barrier island formation process, Louisiana also holds the distinction of having the highest rates of sea-level rise, subsidence, land loss, and shoreline erosion in the northern Gulf of Mexico. Louisiana experiences 0.85 cm/yr of relative sea-level rise, more than five times the mean rate found in the Gulf of Mexico and more than ten times the estimated global average rates of sea-level rise (Ramsey and Moslow, 1987). Louisiana lost 73 km^2 in the Mississippi delta region by 1974 (Britsch and Kemp, 1990) and experiences annual shoreline recession rates of 5-10 m/yr (Penland and Boyd, 1981; McBride et al., 1989). Physical marsh deterioration, subsidence, and deficiency of vertical accretion in Terrebonne and Lafourche Parishes are resulting in the breakup of the valuable wetlands and growth of the estuarine bay systems, producing high annual wetland loss rates which could prove disastrous for the billion dollar fur, fish, seafood and waterfowl industries. This paper identifies and explains the reasons for the severe coastal land loss problems faced in Louisiana, and the role relative sea-level rise and subsidence play in this losing battle.

Regional Geology

Depositional environments of the Louisiana delta plain were created from the delta building processes and subsequent abandonment of the Mississippi River. Delta building begins with prodelta platform formation, followed by distributary progradation and bifurcation, which results in delta plain establishment. This process continues until the distributary course is no longer hydraulically efficient, when abandonment of the river's course occurs in favor of a more efficient route. The abandoned delta complex subsides and coastal processes rework the seaward margin, generating a sandy barrier shoreline backed by bays and lagoons (Kwon, 1969; Penland et al., 1981; Penland et al., 1990). According to Frazier (1967), over the last 7,000 years, the Mississippi River has built six major delta complexes consisting of more than 18 smaller deltas. The modern delta (Balize) has been active for the past 1000 years. Since the 1950's, the Atchafalaya River has carried 30% of the Mississippi River sediment load. This increase in sediment flux has created smaller delta formation at the mouth of the Atchafalaya River beginning in the early 1970's. These delta building processes are responsible for Louisiana's fresh and salt marshes, which together comprise the coastal wetlands.

Coastal Land Loss

Rates of coastal land loss or coastal change as described by Penland et al. (1990) have been assessed throughout Louisiana's coastal zone. According to Penland and Boyd (1981), the total barrier island area in Louisiana decreased from 98.6 km^2 in 1880 to 57.8 km^2 in 1980. Britsch and Kemp (1990) indicate coastal land loss rates increased from the 1930's until 1974, after which they began to decline. Coastal land loss has been extensively investigated in Louisiana, (see, eg. Gosselink et al., 1979; Craig et al., 1980; Wicker, 1980; Gagliano et al., 1981; Scaiffe et al., 1983; Davis, 1986; Coleman et al., 1986; Walker et al., 1987; and Coleman and Roberts, 1989). Although there is general agreement on the causes of wetland loss and coastal erosion, it is difficult to determine the exact cause(s) in any specific place in the Louisiana coastal zone.

Natural and Human-induced Land Loss

Land loss can be divided into two categories: that caused by natural forces and that which is human-induced. Natural causes include phenomenon such as sea-level rise, subsidence, downwarping of the geosyncline, storm events, and salt water intrusion. Human causes include the dredging of navigational canals, building of flood control structures, subsurface fluid withdrawal, and produced water from oil and gas activities. In some areas of the Louisiana coast, dredging of navigational canals and produced water may be the dominant culprit; in other areas, the building of structures depriving the marsh of needed sediment influx could be the more prominent cause. How these natural and human-induced causes interact and impact each environment are poorly understood. What is the leading cause of salt water intrusion? Each of these factors must be carefully studied and understood before management strategies can be adequately implemented. The one process which effects the whole coastal zone is sea-level rise and subsidence.

Sea-level Rise

Sea-level rise is the driving force behind the land loss problem. Data from nine tide gauge stations maintained by NOAA's National Ocean Survey and twenty stations maintained by the U.S. Army Corps of Engineers have been examined to determine the relationship of sea-level rise and subsidence in Louisiana (Figure 1). Mean global sea level rise has been estimated to be 0.12 cm/yr (Gornitz et al., 1982). In the Gulf of Mexico, eustatic sea-level has been estimated at 0.23 cm/yr (Gornitz et al., 1982; Ramsey et al., 1989; Penland et al., 1989). The difference between eustatic sea-level rise and the Gulf of Mexico sea-level rise can be attributed to regional tectonism and the filling characteristics of the Gulf of Mexico basin. In Louisiana, the difference between eustatic sea level and relative sea level is subsidence. The rate of relative sea level rise in Louisiana varies. Generally, in coastal areas where the Holocene sediments are < 20 m thick, sea-level rise averages 0.50 cm/yr. Where Holocene sediments are > 20 m thick, average rates of 1.0 cm/yr are common.

The Chenier plain is a series of ridges and mudflats located in the western Louisiana coast (Russell and Howe, 1935; Howe et al., 1935). Vertical sequences consist of basal and upper layers of marsh or bay mud separated by intermediate layers of shoreface sand and mud (Penland and Suter, 1989). Holocene sediments are only 0.15 m thick. Stations at Cameron, Hackberry, and Calcasieu Lake were established in the 1940's.

Relative sea-level rise averages 0.50 cm/yr in this region (Figure 2). Eastward of the Chenier plain, the Holocene sediment package thickens. In the Atchafalaya basin, relative sea-level rise rates are over 1.5 cm/yr. The station located at the Intracoastal Waterway in Calumet has the highest recorded reading (1.77 cm/yr). However, the data indicates that these high rates are skewed by the influence of the flood stages of the Atchafalaya River. Terrebonne Basin lies east of the Atchafalaya. Here the thickness of the Holocene greatly increases, to up to 200 m of marsh mud and interbedded sandy layers. Water level readings at Houma, Greenwood, and Eugene Island indicate a 1.0 cm/yr rate of rise (Figure 2). This is double the rate found in the Chenier plain. Grand Isle, Louisiana, located in the Barataria Basin, and South Pass at Port Eads, in the active Balize delta, continue the trend with average sea-level rise rates of approximately 1.0 cm/yr (Figure 2). There are two tidal stations on the east coast in the St. Bernard delta which are located on the southern shore of Lake Pontchartrain--South Shore and Little Woods (Figure 2). This area still lies on Holocene sediments and experiences a 1.0 cm/yr water level rise. However, on the Pleistocene terraces of the Pontchartrain basin the water level rise rate drops once again to 0.50 cm/yr.

Louisiana experiences a mean rise in relative sea-level of 0.85 cm/yr, derived from 20 tide gauges with a range 0.50 - 1.8 cm/yr. This compares to 0.65 cm/yr at Galveston, Texas and 0.23 cm/yr in Pensacola, Florida. These higher rates have been attributed to subsidence.

Subsidence

The difference between the Gulf of Mexico sea-level rise rate and the relative sea-level rise is illustrative of subsidence. Subsidence in Louisiana can be attributed to compaction of Holocene deposits. Subsidence refers to the downward displacement of the delta plain surface with respect to a vertical datum. The contribution of subsidence to relative sea-level rise can be estimated from the tide gauge water-level time series by subtracting the eustatic change from the sea-level rise rate calculated from the tidal station. Eighty percent of the observed rates in water-level rise in Louisiana are attributable subsidence (Figure 3). In Texas, roughly 30-50% of the water-level rise rate is due to subsidence. East of Louisiana, Mississippi and Florida experience only the effects of eustasy.

Summary

Human and natural causes of coastal land loss in Louisiana have been well-documented. However, the exact role played by each is still unknown. One of the main driving forces behind coastal land loss and erosion problems in Louisiana is sea-level rise. Louisiana experiences the highest rates of sea-level rise and subsidence in the northern Gulf of Mexico. The NRC and EPA predict higher rates of sea-level rise in the near future due to global warming. If these predictions prove true, Louisiana may be faced with even higher rates of subsidence and salt water intrusion, resulting in greater rates of coastal land loss.

References

Britsch, L.D. and E.B. Kemp III. 1990. Land Loss Rates: Mississippi River Deltaic Plain. U.S. Army Corps of Engineers Technical Report GL-90-2, 2 p.

Coleman, J.M. and H.H. Roberts. 1989. Deltaic coastal wetlands. Geologic en Mijnbouw 68:1-24.

____, ______, and R.P. Tye. 1986. Causes of Louisiana Loss. Report: Louisiana Mid-Continent Oil and Gas Association, 28 p.

Craig, N.J., R.E. Turner, and J.W. Day, Jr. 1980. Wetland losses and their consequences in coastal Louisiana. Z. Geommorph. N.F. 34:225-241..

Davis, D.W. 1986. The retreating coast. Journal Soil and Water Conservation 41(3):146-151.

Environmental Protection Agency. 1988. Greenhouse Effect, Sea Level Rise and Coastal Wetlands. Office of Policy, Planning and Evaluation, Washington, DC EPA-230-05-86-013, 152 p.

Frazier, D.E. 1967. Recent deposits of the Mississippi River, their development and chronology. Trans. Gulf Coast Assoc. Geological Societies 17:287-311.

Gagliano, S.M., K.J. Meyer-Arendt, and K.M. Wicker. 1981. Land loss in the Mississippi River deltaic plain. Trans. Gulf Coast Assoc. Geological Societies 31:295-300.

Gornitz, V., S. Lebedeff, and J. Hansen. 1982. Global sea level trend in the past century. Science 215:1611-1614.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An Ecological Characterization Study of the Chenier Plain Coastal Ecosystem of Louisiana and Texas. Volume I: Narrative Report. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-78/9. Washington, D.C. 302 p.

Howe, H.V., R.J. Russell and J.H. McGuirt. 1935. Physiography of coastal southwest Louisiana. Dept. Conserv. Geol. Surv., Geol. Bull. 6.

McBride, R.A., S. Penland, F. Jaffe, S.J. Williams, A.H. Sallenger, and K.A. Westphal. 1989. Erosion and deterioration of the Isles Dernieres barrier island arc, Louisiana U.S.A.: 1853- 1988. Trans. Gulf Coast Assoc. Geological Societies 39:431-444.

National Research Council. 1987. Responding to Changes in Sea Level. Marine Board, Commission on Engineering and Technical Systems, National Academy Press, 148 p.

Penland, S. and R. Boyd. 1981. Shoreline changes on the Louisiana barrier coast. Oceans 81:209-219.

_____, K.E. Ramsey, R.A. McBride, T.F. Moslow, and K.A. Westphal. 1989. Relative Sea Level Rise and Subsidence in Louisiana and the Gulf of Mexico. Coastal Geology Technical Report No. 3, 65 p.

_____, H.H. Roberts, S.J. Williams, A.H. Sallenger, Jr., D.R. Cahoon, D.W. Davis, and C.G. Groat. 1990. Coastal land loss in Louisiana. Trans. Gulf Coast Assoc. Geological Societies 40:685- 699.

_____ and J.R. Suter. 1989. The geomorphology of the Mississippi River chenier plain. Marine Geology 90:231-258.

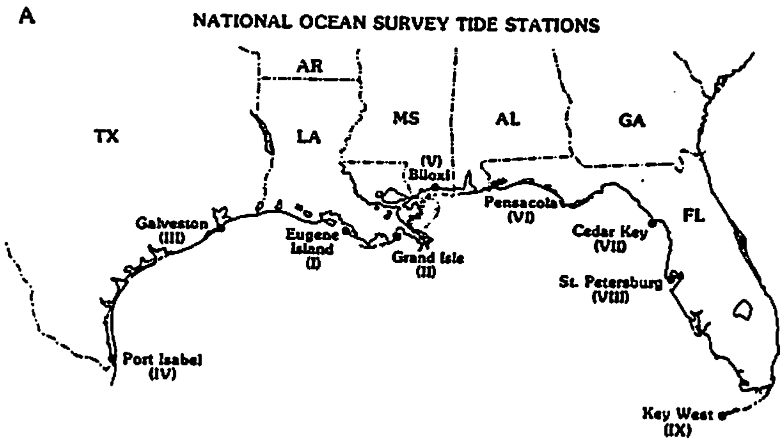
Ramsey, K.E., and T.F. Moslow. 1987. A numerical analysis of subsidence in Louisiana and the Gulf of Mexico. Trans. Gulf Coast Assoc. Geological Societies 39:491-500.

Russell, R.J. and H.V. Howe. 1935. Cheniers of southwestern Louisiana. Geog. Rev. 25:449-461.

Scaiffe, W.B., R.E. Turner, and R. Constanza. 1983. Recent land loss and canal impacts in coastal Louisiana. Environmental Management 7(5):433-442.

Walker, H.J., J.M. Coleman, H.H. Roberts, and R.S. Tye. 1987. Wetlands loss in Louisiana. Geografiska Annaler 69(1):189-200.

Wicker, K.M. 1980. Mississippi deltaic plain region ecological characterization, a habitat mapping study: user's guide to the habitat maps. Washington, D.C.: U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-79-07.



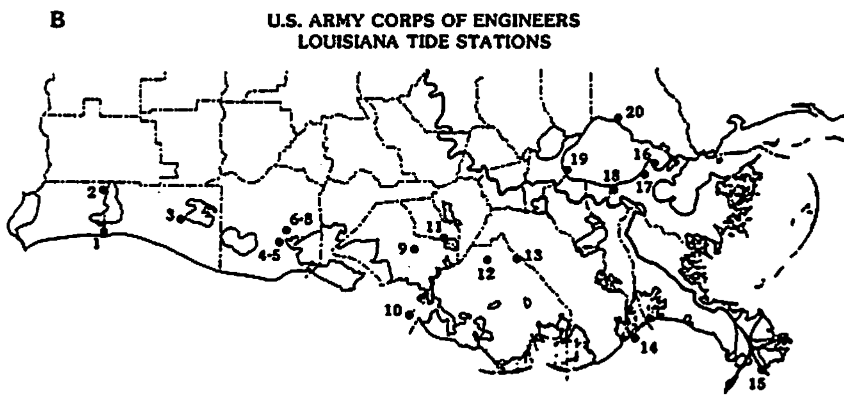


Figure 1. (A) Location of the National Ocean Survey tide gauge stations in the Gulf of Mexico
(B) Location of the U.S Army Corps of Engineers tide gauge stations in Louisiana.

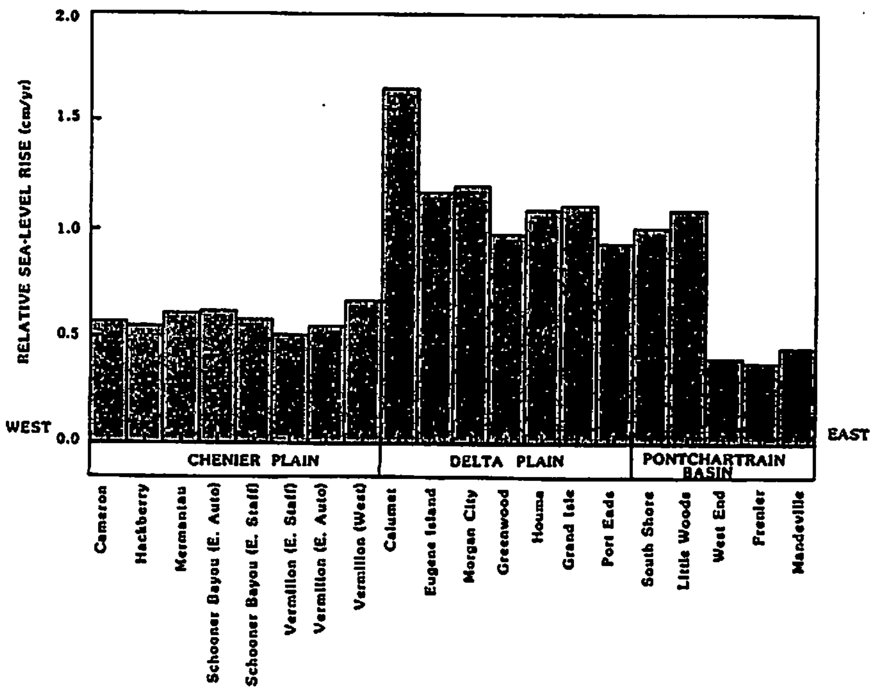


Figure 2. Relative sea-level rise histogram for the U.S. Army Corps of Engineers Louisiana stations.

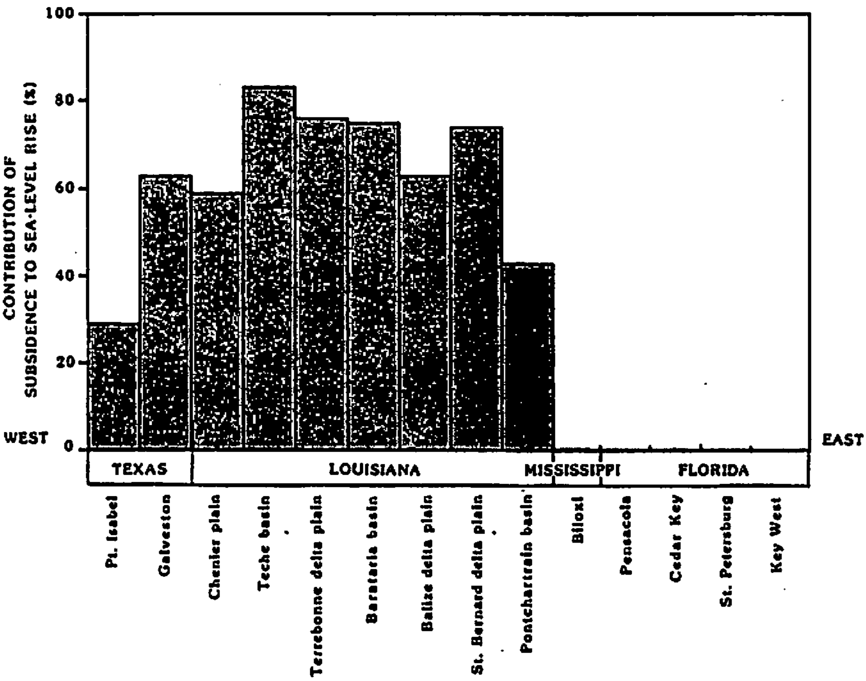


Figure 3. Contribution of subsidence to rates of observed sea-level rise in Louisiana geomorphic regions and surrounding states.

Coastal Erosion and Wetland Loss in Louisiana

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Abstract

The Mississippi River delta and chenier plains in Louisiana are experiencing catastrophic coastal land loss rates exceeding 100 km^2/yr. Louisiana's coastal zone contains 40% of total U.S. wetlands; 80% of the Nation's wetlands loss occurs here. The origin and stability of these coastal environments are tied to sediments discharged by the Mississippi River through the delta cycle process. Sediments accumulate in well-defined delta complexes at approximately 800-1000 year intervals, followed by abandonment and barrier island formation. The delta-cycle process that builds new delta complexes, barrier islands, and cheniers is currently stopped by flood and navigation control structures. These structures harness the flow of the Mississippi River within a massive levee system, channeling most of the sediments off the continental shelf. Deprived of sediments and subsiding rapidly, Louisiana's wetlands are vanishing. Researchers have long recognized the catastrophic coastal land loss occurring and speculated on the causes. The chronic problem of wetland loss is well-documented, but poorly understood. Over the last decade, two schools of thought have developed concerning the relative roles of the causal factors producing the extreme rates of land loss and change. One school of thought emphasizes the natural processes of the delta cycle process; human activities are ranked as secondary in importance. In contrast, the other view attaches primary importance to human activities; natural processes are seen as of secondary consequence. A review of previous coastal land loss research indicates the only way to accurately determine the relative roles of different types and processes of land loss is to develop a classification suitable for quantitatively mapping the spatial distribution and contribution of each geomorphic loss type to the total amount of land loss in a given interval of time.

Introduction

Coastal erosion and wetland loss are serious and widespread problems of national importance with long-term economic and social consequences. Louisiana is experiencing the highest rates of coastal erosion and wetland loss in the United States and possibly the world. Rates of coastal loss have increased from 10 km^2/yr to more than 100 km^2/yr over the last century (Morgan and Larimore, 1957; Craig et al., 1980; Gosselink et al., 1979; Wicker, 1980; Gagliano et al., 1981; Sasser et al., 1986; Adams et al., 1978; Walker et al., 1987; Coleman and Roberts, 1989; Britsch and Kemp, 1990; Penland et al., 1990). Louisiana's barrier islands, whose presence creates and maintains an extensive barrier-built estuarine system, protect the marshes and bays from offshore wave conditions and saltwater intrusion from the Gulf of Mexico. These islands are vanishing, decreasing in area, and eroding at very rapid rates (Peyronnin, 1962; Penland and Boyd, 1981 and 1982; Morgan and Morgan, 1983; McBride et al., 1989). The disappearance of Louisiana's barrier islands will result in the destruction of the large estuarine bay systems and the acceleration of wetland loss. Coastal land loss severely impacts the state's fur, fish, and waterfowl industries, valued at an estimated $1 billion per year, as well as the environmental quality and public safety of south Louisiana's sea level citizens (Gagliano and van Beek, 1970; Turner and Cahoon, 1987; Chabreck, 1988; Davis, 1983 and 1986). The region's renewable resource base depends on the habitat provided by these fragile estuarine ecosystems. Understanding the coastal geomorphological processes, both natural and human-induced, that control barrier island erosion, estuarine deterioration, and wetland loss in Louisiana is essential in evaluating the performance of the various restoration, protection, and management methods currently employed or envisioned.

Coastal erosion and wetland loss are posing a growing challenge to Louisiana and other Gulf Coast states as their population becomes increasingly concentrated in and dependent upon coastal areas. The Environmental Protection Agency (EPA) and National Research Council (NRC) forecast that rates of sea level rise will increase over the next century. This increase will dramatically accelerate coastal land loss (Barth and Titus, 1984; National Research Council, 1987). Because of its geologic setting, the severe coastal land loss conditions found today in Louisiana provides a worse-case scenario for the future coastal conditions forecast by the EPA and NRC. More importantly, Louisiana's coastal problems document the importance of understanding the processes driving coastal land loss. The cooperative coastal research program of the U.S. Geological Survey (USGS) and Louisiana Geological Survey (LGS) strives to improve knowledge and understanding of the processes and patterns of coastal land loss and of the forecast of adverse impacts on people and resources in the coastal zone (Sallenger and Williams, 1989). Many solutions to most coastal land loss problems caused by geologic processes unduly emphasize stopping the result of the process and do not give adequate consideration to the process itself. This approach results in many engineering solutions that rely on costly brute force rather than more sophisticated, less expensive approaches that are in concert with natural processes defined by scientific study (Penland and Suter, 1988; Penland et al., 1989b). Lack of understanding of the processes also leads to oversimplified concepts producing false hope that simple solutions exist. The key objectives of the USGS and LGS cooperative coastal research program are to provide good scientific information on coastal erosion and wetland loss suitable for developing a strategy to conserve and restore coastal Louisiana and to improve communication among scientists, engineers, and decision makers. This paper summarizes the geologic framework in which coastal erosion and wetland loss occurs in Louisiana. In addition, this paper discusses the controversy surrounding the causes of coastal land loss and the relative roles of natural processes and human activities in this phenomenon..

Regional Geology

Delta Plain

The coastline of the northern Gulf of Mexico is dominated by the Mississippi River. Since about 7,000 yr BP, the Mississippi River has built a deltaic platform comprising numerous individual delta lobes and groups of unrelated lobes known as delta complexes (Russell, 1936; Fisk, 1944; Kolb and Van Lopik, 1958; Scruton, 1960; Frazier, 1967; Coleman, 1988). The delta-building process consists of prodelta platform establishment, followed by distributary progradation and bifurcation that results in delta plain consolidation (Figure 1). This process continues until the distributary course is no longer hydraulically efficient. Abandonment then occurs, initiating the transgressive phase of the delta cycle. The abandoned delta subsides and coastal processes rework its seaward margin, generating a sandy barrier shoreline backed by bays and lagoons (Kwon, 1969; Penland et al., 1981). Coastal land loss occurs naturally during this stage. Transgressions occur repeatedly, both for delta complexes and delta lobes.

The contemporary delta plain can be subdivided into two distinct categories, active deltas and abandoned deltas. Delta building occurs in 20% of the delta plain and is restricted to the Modern complex and the newly active Atchafalaya complex. The Plaquemines delta of the Modern complex is abandoned. The four remaining complexes, the Maringouin, Teche, St. Bernard, and Lafourche, are all abandoned and have some type of transgressive shoreline or shoal sand body developing. The Balize lobe of the Modern delta complex is represented by the familiar "bird-foot" delta model. The delta has prograded into deep water near the shelf margin and the greater accommodation space results in the accumulation of hundred of meters of sediment in one deltaic cycle. Mass movement of sediments is extremely important in building the deltaic sequence. The Atchafalaya delta complex emerged as a subaerial feature after the 1973 flood (van Heerden and Roberts, 1988). According to Fisk (1952), the Atchafalaya has been a distributary of the Mississippi River since the mid-1500's and by the 1950's had captured about 30% of the Mississippi's flow. Because the route of the Atchafalaya River to the Gulf of Mexico is some 300 km shorter than the present course of the Mississippi River, Fisk (1952) predicted a relocation of the main distributary to the Atchafalaya course. As a result, a series of large control structures has been built north of Baton Rouge, Louisiana to hold the Mississippi River in its present position. Were it not for these structures, the Balize delta would probably have been abandoned by now and entered the transgressive phase.

As a delta is abandoned, marine processes begin to dominate the system. Coastal land loss occurs and deltaic sand bodies supply coarse sediment to the nearshore current field. An erosional headland with flanking barrier spits develops, and an evolutionary process of barrier island formation begins (Penland et al., 1988). The abandoned Bayou Lafourche delta headland is the most recent example of this landform. Erosion rates on the central headland average as much as 20 m/yr, reaching over 50 m/yr in hurricane years (Ritchie and Penland, 1988). The Timbalier Islands to the west of the Bayou Lafourche headland, and Grand Isle to the east, represent Stage 1 barrier systems (Figure 2). The Plaquemines barrier shoreline associated with the Modern delta complex is also a Stage 1 barrier system (Ritchie et al., 1990). With continued subsidence, marine waters intrude into the marshes behind the barrier islands, resulting in the formation of a saline lagoon separating the barrier from the mainland marshes and forming Stage 2, the barrier island arc. The best examples of this are the Isles Dernieres, derived from the Lafourche delta complex, and the Chandeleur Islands, derived from the St. Bernard delta complex (Penland et al., 1985; Ritchie et al., 1989). Further subsidence removes the coarser-grained distributary mouth bar and channel deposits from the nearshore wave field, resulting in a cessation of sediment supply to the barrier islands. Continued reworking by waves and storms begins to erode the barrier islands. The subaerial island area decreases greatly as sands are lost seaward to an inner shelf sand sheet, landward by overwash, and captured in tidal-inlet sinks. This process is well illustrated by the evolution of the Isles Dernieres. Ultimately, the barrier system loses its subaerial integrity and forms Stage 3, an inner-shelf shoal (Penland et al., 1989a).

Chenier Plain

The chenier plain is a series of alternating ridges and mud flats, first described by Russell and Howe (1935) and Howe et al. (1936). The term "chenier" is derived from the French word "Chene" for oak; oaks grow on the crests of the higher ridges. The chenier plain stretches 200 km from west of Sabine Pass, Texas, to Southwest Point, Louisiana (Penland and Suter, 1989). The width of the deposit ranges from 20 - 30 km, with elevations of the ridges varying from 2 - 6 m (Figure 3). Gould and McFarland (1959) used shallow borings and radiocarbon dates to interpret the sedimentary facies and stratigraphic history of the chenier plain. Transgressive and regressive wedges overlie a soil zone that is also the Pleistocene-Holocene unconformity. The wedge thickens from 3 - 6 m and is progressively younger seaward. Vertical sequences consist of basal and upper layers of marsh or bay mud separated by intermediate layers of shoreface sand and mud. Shoreface deposits either grade upward into chenier sand shell or are overlain by bay and tidal-flat sand and mud. A thin but extensive layer of organic-rich marsh sediments caps the sequence.

Shoreline composition and rate of seaward progradation of the chenier plan were determined by proximity of the Mississippi River outlet. Shallow-water mudflats were rapidly deposited when the main distributaries of the river lay in the southwest portion of the delta plan. When those deltas were abandoned, marine processes reworked the mudflats, concentrating the coarsest material into chenier ridges. Periodic repetition of these processes produced the alternating chenier ridge and mudflat topography. Recent work on mud-flat progradation associated with the development of the Atchafalaya delta (Wells and Roberts, 1981) has shed some new light on the processes of chenier formation (Wells and Kemp, 1981; Wells, 1986; Kemp, 1986). With the Atchafalaya River delta complex at the western margin of the deltaic plain, significant mudflat progradation is occurring in the area west of Freshwater Bayou and in the Cameron-Calcasieu area. Major mudflat progradation appears to be linked to the passage of cold fronts and hurricanes.

Coastal Land Loss

Behind the protective barrier islands are extensive estuaries that are rapidly disintegrating because of pond development, bay expansion, coastal erosion, and human impacts (Morgan, 1967). The chronic problem of wetland loss in Louisiana is well-documented, but poorly understood (Wicker, 1980; Gagliano et al., 1981; Britsch and Kemp, 1990). Previous studies show coastal land loss has persisted and accelerated since the 1900's. Much speculation and debate in the research, government, and environmental communities surrounds the issue of coastal land loss, the processes causing coastal change, and the appropriate strategy for coastal protection and restoration.

Coastal land loss refers to the set of processes that convert land to water. **Coastal change** is a more complex concept, describing the set of processes driving the conversion of one geomorphic habitat type into another geomorphic habitat type. The processes of coastal land loss and coastal change typically involves the conversion of vegetation wetlands to an estuarine water body, followed by barrier island destruction and the conversion of estuarine water bodies to less productive, open Gulf of Mexico conditions. The coastal land loss process can be subdivided into two major types: coastal erosion and wetland loss. Coastal erosion describes the retreat of the shoreline along the exposed coasts of large lakes, bays, and the Gulf of Mexico. In contrast, wetland loss is the development of ponds and lakes within interior wetlands and the expansion of large coastal bays behind the barrier islands and mainland shoreline.

Coastal Erosion

Louisiana is experiencing the highest coastal erosion rates in the United States (Morgan and Larimore, 1957; Adams et al., 1978; Penland and

Boyd, 1981; van Beek and Meyer-Arendt, 1981; Morgan and Morgan, 1983; McBride et al., 1989). In the U.S. Geological Survey's National Atlas of the United States of America (1988), Louisiana appears on the coastal erosion and accretion plate as the nation's erosion hot spot (Figure 4). Coastal erosion rates in Louisiana average - 4.2 m/yr (S.D. = 0.3), with a range of +3.4 m/yr to -15.3 m/yr. The average Gulf of Mexico shoreline change rate is -1.8 m/yr, the highest in the U.S. By comparison, the Atlantic Coast erodes at an average rate of -0.8 m/yr, while the Pacific Coast is relatively stable. In Louisiana, coastal erosion is concentrated in the barrier shoreline that fronts the Mississippi River delta plain. The average coastal erosion rate of -4.2 m/yr represents the long-term conditions exceeding 50 years averaged together by per unit length of shoreline for 600 km of coast. This number is not representative of the individual storm events that drive the long-term average as well as the coastal erosion hot spots. Coastal erosion is not a constant 365-day-a-year process; bursts of erosion are associated with the passage of major cold fronts, tropical storms, and hurricanes (Harper, 1977; Penland and Ritchie, 1979; Boyd and Penland, 1981; Dingler and Reiss, 1988; Ritchie and Penland, 1988; Dingler and Reiss, 1990). Field measurements have documented 20-30 m of coastal erosion during a single 3 to 4-day storm event. These major storms produce energetic overwash conditions that erode the beach and reduce the barrier landscape into lower relief landforms (Penland et al., 1989b). In addition to beach erosion, the total area of Louisiana's barrier shoreline is decreasing rapidly. In 1880, the total barrier island area in Louisiana was 98.6 km^2; by 1980, this had decreased to 57.8 km^2--a 41% decrease in area at a rate of 0.41 km^2/yr (Penland and Boyd, 1982).

The barrier shoreline system with the highest rate of coastal erosion in Louisiana is the Isles Dernieres, located in Terrebonne Parish (Penland and Boyd, 1981; McBride et al., 1989). From 1890 - 1988, the Isles Dernieres shoreline experienced an average of 1644 m of beach erosion at a rate of - 12.2 m/yr (Figure 5). The greatest amount of beach erosion was in the central barrier island arc at Whiskey Island, where a total of 2573 m of beach retreat took place at an average rate of -19.1 m/yr. In 1890, the total area of the Isles Dernieres was 3360 ha. By 1988, the island area had shrunk to 771 ha, a decrease of 2589 ha (77%) in 135 years, at a rate of 26.4 ha/yr. The first island in the Isle Dernieres barrier island arc forecasted to be destroyed by coastal erosion is East Island in 1998 and the last is Trinity Island by 2007. The predicted loss of the Isles Dernieres by the early 21st-Century poses an immediate threat to Louisiana, particularly Terrebonne and Lafourche parishes. The destruction of these islands will dramatically impact the stability and quality of the Terrebonne Bay barrier-built estuary and the associated coastal wetlands.

Wetlands Loss

Louisiana contains at least 40% of the total United States coastal wetlands and is suffering 80% of the nation's coastal wetland loss (Figure 6). Nationwide, excluding Alaska, Hawaii, and the Great Lakes states, coastal marshes occupy an area of 46,971,000 ha; most occur in the Gulf of Mexico and south Atlantic region of the United States. The northern Gulf of Mexico contains 21,510,000 ha of coastal wetlands or 45.8% of the U.S. total (Alexander et al., 1986; Reyer et al., 1988). The Atlantic coast accounts for 24,773,000 ha, or 52.7% of the Nation's total, and while only 1.5% or 688,000 ha are located along the Pacific coast. Louisiana's 11,928,000 ha of coastal wetlands is equivalent to 48% of all the coastal wetlands found in the 14 U.S. Atlantic Coast states. Louisiana contains 55.5% of the coastal wetlands found in the northern Gulf of Mexico (11,928,000 ha of a total of 21,510,000 ha). Within Louisiana, the Mississippi River delta plain contains 995,694 ha of salt marsh, fresh marsh, and swamp, representing 74% of the state's coastal wetlands. To the west, the chenier plain contains 347,593 ha of coastal wetlands, accounting for the remaining 26%. Cameron Parish on the chenier plain encompasses the largest expanse of salt and fresh marsh in a single parish--302,033 ha. On the delta plain, the 233,711 ha within Terrebonne Parish is the region's largest expanse of coastal wetlands, followed by Plaquemines Parish (167,980 ha), Lafourche Parish (118,224 ha), and St. Bernard Parish (104,906 ha). Louisiana's wetland parishes constitute the largest concentration of coastal marshes in the contiguous United States.

The current estimated coastal land loss rate exceeds 12,000 ha/yr for the Mississippi River delta and chenier plains in south Louisiana (Figure 6). Of this loss, 80% occurs in the delta plain and 20% in the chenier plain (Gosselink et al., 1979; Gagliano et al., 1981). Previous studies indicate the rate of coastal land loss has accelerated over the last 75 years. Rates of loss within the delta plain alone have accelerated from 1735 ha/yr in 1913, to 4092 ha/yr in 1946, 7278 ha/yr in 1967, and 10,205 ha/yr in 1980 (Figure 7). Forecasts made in 1978 suggested that Lafourche Parish would be destroyed in 205 years, St. Bernard Parish in 152 years, Terrebonne Parish in 102 years, and Plaquemines Parish in 52 years due to accelerating coastal land loss conditions (Gagliano et al., 1981).

New research results indicate coastal land loss persists at levels below those measured in the 1970's. Britsch and Kemp (1990) conducted a mapping study of coastal land loss using 50 15' USGS topographic quadrangle maps from the Mississippi River delta plain. Coastal land loss rate curves were developed for each quadrangle and the delta plain. The 1932-33 U.S. Coast and Geodetic Survey T-Sheets served as the base for aerial photography interpreted for the years 1956-58, 1974, and 1983. The results showed coastal land loss rates increased after the 1930's from 3339 ha/yr (12.89 mi^2/yr) in 1956-58 to 7257 ha/yr (28.01 mi^2/yr) in 1974. After 1974, the coastal land loss rates decreased to 5949 ha/yr (22.97 mi^2/yr) in 1983 (Figure 8). The numbers compared well with those measured by Gagliano et al. (1981) through 1967;

however, the maximum rate of land loss mapped in 1978 exceeded the maximum rate mapped by Britsch and Kemp (1990) for 1974. The Britsch and Kemp (1990) study again substantiated the catastrophic nature of the coastal land loss problem in Louisiana.

Summary

Louisiana is experiencing catastrophic coastal land loss due to the complex interaction of natural and human-induced causes. Controversy surrounds the issues of coastal land loss and coastal restoration. State and federal supported research on coastal land loss as well as events in Louisiana have documented that the most cost-effective methods of restoring Louisiana's coastal environments are those that work with or enhance natural coastal geomorphological processes. Sediment and vegetation are the only tools that will be effective in restoring Louisiana's coastal zone. The protection and restoration of barrier islands, estuaries, and wetlands must be placed on the same priority as navigation and flood control in order to ensure the future of these important national coastal resources, the delta and chenier plains of the Mississippi River.

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References

Adams, R.D., R.J. Banas, R.H. Bauman, J.H. Blackmon, and W.G. McIntire. 1978. Shoreline erosion in coastal Louisiana; inventory and assessment. Louisiana Department of Natural Resources, Baton Rouge, LA., 103 p.

Alexander, C.E., M.A. Broutman, and D.W. Field. 1986. An inventory of coastal wetlands of the USA. National Oceanic and Atmospheric Administration.

Barth, M.C. and J.G. Titus, 1984. Greenhouse Effect and Sea Level Rise. Van Nostrand Reinhold Company, 325 p.

Baumann, R.H., T.E. Turner, and A.R. Reed. 1987. Direct impacts of OCS activities. In: Turner, R.E. and D.R. Cahoon (eds.), Causes of Wetland Loss in the Coastal Central Gulf of Mexico. Volume II: Technical Narrative. Final report submitted to Mineral Management Service, New Orleans, La. Contract No. 14-12- 0001-30252. OSC Study/MMS 87-120. 400 p.

Boyd, R. and S. Penland. 1981. Washover of deltaic barriers on the Louisiana coast. Trans. Gulf Coast Assoc. Geological Societies, 31:243-248.

Britsch, L.D. and E.B. Kemp III. 1990. Land Loss Rates: Mississippi River Deltaic Plain. U.S. Army Corps of Engineers, Technical Report GL-90-2, 2 p.

Chabreck, R.A. 1988. Coastal Marshes: Ecology and Wildlife Management. University of Minnesota Press, Minneapolis, MN., 138 p.

Coleman, J.M. 1988. Dynamic changes and processes in the Mississippi River delta. GSA Bulletin, 100:999-1015.

_______, and H.H. Roberts. 1989. Deltaic coastal wetlands. Geologic en Mijnbouw, 68:1-24.

_______, H.H. Roberts, and R.P. Tye. 1986. Causes of Louisiana Loss. Rept: Louisiana Mid-Continent Oil and Gas Association, 28 p.

Craig, N.J., R.E. Turner, and J.W. Day, Jr. 1980. Wetlands losses and their consequences in coastal Louisiana. Z. Geommorph. N.F. 34:225-241.

Davis, D.W. 1983. Economic and cultural consequences of land loss in Louisiana. Shore and Beach, 51(4):30-39.

______. 1986. The retreating coast. Jour. Soil and Water Conservation, 41(3):146-151.

______. 1990. Wetlands recreation: Louisiana style. Pages 149-163 In: P. Fabbri (ed). Recreational Uses of Coastal Areas. Kluwer Academic Publishers.

Dingler, J.R. and T.E. Reiss. 1988. Louisiana Barrier Island Study: Isles Dernieres Beach Profiles August 1986 to September 1987. U.S. Geol. Survey Open-File Rep. 88-7; 27 p.

________, and ________. 1990. Cold-front driven storm erosion and overwash in the central part of the Isles Dernieres, a Louisiana barrier arc. Marine Geology, 91:195-206.

Fisk, H.N. 1944. Geological Investigations of the Alluvial Valley of the Lower Mississippi River. Comm. U.S. Army Corps of Engineers, Vicksburg, Mississippi, 69 p.

_______. 1952. Geological Investigation of the Atchafalaya Basin and the Problem of Mississippi River diversion. U.S. Army Corps of Engineers, Waterways Expt. Sta., Vicksburg, MS., 145 p.

Frazier, D.E. 1967. Recent deposits of the Mississippi River, their development and chronology. Trans. Gulf Coast Assoc. Geological Societies, 17:287-311.

Gagliano, S.M., K.J. Meyer-Arendt, and K.M. Wicker. 1981. Land loss in the Mississippi River deltaic plain. Trans. Gulf Coast Assoc. Geological Societies, 31:295-300.

______, and J.L. van Beek, 1970. Geologic and Geomorphic Aspects of Deltaic Processes, Mississippi Delta System. Hydrologic and Geologic Studies of Coastal Louisiana, Report 1. Louisiana State University, Center for Wetland Resources, Baton Rouge, LA., 89 p.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An Ecological Characterization Study of the Chenier Plain Coastal Ecosystem of Louisiana and Texas. Volume I: Narrative Report. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-84-09. Louisiana State University, Baton Rouge, LA., 134 p.

Gould, H.R. and E. McFarlan. 1959. Geological history of the Chenier Plain, southwestern Louisiana. Trans. Gulf Coast Assoc. Geological Societies, 9:261-272.

Harper, J. 1977. Sediment disposal trends of the Caminada-Moreau beach ridge system. Trans. Gulf Coast Assoc. Geological Societies, 27:283-289.

Howe, H.V., R.J. Russell, and J.H. McHuirt. 1935. Physiography of coastal southwest Louisiana. Dep. Conserv. Geol. Surv., Geol. Bull. 6.

Kemp, G.P. 1986. Mud deposition at the shoreface: wave and sediment dynamics on the chenier plain of Louisiana. unpubl. Ph.D. dissertation, Louisiana State University, Baton Rouge, LA.

Kesel, R.H. 1989. The role of the Mississippi River in wetland loss in southeastern Louisiana, U.S.A. Environ. Geol. Water Sci., 13(3): 183-193.

Kolb, C.R. and J.R. Van Lopik. 1958. Geology of the Mississippi River Deltaic Plain, Southeastern Louisiana. U.S. Army Corps of Engineers Waterways Experiment Station, Technical Report No. 3- 483.

Kwon, H.J. 1969. Barrier islands of the northern Gulf of Mexico coast: sediment source and development. Louisiana State University Press, CSI Series, 51 p.

McBride, R.A., S. Penland, B. Jaffe, S.J. Williams, A.H. Sallenger, and K.A. Westphal. 1989. Erosion and deterioration of the Isles Dernieres barrier island arc, Louisiana, U.S.A.: 1853-1988. Trans. Gulf Coast Assoc. Geological Societies, 39:431-444.

Meade, R.H. and R.S. Parker. 1985. Sediments in rivers of the United States, National Water Supply Summary. U.S. Geological Survey Water-Supply Paper #2275.

Morgan, J.P. 1967. Ephemeral estuaries of the deltaic environment. Pages 115-20 In: G.H. Lauff (ed.) Estuaries. American Association for the Advancement of Science monograph. Washington, D.C.: American Association for the Advancement of Science.

______ and P.B. Larimore. 1957. Changes in the Louisiana shoreline. Trans. Gulf Coast Assoc. Geological Societies 7:303- 10.

______ and D.J. Morgan. 1983. Accelerating retreat rates along Louisiana's coast. Louisiana Sea Grant College Program, Louisiana State University, 41 p.

National Research Council. 1987. Responding to Changes in Sea Level. National Academy Press, Washington, D.C., 148 p.

Penland, S. and R. Boyd. 1981. Shoreline changes on the Louisiana barrier coast. Oceans 81:209-19.

____ and____. 1982. Assessment of geological and human factors responsible for Louisiana coastal barrier erosion. Pages 20-59 In: D.F. Boesch (ed.), Proceedings of the Conference on Coastal Erosion and Wetland Wodification in Louisiana: Causes, Consequences and Options. Joint publication FWS/OBS82159. Louisiana Universities Marine Consortium/U.S. Fish and Wildlife Service.

____, ________, D. Nummedal, and H. Roberts. 1981. Deltaic barrier development on the Louisiana Coast. Trans. Gulf Coast Assoc. Geological Societies, 31:471-476.

____, ____ and J.R. Suter. 1988. The transgressive depositional systems of the Mississippi River delta plain: a model for barrier shoreline and shelf sand development. Journal Sedimentary Petrology, 58(6):932-949.

_____, K. Debusschere, K.A. Westphal, J.R. Suter, R.A. McBride, and P.D. Reimer. 1989b. The 1985 hurricane impacts on the Isles Dernieres: a temporal and spatial analysis of the coastal geomorphic changes. Trans. Gulf Coast Assoc. Geological Societies, 39:455-470.

_____ and K.E. Ramsey. 1990. Relative sea-level rise in Louisiana and the Gulf of Mexico. Journal of Coastal Research, 6(2):323-342.

_____ and W. Ritchie. 1979. Short-term morphological changes along the Caminada-Moreau coast, Louisiana. Trans. Gulf Coast Assoc. Geological Societies 29:342-246.

_____ and J.R. Suter. 1988. Barrier island erosion and protection in Louisiana: a coastal geomorphological perspective. Trans. Gulf Coast Assoc. Geological Societies, 38:331-342

_____ and ____. 1989. The geomorphology of the Mississippi River chenier plain. Marine Geology, 90:231-258.

_____, ______ and R. Boyd. 1985. Barrier island areas along abandoned Mississippi River deltas. Marine Geology, 63:197-233.

_____, ______, R.A. McBride, S.J. Williams, J.L. Kindinger, and R. Boyd. 1989a. Holocene sand shoals offshore of the Mississippi River deltaic plain. Trans. Gulf Coast Assoc. Geological Societies, 39:471-480.

Peyronnin, C.A., Jr. 1962. Erosion of Isles Dernieres and Timbalier Islands. Journal Waterways and Harbors Division, American Society of Civil Engineers, 88 (WWI):57-69.

Reyer, A.J., D.W. Field, J.E. Cassells, C.E. Alexander, and L.L. Holland. 1988. The distribution and areal extent of coastal wetlands in estuaries of the Gulf of Mexico. National Oceanic and Atmospheric Administration, 19 p.

Ritchie, W. and S. Penland. 1988. Rapid dune changes associated with overwash processes on the deltaic coast of south Louisiana. Marine Geology, 81:97-122.

______, K.A. Westphal, R.A. McBride, and S. Penland. 1989. Coastal Sand Dunes of Louisiana: the Isles Dernieres. Louisiana Geological Survey, Coastal Geology Technical Report No. 5, 60 p.

______, ______, ______, and ______. 1990. Coastal Sand Dunes of Louisiana: the Plaquemines Shoreline. Louisiana Geological Survey, Coastal Geology Technical Report No. 6, 90 p.

Russell, R.J. 1936. Physiography of the lower Mississippi River delta. Pages 3-199 In: R.J. Russell, H.V. Howe, J.H. McGuert, C.F. Dohm, Wade Hadley, Jr., F.B. Kniffen, and C.A. Brown. Lower Mississippi delta: reports on the geology of Plaquemines and St. Bernard parishes. Geological Bulletin No. 8. New Orleans: Department of Conservation.

______ and H.V. Howe. 1935. Cheniers of southwestern Louisiana. Geogr. Review, 25:449-461.

Sallenger, A.H., Jr. and S.J. Williams. 1989. U.S. Geological Survey Studies of Louisiana Barrier Island Erosion and Wetlands Loss: an Interim Report on Status and Results. U.S. Geological Survey Open File Report, 89-372, 17 p.

Sasser, C.E., M.D. Dozier, J.G. Gosselink, and J.M. Hill. 1986. Spatial and temporal changes in Louisiana's Barataria basin marshes 1945-1980. Environmental Management 10(5):671-680.

Scaife, W.B., R.E. Turner, and R. Costanza. 1983. Recent land loss and canal impacts in coastal Louisiana. Environmental Management, 7(5):433-442.

Scruton, P.C. 1960. Delta building and the deltaic sequence. Pages 82-102 In: F.P. Shepard, F.B. Phleger, and T.H. van Andel (eds.), Recent Sediments, Northwest Gulf of Mexico. American Association of Petroleum Geologists, Tulsa, OK.

Swenson, E.M. and R.E. Turner. 1987. Spoil banks: effects on coastal marsh water level regime. Estuarine Coastal Shelf Science, 24:599-609.

Turner, R.E. and D.R. Cahoon. 1987. Causes of Wetland Loss in the Coastal Central Gulf of Mexico. Volume II: Technical Narrative. Final report submitted to Minerals Management Service. New Orleans, La. Contract No.

14-12-001-30252. OCS Study/MMS 87-0120. 400 p.

U.S. Geological Survey. 1988. Map of coastal erosion and accretion. In: National Atlas of the U.S.A. The Department of the Interior, U.S. Geological Survey, Reston, Va.

van Beek, J.L., and K.J. Meyer-Arendt. 1982. Louisiana's eroding coastline: recommendations for protection. Louisiana Department of Natural Resources, Baton Rouge, LA, 49 p.

van Heerden, I.L., and Roberts, H.H. 1988. Facies development of Atchafalaya Delta, Louisiana: a modern bayhead delta. Am. Assoc. Pet. Geol. Bull., 72:439-453.

Walker, H.J., J.M. Coleman, H.H. Roberts, and R.S. Tye. 1987. Wetland loss in Louisiana. Georg. Ann. 69A(1):189-200.

Wang, F.C. 1987. Saltwater intrusion modeling: the role of man-made features. In: Turner, R.E. and D.R. Cahoon (eds), Causes of Wetland Loss in the Coastal Central Gulf of Mexico, Volume II: Technical Narrative. Final Report submitted to Minerals Management Service, New Orleans, La. Contract No. 14-12-001- 30252. OCS/MMS 87-0120, 400 p.

Wells, J.T. 1986. Louisiana Chenier plain. Pages 425-430 In: Geological Society of America, Centenary Field Guide-Southeastern Section. Geol. Soc. Am., Boulder, CO.

______ and H.H. Roberts. 1981. Fluid mud dynamics and shoreline stabilization: Louisiana Chenier Plain. Pages 1382-1401 In: Proc. 17th International Coastal Engineering Conference.

Wicker, K.M. 1980. Mississippi deltaic plain region ecological characterization, a habitat mapping study: user's guide to the habitat maps. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-79-07, Washington, DC.

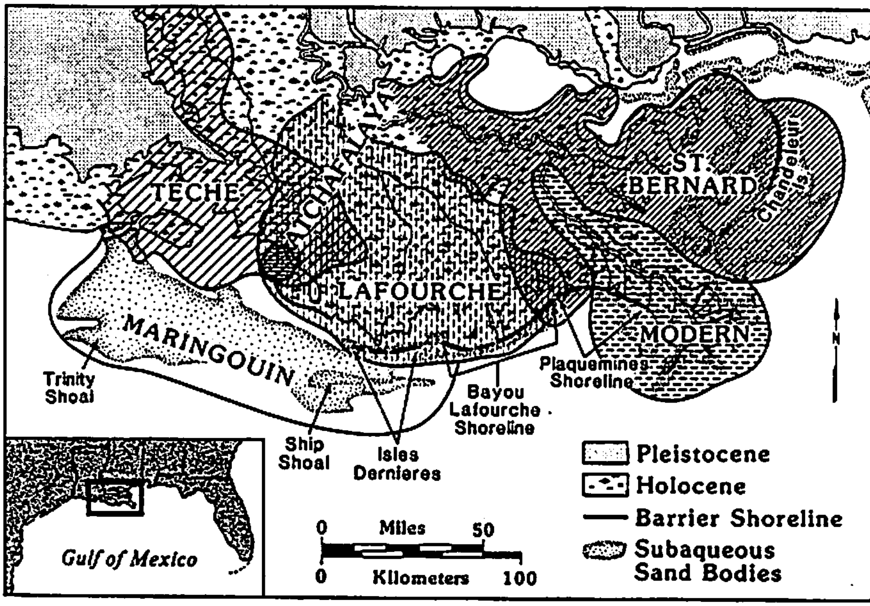

Figure 1. Frazier's (1967) model of the Mississippi River delta plain depicting the location of the transgressive barrier shorelines and shoals.

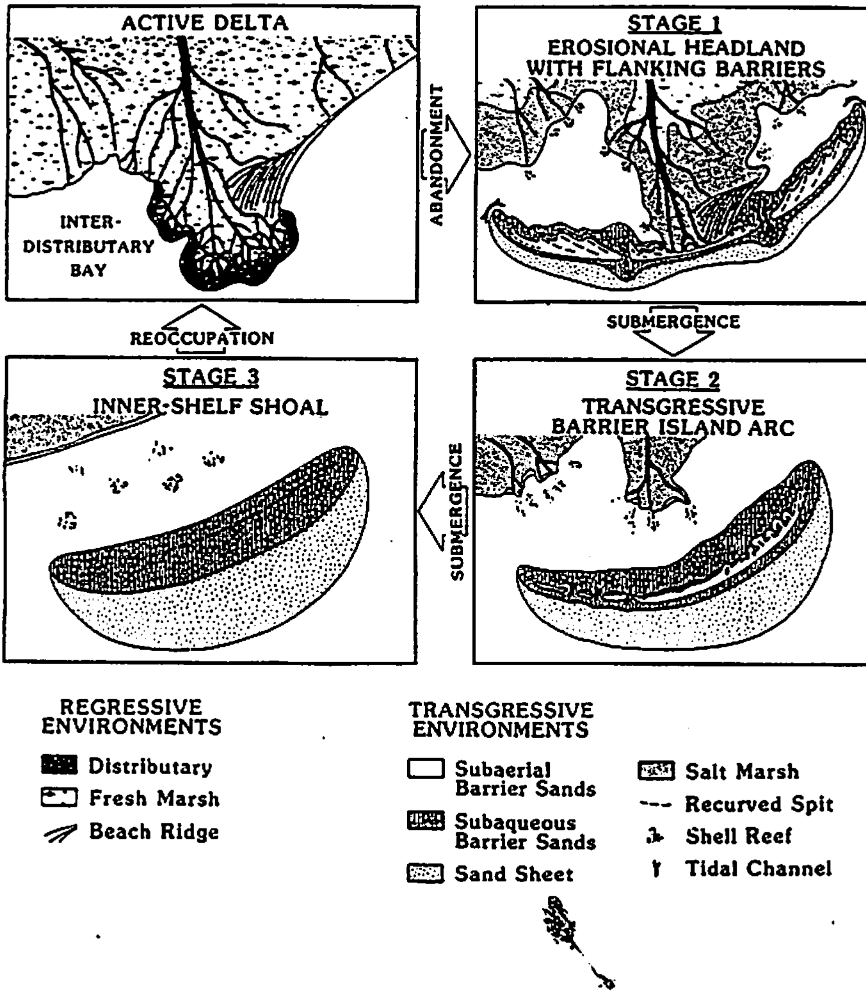

Figure 2. The genesis and evolution of the transgressive depositional systems in the Mississippi River delta plain are best summarized within the framework of a three-stage geomorphic model (Penland et al. 1988).

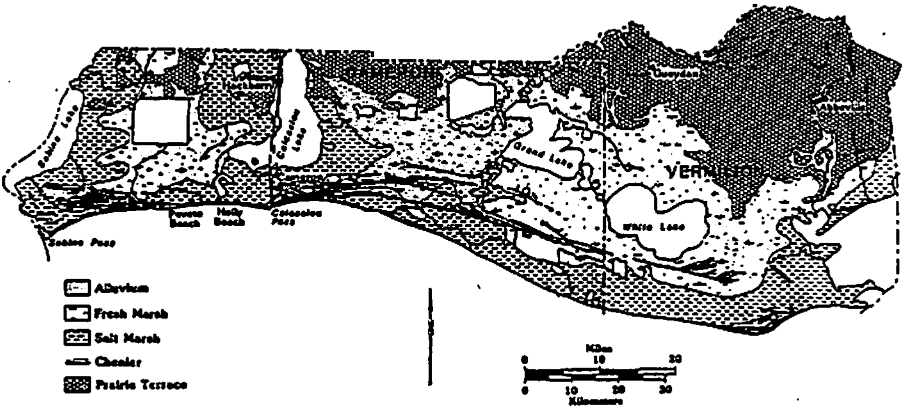

Figure 3. The regional geomorphology of the Mississippi River chenier plain.

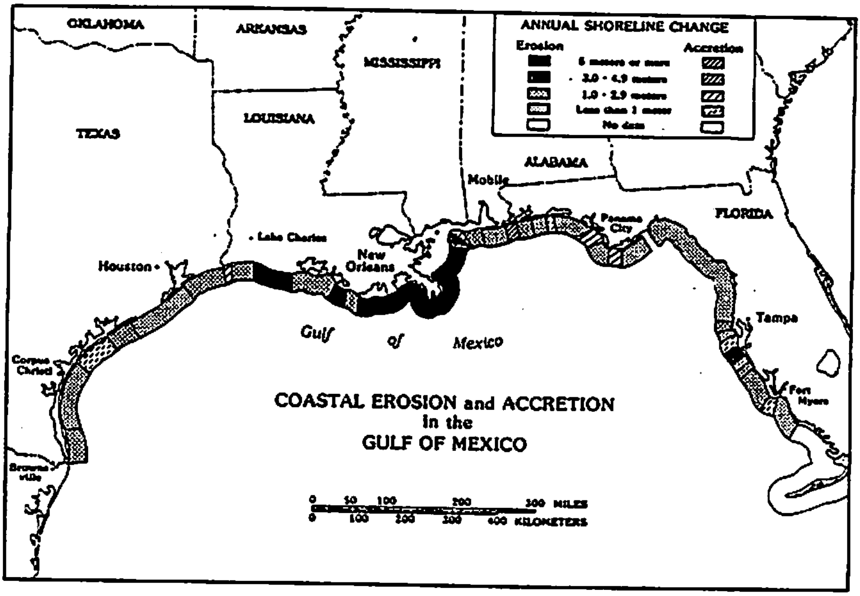

Figure 4. The distribution of coastal erosion in the Gulf of Mexico (U.S. Geological Survey 1988).

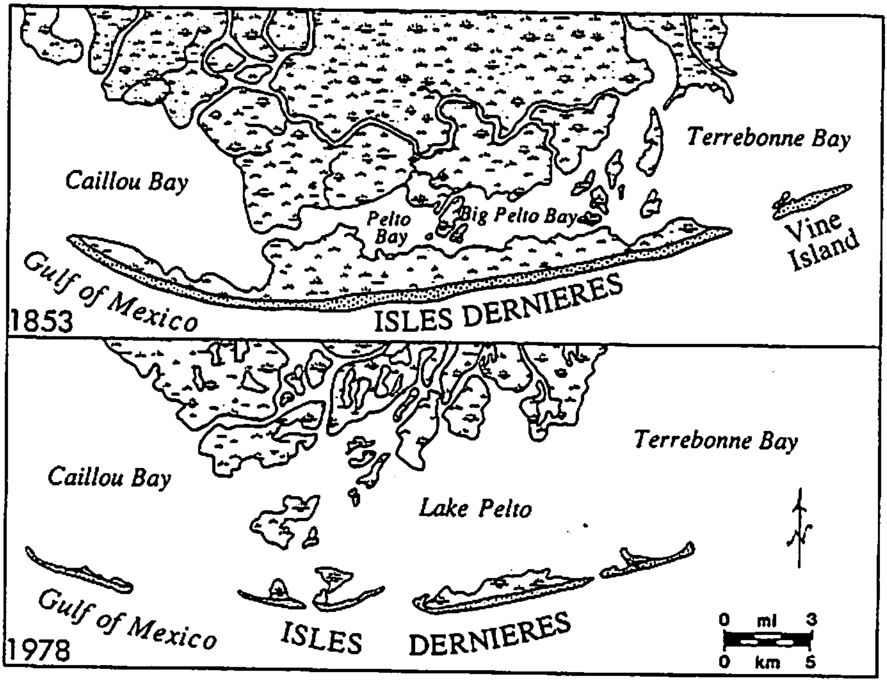

Figure 5. Coastal erosion in the Isles Dernieres between 1853 and 1978 (Penland et al. 1981).

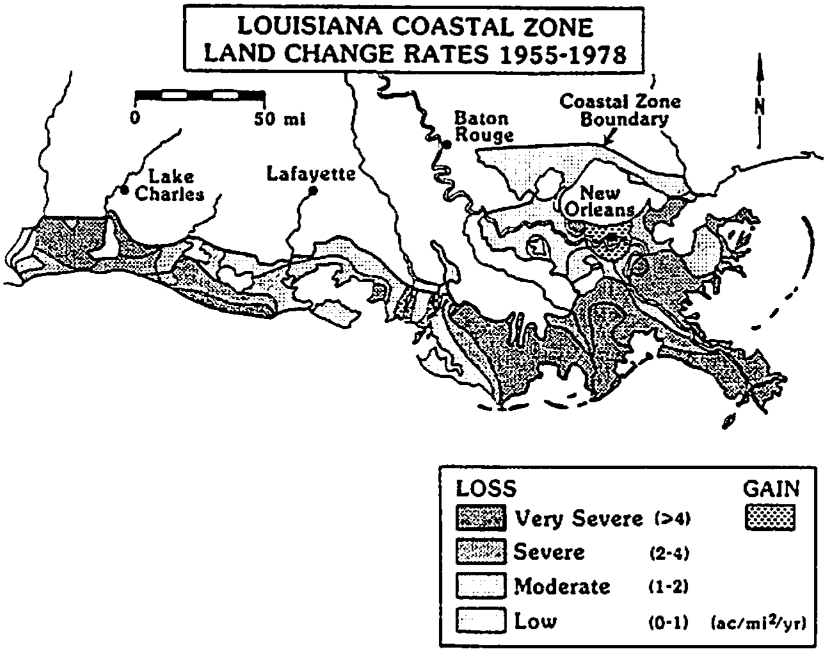

Figure 6. The distribution of coastal land loss in Louisiana (van Beek and Meyer-Arendt, 1982).

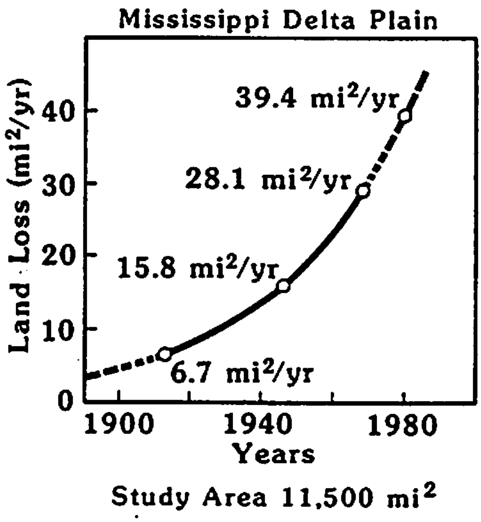

Figure 7. Coastal land loss curve for the Mississippi River plain by Gagliano et al. (1981).

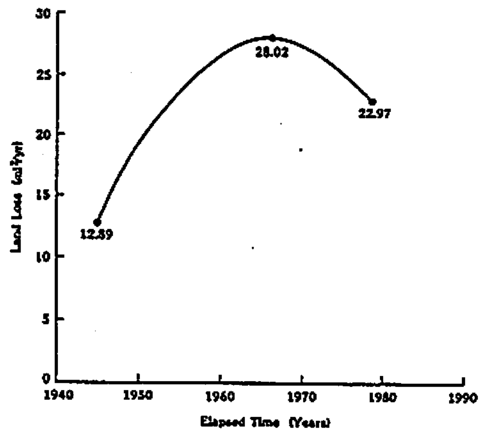

Figure 8. Coastal land loss curve for the Mississippi River delta plain by Britsch and Kemp, (1990).

Coastal Currents Off an Eroding Louisiana Barrier Island

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Louisiana State University

Introduction

The dynamics of coastal currents on the inner shelf during winter storms was studied off the Louisiana barrier islands (Figure 1). Along a long, straight coast in water depths of 0-10 m and under dynamical conditions similar to this study, Murray (1975) has shown the close coupling and minimal phase lag (order of a few hours) between wind driving and current response. The importance of baroclinic pressure gradients set up by large freshwater inputs to the coast in accelerating currents in this near-coastal regime was studied by Murray and Young (1985). The findings of both these studies justified the neglect of long-shore gradients in the dynamical balance on long, straight coasts. However, along a coast in a similar dynamic regime, but with closely spaced inlets, Blanton et al. (1989) found the long-shore sea surface slope to be a key element among the forces controlling the nearshore current field. Understanding the long-shore pressure gradient inside the coastal boundary layer, whether caused by long-shore gradients in bottom topography, wind stress, or coastal curvature, is now a fundamental objective in understanding coastal currents. Some aspects of these problems are reviewed in Pettigrew and Murray (1986) and Csanady (1982).

Two deployments of three current meter moorings were made over the winter of 1987-88; the first from September to November, 1987, and the second from February to May, 1988. Current meters were placed at the 7 m, 10 m, and 13 m isobaths; all were within 7 km of the coast. In addition, a meteorological station and two pressure gauges for monitoring cross-shore sea-level differences were maintained in the study area. The details of the instrument deployments are shown in Figure 2. The only difference between the two deployments was that the lower current meter at the offshore mooring was absent in the first deployment.

The coordinate system used throughout is: x positive onshore, y positive to left looking onshore, and z positive down.

Discussion

Since the objective was to understand the sub-tidal variability of the currents, local wind and current time series data were processed with standard 40-hour low pass (LP) filters. Figures 3a-c presents vector (stick) diagrams of the inshore, midshore, and offshore currents oriented such that <u>shore parallel</u> flow vectors orient vertically on the figure. Long-shore flow upcoast to the northeast points vertically up on the figure. The local wind measurement is similarly presented in Figure 3d, except here the cross-shore wind is oriented vertically up. Note that the currents are strongly polarized by the presence of the coastal boundary, the flow being restricted to a shore-parallel dominant mode. The wind vector is, of course, unconstrained and exhibits the strong clockwise rotation associated with migrating low pressure systems and cold frontal passages typical of this location and season.

Visually, there is a very strong correlation between episodes of strong currents both upcoast and downcoast at all three meter locations. As expected, the outer current meter exhibits more rotary energy than the inshore meter--attributable to distance from the coast and greater depth. The inshore water prism is reacting as a slab to the local wind driving in this shallow water.

Throughout most of the record, there is a strong correlation between the long-shore component of the wind stress and the current response, albeit with a significant time lag. There are several episodes during each deployment, however, when an extremely strong current is clearly unrelated to local wind forcing. Episode "A" in Figure 3 is clearly the most energetic of the deployment, with current speeds reaching 40 cm/sec at the inshore meter for over 40 hours. One likely explanation for these anomalous current events is associated with the Mississippi River outflow plume. The axis of the current stream exiting Southwest Pass is known from satellite observations to dramatically shift its location almost like the discharge of an unrestrained water hose. One mode often observed in satellite images is the Southwest Pass plume deflected westerly into a clockwise circulation eddy that appears trapped in the western lee of the Mississippi Delta. The paths of near-surface drifters entrained in this plume eddy tracked in earlier studies in this area are shown in Figure 4. They illustrate the flow of the Mississippi River discharge stream directly toward the coast near our study area. Particularly note in Figure 4a how the drifter abruptly changes direction close to the 9 m contour as it enters the shore-parallel coastal current, in agreement with our current meter observations. While conclusive evidence is lacking, intermittent impingement of the Mississippi River discharge stream directly onto the coast is certainly capable of producing the extremely strong coastal currents shown as episode A in Figure 3.

The Long-shore Momentum Balance

Time-series of the terms in the long-shore momentum balance were calculated and compared. Using the coordinate system described previously, the long-shore momentum is:

$$\frac{dv}{dt} = -fu - \frac{g}{\rho}\, z\int_{\eta}^{h} \frac{\partial\rho}{\partial y}\, dz - g\frac{\partial\eta}{\partial y} - \frac{1}{\rho}\frac{\partial\tau_y}{\partial z}$$

where u and v are the cross- and long-shore components, respectively, of the current, dv/dt is the total derivative, f is the Coriolis parameter, g is gravity, p is the density of water, n is the sea surface coordinate positive up from the mean level, and τ_y is the shear stress in the y direction.

Since our direct observations indicated that the density gradient term could be neglected and that the current meter data appeared to be representative of the depth-averaged flow, the vertically-averaged form of equation (1) was used to compute the long-shore momentum balance:

$$\frac{d\bar{v}}{dt} = -f\bar{u} - g\frac{\partial\eta}{\partial y} \frac{1}{\rho h}(\tau_{yh} - \tau_{ys})$$

The overbar denotes vertically-averaged quantities, h is the depth of the water column, and τ_{yh} and τ_{ys} are the bottom and surface shear stresses, respectively, in the y direction. The shear stresses were calculated from the usual quadratic expressions involving drag coefficients. Thus, all of the terms in equation (2) are calculated from the data with the exception of the long-shore slope.

Analysis shows (Figure 5) that the local and advective accelerations and the Coriolis term are 1-3 orders of magnitude smaller than the wind stress and bottom friction terms. Additionally, for extensive periods (e.g., see events labelled A and B in Figure 5) these two terms are clearly out of balance. A strong long-shore wind stress, thus, is not producing a correspondingly strong current (and bottom shear stress) to balance it. A likely candidate to complete the force balance is the unmeasured long-shore surface slope n/ y, as the Mississippi Delta, only 50 km to the northeast, provides a cross- shore wall to enhance long-shore set up and set down. To test this idea, the long-shore slope term can formally be calculated as a residual from the momentum balance at each current meter location. Figure 6 strongly supports this interpretation as the suspected slope terms are of the right order of magnitude (10^{-6}), always oppose the wind stress, and are in good agreement between instrument sites.

Modelling

To further investigate the role of the Mississippi Delta as a cross-shore wall in the local coastal current, we have begun a simple 2-D model simulation of the area. Preliminary results assuming a fixed water level around the edges of a 60 x 60 km area with a 7 m/sec long-shore wind are encouraging. Current speeds in the model at the instrument site are reasonable compared to the field data (Figure 7) and a setup of 2-3 cm amplitude (Figure 8) trapped in the corner is formed by the coast and the cross-shore wall. A shift in wind direction or drop in wind speed causes an abrupt collapse of the set up zone, producing current fluctuations not unlike those observed by the current meters.

Summary

Current meter observations on the inner shelf west of the Mississippi River show the coastal current to be dominated by the strong winds associated with frontal passages. Currents are polarized to run parallel to shore with minimal cross-shore components. Episodes of the strongest current speeds (40-50 cm/sec) lasting over two days appear unrelated to wind driving and are thought to be caused by the direct impact of the Mississippi River outflow onto the coast. Momentum balance computations suggest the cross-shore wall formed by the Mississippi Delta plays an important role in the local current dynamics. Preliminary results from a 2-D model of this corner region support these ideas.

References

Blanton, J. O., L. Y. Oey, J. Amft, and T. N. Lee. 1989. Advection of momentum and buoyancy in a coastal frontal zone. J. Phys. Oceanography, 19:98-115.

Csanady, G. T. 1982. Circulation in the Coastal Ocean. D. Reidel Publ. Co., Dordect, 279 p.

Murray, S. P. 1975. Trajectories and speeds of wind driven currents near the coast. J. Phys. Oceanography, 5:347-360.

____ and M. Young. 1985. The nearshore current along a high rainfall, trade-wind coast-Nicarauga. Estuarine Coastal and Shelf Science, 21:687-699.

Pettigrew, N. and S. P. Murray. 1986. The coastal boundary layer and inner shelf. Pages 95-108 In: C.N.K. Mooers (ed.), Baroclinic Processes on Continental Shelves. Amer. Geophysical Union.

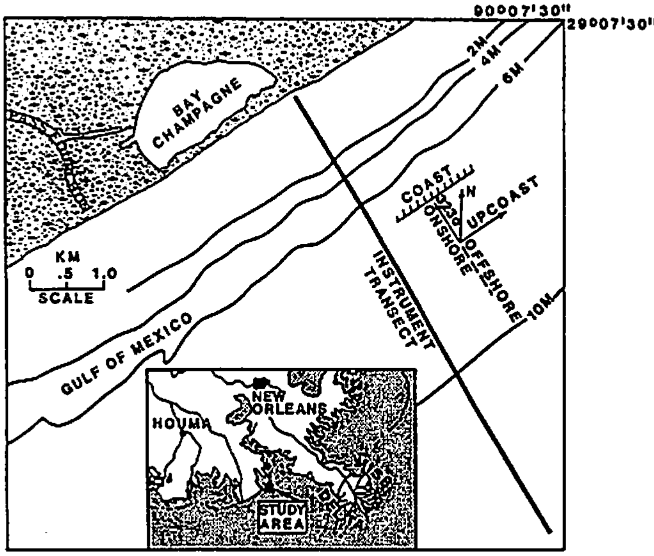

Figure 1

Location of study area.

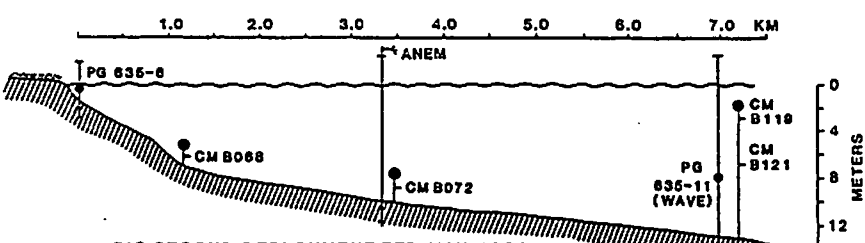

Figure 2

• CM CURRENT METER

• PG PRESSURE GUAGE

• ANEM MET STATION

Details of instrument transect.

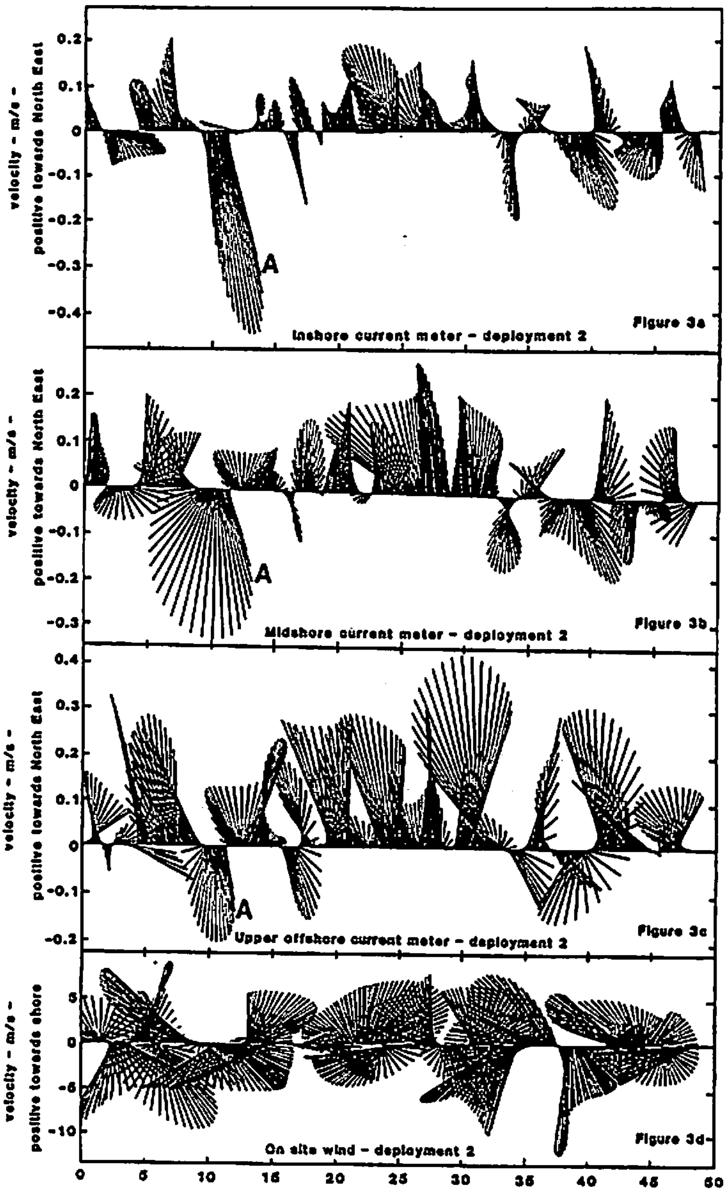

Figure 3. Vector stick diagram of currents and local wind.

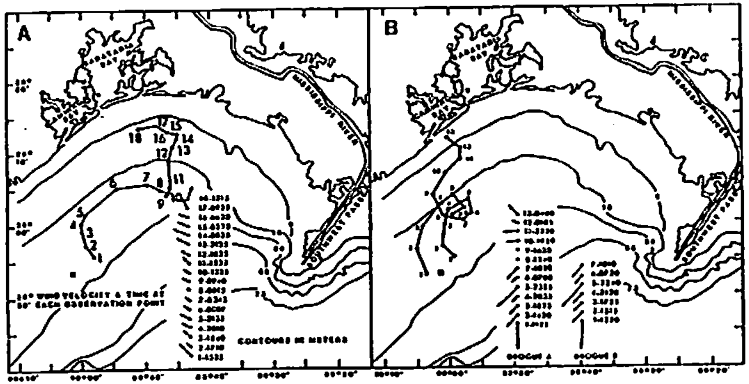

Figure 4. Trajectories of near-surface drifters in west Delta area.

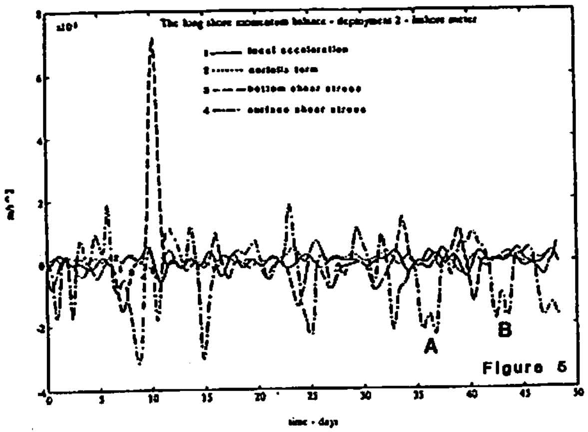

Figure 5. Time series of terms in the long-shore momentum balance.

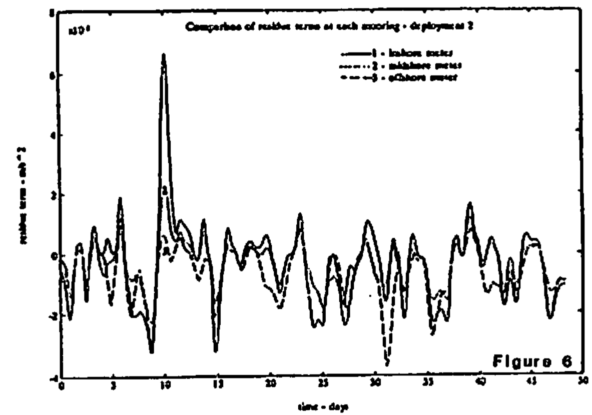

Figure 6. Time series of the residual term in the longshore momentum balance--the longshore surface slope term.

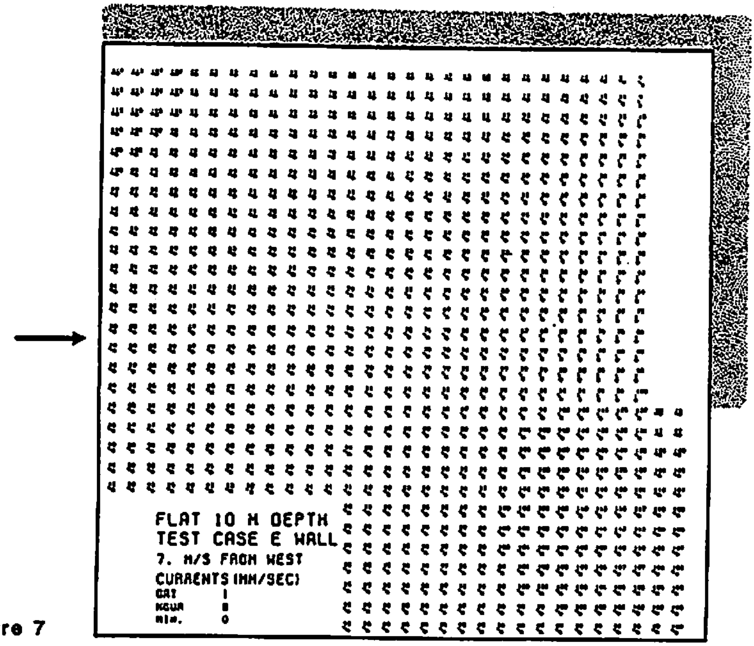

Figure 7

Current velocities from 2-D numerical model in corner region.

SEA SURFACE TOPOGRAPHY AFTER 8 HOURS

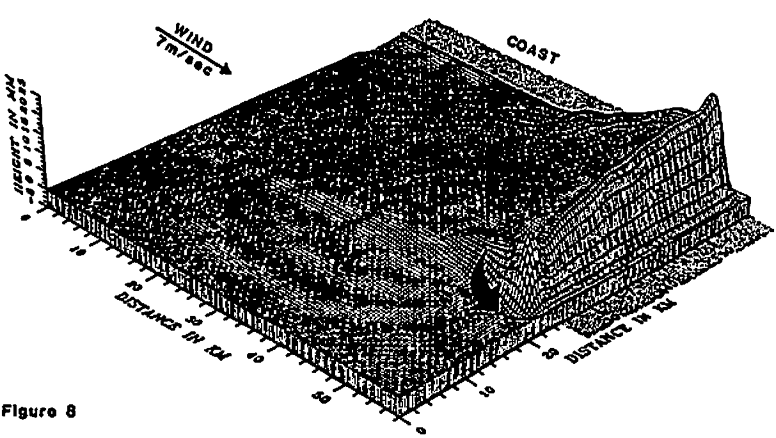

Figure 8

Sea surface topography from 2-D model in corner region.

Man at Risk in Louisiana's Coastal Zone - The Need for a Comprehensive GIS

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Abstract

Data management techniques have begun to focus on spatial information. With the introduction of minicomputer-based interactive graphic systems, these computer-driven "tools" have emerged over the past two decades as powerful aids to data acquisition and administration. Known by such names as geographic information systems (GIS) and automated mapping and facilities management (AM/FM), this technology is now in a state of transition as microprocessors, personal computers, workstations, networks, linkages to mainframes, and other developments have changed the way people look at the environment. Information can now be layered, like the pages in a book, to see interrelationships.

This type of technology is most useful in Louisiana's eroding, subsiding, and deteriorating coastal lowlands. Forty-One percent of the total U.S. tidal marsh average is located in Louisiana. GIS technology can play a key, indeed pivotal, role in assessing and monitoring coastal change in Louisiana, and elsewhere. Spatial, textual, and graphic information can be translated into a machine-readable format and retrieved in a number of ways to help manage the coastal zone efficiently. The technology becomes a coast-wide link in data management. Decisions are regionalized, not compartmentalized by political subdivisions.

Introduction

The world's coasts have served man's needs since prehistoric times. This littoral band has functioned as a settlement site, a source of livelihood, a center for water-oriented recreation, inspiration, employment opportunities, and as a diversified ecosystem that encouraged humankind to utilize the sea's resources to meet industrial and food needs (Walker, 1981). To successfully manipulate coastal property has required considerable engineering expertise. Swamps and marshes needed to be cleared, drained, and reclaimed. Mosquito problems had to be corrected. Disposal of sewage and trash was a difficult issue that was often not solved in a rational manner. Hurricanes and other natural hazards needed to be monitored, predicted, and evacuation plans implemented. In many coastal regions, counteracting subsidence and sea level rise was an issue. Cities, towns, villages, and hamlets had to be designed to successfully survive the dynamics of the coastal environment. These components of contemporary society have adversely effected the wetlands. The problem is their destruction. Since the 1950s, more than 4.4 million ha of U.S. coastal wetlands have been lost due to human activity and natural processes (Frayer et al., 1983).

The coast represents the land/water interface -- the end of one landscape element and the beginning of another. On a micro-scale, all coasts are different. Moreover, most of the world's 450,000 km of coastline has been modified to meet the population's needs. For more than 2000 years, humankind has manipulated the coast. It was, and is, the focal point of considerable human activity. As a geographic/geologic element, the coast is limited in its ability to absorb engineering modifications. It is a delicate environment, its form constantly changing and evolving. Drainage and reclamation measures brought the wetlands under the control of agricultural and urban interests. However, in the process a vital and irreplaceable natural resource was lost. Prior to the National Environmental Policy Act (NEPA), this was the accepted practice, since most wetlands were considered waste lands, best reclaimed for supermarkets, parking lots, residential housing, or other uses. After passage of the NEPA and development of a new body of science associated with wetlands, coasts, and associated ecosystems, it became apparent these regions were far more important in their natural state than paved over with asphalt.

The Abused Coastal Zone Is Under Stress

Coastal change, natural and human made, is a national and international issue. For example, on 8 September 1900, a hurricane struck Galveston, Texas. Property damage exceeded $25 million and more than 6,000 people died. The storm surge was estimated in excess of 4.5 m. At least 3,600 homes were destroyed in an area of approximately 607 hectares. Ten thousand people, of a population of 38,000, were made homeless (Davis et al., 1987). The city did not want a disaster of this magnitude to reoccur, so in 1902 a solid-concrete seawall was begun and engineers decided to raise the city's elevation. The latter provided added protection from storm surge and aided local drainage from the seawall to about half way across the island. Five hundred city blocks were involved in the grade-raising project. Everything was raised, streets, signs, water and gas lines, sidewalks, and flowers in the front yard. Permanent structures were elevated at a cost of $1000 each, with an average depth of fill of 2.3 m. The seawall and elevation project has helped protect the city, but where the seawall ends several new condominiums are at risk (Davis, 1951; Davis et al., 1987). Erosion is of concern along the entire Texas coast. The seawall's success is limited to its length.

At Encinidas, California, the coast eroded more than 300 m between 1883 and 1980. The cliffs are unstable. Two city blocks have disappeared, but people continue to build in this hazard zone (Kuhn and Shepard, 1981). In the San Francisco Bay area, dewatering of the soils that constitute the alluvium-filled Santa Clara Valley has caused considerable subsidence. In the South Bay communities of Alviso and San Jose, 4 m of subsidence was recorded in 1969. Land once above, is now below high tide or mean sea level. On occasion, sand bags have to be used to protect the highways from flooding (Fowler, 1981; Poland, 1981; Poland, 1984; Ireland et al., 1984; Dolan and Goodell, 1986). To reduce flooding, levees ring part of the Bay. Local governments have spent about $9 million on these flood-control embankments. An estimated 44 km^2 of land below sea level is now protected. In addition, a major salt company has spent a substantial sum maintaining levees in conjunction with 78 km^2 of salt ponds to counter 2.4 m of subsidence. An ancillary benefit to communities bordering these levees was a reduction in the landward movement of the Bay's saline water (Poland, 1984).

Shoreline change is not confined to the United States; it is worldwide. In Japan, more than 45% of the country's coast is protected by large cement structures called tetrapods. The shoreface is being armored; the Japanese have installed at least 90,000 of these units, each weighing about 4.4 tons. In some cases, small islands have been surrounded by armor units to protect no more than six families. At a cost of up to $1,000,000/m, the Japanese are apparently willing to spend whatever is required to protect their fragile, eroding coast (Walker, 1981b).

In England, coastal cliffs are eroding rapidly. Flooding in London became so acute that a series of large protection gates were constructed across the Thames River to prevent flood waters from inundating the city. Along the Atlantic coast of France, cliff erosion is so great that many World War II bunkers, built on the cliffs, are now in the surf zone. In Spain, coastal erosional rates are quite variable (Marques, 1986). Venice, Italy, surrounded by water, has learned to endure high water, or **acqua alta**. Since 1872, average **acqua alta** levels have increased at least 40 cm (Pirazzoli, 1983). The level, intensity, and frequency of this phenomenon has accelerated; consequently, temporary, elevated boardwalks are becoming the city's sidewalks (Davis, 1986).

Regardless of the engineering solutions, coastal real estate is threatened. Between 1850 and 1950 at least 270 million m^3 of earth eroded from Chesapeake Bay's Virginia shoreline (Byrne and Anderson, 1977; Kerns et al., 1980) -- enough material to cover the District of Columbia to a depth of 1.2 m. The Bay's shoreline is currently retreating at a rate of 0.6 m to 2.4 m annually. Along the Bay's Maryland shore, more than 10,000 ha eroded away between the mid-1800's and 1947 (Byrne and Anderson, 1977; Kerns et al., 1980; Maurmeyer, 1985). Along parts of the Ocean City, Maryland shoreline there are segments where erosion averages 0.6 m/yr (Leatherman and Dubois, 1983). Called the "Miami Beach of the North," the city is losing its beach. Groins and other bulwarks provide solutions, but they are expensive. One groin cost an average of $300,000 and Ocean City, Maryland has one groin for every 335 m of shoreline (Monte, 1988).

Mankind has manipulated New Jersey's and New York's shorelines so completely that little natural shoreline remains. Protected by shore defenses, the area nevertheless continues to erode (Vaccaro, 1981). Along the 1000 km stretch between New Jersey and North Carolina, the shoreline is eroding at an average of 1.5 m/yr (Dolan et al., 1979; Dolan and Hayden, 1980-81). On the west coast, the annual rate of retreat is about 0.9 m (Orme and Orme, 1988). On the east coast, more than 25% of Florida's beaches are in a critical state of erosion (Davis et al., 1987). Awareness of coastal issues has become international in scope. Solutions require a diverse collection of data. The computer provides an avenue into the required databases. This approach assists in making decisions based on multifaceted information. This technology has certainly aided Louisiana in its appraisal of its coastal problems.

Louisiana's Coastal Zone: Managing and Monitoring Coastal Change

Louisiana is part of the Mississippi River's alluvial empire. Over the last 7000 years, the state's wetlands were created from sediments derived from the 31 states and two Canadian Provinces within the Mississippi's drainage basin. In any given year, the river carries from 0.75 - 1.25 million tons of suspended material. This substantial sediment load has historically been deposited in the coastal lowlands, creating a marsh/swamp complex larger than the states of Connecticut and Delaware combined. Louisiana's near featureless marshes and adjacent water bodies span the entire coast. The low lying marshes vary in width from 25 km to 80 km and a less than 4 m difference exists in height between the marsh and adjacent natural levees, cheniers, and beaches. With 41% of the country's marsh ecosystems, the region is defined by elevation and the absence of trees (Gosselink, 1980). Where the land is at least 45 cm above sea level, a cypress/tupelo swamp will often be evident. The marsh, on the other hand, is a conspicuous lowland - literally a sea of grass (Valiela and Vince, 1976). These environments are valuable, but vanishing, natural resources.

Early investigators determined that Louisiana's marshes are a product of the wandering distributaries and alluvial processes of the Mississippi River. With each channel change, river-borne sediments were diverted into new areas, creating the deltaic and chenier plains (Coleman and Gagliano, 1964). This swath of coastal property provides a habitat for more than two-thirds of the Mississippi Flyway's wintering waterfowl, a large portion of North America's fur and alligator harvest, more than 20% of the country's commercial fisheries, approximately one-third of the country's natural gas and nearly one-fourth of its petroleum (Davis, 1982). The world's greatest pipeline network moves these mineral fluids to processing plants that support a national and international industrial infrastructure. In addition, the size of the wetlands, coupled with the barrier islands, serves as an effective barrier against the full force of a hurricane.

These wetlands are disappearing at a rate of more than 100 km^2/yr (Gosselink et al., 1979; Gagliano et al., 1981; Penland and Boyd, 1981; Turner and Cahoon, 1987; Penland et al., 1990). Their destruction is explained partially by natural processes -- subsidence and sea-level rise (Ramsey and Penland, 1989). Humans have relatively little control over these natural events. The human elements, specifically those levee-building activities that locked the Mississippi River into a controlled conduit, have altered flow regimes, sediment patterns, and vegetative assemblages that created, and continue to contribute to, the land loss predicament.

Prior to 1950, the Mississippi River carried a stable load of about 485 million tons of suspended material each year. After 1950, the quantity of sediments reaching the delta declined nearly 50%. The balance of the sediment load is funnelled through the basin and channeled off the continental shelf, lost to the nearshore sediment budget. Thus, the coast is deprived of the material necessary to build new land at a rate slightly greater than subsidence (Baumann et al., 1984). The problem is directly related to man's interference with the flow regime of the Mississippi River, compounded by the effects of compaction, sea level rise, subsidence, saltwater intrusion, and erosion created by natural and human-induced processes. Land building by river-flood-flow deposition has been replaced by extensive and rapid wetland loss.

Subsidence, coupled with the rising eustatic sea level, creates submergence conditions. Marsh surfaces cannot accrete rapidly enough to keep pace with relative sea level rise. Estimates suggest that the contiguous United States lost more than 220,000 ha of wetland annually between 1955 and 1975; most of this loss is attributable to man's activities. Currently, land loss rates have decreased slightly, largely due to reductions in agricultural reclamation. This trend benefited upland wetlands, but is insignificant in the coastal zone, where land loss issues remain critical. In Louisiana, on average, one hectare of coastal wetlands is lost every 49 minutes, or the equivalent of about 36 ha a day, or 278 m^2 every minute. In its simplest sense, Louisiana's coastal zone is presently out-of-balance. A great natural catastrophe is occurring; land is disappearing rapidly. For Louisiana's coast, marsh losses exceed 12,000 ha annually. Land building has been replaced by a loss of at least 100 km^2/yr (Salinas, 1986).

When coupled with a rise in relative sea level estimated to be 1.04 cm/century, the wetlands are in serious danger (Baumann and DeLaune, 1982; Boesch et al., 1983; Nummedal, 1982; Barth and Titus, 1984; Ramsey and Penland, 1989). By comparison, since 1954 approximately 400,000 ha of coastal marshes, at a rate of 15,000 ha/yr have been lost in the United States. In Louisiana, more than 400,000 ha, 4040 km^2 have been eradicated in the last 90 years. Half of this has occurred since 1950 and has affected the many interlocking subsystems that make up an estuary's productive habitat. This is crucial, as the estuary represents a transition zone between freshwater and marine ecosystems that provides critical habitat for fish, shellfish, and other wildlife (Davis, 1982).

Both natural and human-induced processes are responsible for this land loss within North America's largest and most productive deltaic/estuarine environment. Louisiana's coastal zone is an excellent example of the problems associated with shoreline and wetland loss. The state's alluvial wetlands serve as a contemporary illustration of coastal modifications (subsidence, erosion, and saltwater intrusion) that will, to some degree, be a part of all coastal states within the next 50 years.

Managing Our Coastal Inheritance

In many ways, coastal environments are the United States' most valuable geographic/geologic features. Within this low-lying band of coastal property there has been increased population pressure. Almost one-half of the country's total population live in coastal areas. If current projections are accurate, the coastal population in some states will more than double in the next decade (Culliton et al., 1990). The nation's coastal areas include some of the most rapidly growing and densely populated counties (parishes) in the United States. In the conterminous United States, these political units represent only 11% of the country's land area, and yet are witnessing phenomenal growth - a growth pattern that is going to notably increase population densities. With the fragile nature of coasts on one hand and the dynamic, often violent, behavior of winds and waves on the other, these people are at risk.

Public consciousness about coastal environments has increased substantially since the 1970's. Over the last decade, oil spills such as the Exxon Valdez, medical wastes on east coast beaches, red tides in Florida, shellfish bed closures, overfishing, kelp forest destruction, coastal erosion, and wetland loss have been publicized widely. These are a few of the issues that augmented the public's awareness of the profound and widespread nature of coastal issues. Concomitant with the boost in civic involvement, and the adoption of coastal issues by national and regional environmental organizations, systematic monitoring of a vast assortment of statistically appropriate information has been assembled by numerous governmental organizations.

Environmental protection has become the watch word and standard bearer of a new coastal consciousness. The rush to the shore has been so intense that the nation's estuaries are under stress (Mitchell, 1975). Coastal dwellers have turned many estuarine areas into "giant cesspools" (Morrissey, 1988). With passage of the Coastal Zone Management Act, the coast became an entity of political concern. The Act prompted states to begin a systematic analysis of their coastal resources, as the Act's three major goals are to preserve, develop, and use coastal areas in an orderly manner. Data became critical. Managing that data became a multiagency task, requiring extensive computer manipulations. Using ERDAS, ELAS, MOSS, ARC/INFO, and other hardware/software packages, Louisiana's Coastal Zone Management Division became an early convert to the advantages of geographic information technology in assessing coastal-related issues. Along with the state's mapping efforts, the Louisiana Geological Survey was amassing considerable data. In July, 1984, the Coastal Geology Section began to use helicopters to monitor coastal change. These aerial video surveys represent a visual record/archive of the coast. Every year, and after every hurricane or major storm period, the Survey has flown the coast. Eleven flights have been made, compiling an important data set. These data and the analysis of shoreline change became the focal point for developing geographic information system capabilities.

The Usefulness of Geographic Information Systems (GIS)

In response to Louisiana's coastal-land-loss crisis, the United States Geological Survey (USGS) developed a cooperative research initiative with the Louisiana Geological Survey (LGS) to investigate the critical processes of barrier islands and wetland loss. This state/federal effort focused on understanding the coastal land-loss problem from human, geomorphic, stratigraphic, and process points of view. Along with this program, several state and federal agencies were studying and mapping additional elements. The product of these intensive research endeavors is one of the country's largest multidisciplinary and multifaceted wetland's databases. Considerable information has been generated and archived in numerous forms. Digital maps, high-resolution seismic profiles, vibracores, aerial videotapes, standardized bibliography, sequential satellite images, tabular records, high and low altitude photography, and field surveys make up the information repository. Most of these data are stored manually on incompatible geo-processing systems. Unfortunately, much of the digital information is unknown to other agencies, inaccessible due to format, or simply not in a compatible form. Moreover, considerable material has been processed into digital formats on different projections, at a variety of scales, and on a diverse array of hardware and software. To help organize this material into a user-friendly format, the USGS has committed funds to help establish, over the next five years, the Louisiana Coastal Geographic Information System Network (LCGISN).

The purpose of LCGISN is to take the wide range of available coastal information and consolidate it into an easily retrievable form, despite format, platform, software, and method of storage. The intent is to put information into the hands of people to whom it has traditionally been unavailable. This is a distinctively different approach, as LCGISN is concerned with disseminating geographic information, regardless of the type of media involved. The distributive network is not limited to a single medium, but designed to link media into a coherent network.

Over the past decade, demand for spatial analysis of geographic, resource, and environmental data has increased dramatically. With the continuous enlargement of the user community, and the profusion of data developed, collected, and manually stored by environmental agencies, along with contrasting data formats among GIS platforms, some coordination, networking, and data transformation standards are required to easily access the mounting volume of data. Data collected in 157 counties and parishes within six states (Texas, Louisiana, Mississippi, Alabama, Florida, and a small section of Georgia that drain into the Gulf of Mexico) is substantial. Each of these political units could benefit from easy access to data management in a GIS (Reyer et al., 1988). Networking the GIS platforms offers a forward-looking and progressive means to fill this need, along with a way to substantially improve the application of our acquired knowledge to environmental problems across political boundaries.

The purpose of a GIS is to prepare, present, and interpret facts pertaining to the earth's surface, using computer hardware and software specifically designed for the acquisition, maintenance, and use of map data. Geographic data is reorganized and manipulated in a computer into a single-factor overlay. Once in the system, overlays can be custom tailored to meet a user's needs.

Over the past decade, demand for superimposing layers of geographic resource and environmental data has grown. Spatial analysis demands of these data have led to creation and development of geographic information systems. Expansion within the GIS field now includes a number of traditionally unrelated disciplines. From these new working relationships, research conducted within the public and private community has created extensive data sets.

As software and hardware markets become more competitive, spatial analysis and geographic information storage and retrieval technology will improve. New, smaller, and faster hardware is appearing on the market monthly and "beta tested" software is proliferating. Several competing GIS hardware/software packages exist; all have different data structures, file formats, and capabilities. Providing easy access to geographic information is, therefore, a problem. The technology has developed faster than our capability to link, in a cost effective manner, the various GIS units into a practical interconnected computer-drive structure. Underlying the need for better geographical information management is the expanding volume of information in a machine-readable format. Even a small quantity of digital data, without a suitable clearinghouse, is difficult to manipulate. Satellites and other airborne platforms are generating immense volumes of digital information, thousands of new flight lines of aerial photographs; gigabytes of environmental data are accumulated rapidly. The need to encourage the rapid retrieval of this information, by diverse users, led to development of LCGISN - a hardware/software interface that can assist the coastal community to integrate the vast array of expanding databases into a fine-tuned network.

References

Barth, M.C. and J.C. Titus. 1984. Greenhouse Effect and Sea Level Rise: A Challenge for This Generation. Van Nostrand-Reinhold Company. New York, NY. 325 p.

Baumann, R.H. and R.D. DeLaune. 1982. Sedimentation and apparent sea-level rise as factors affecting land loss in coastal Louisiana. Pages 2-13 In: D.F. Boesch (ed.), Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options. FWS/OBS-82/79. United States Fish and Wildlife Service, Biological Services Program. Washington, D.C.

_________, R.W. Day, Jr., and C.A. Miller. 1984. Mississippi deltaic wetland survival: sedimentation versus coastal submergence. Science 224:1093-1095.

Boesch, D.F., D. Levin, D. Nummedal, and K. Bowles. 1983. Subsidence in coastal Louisiana, causes, rates and effects on wetlands. FWS/OBS-83/26. United States Fish and Wildlife Services, Division of Biological Services. Washington, D.C. 30 p.

Byrne, R.J. and G.L. Anderson. 1977. Shoreline Erosion in Tidewater Virginia. Special Report in Applied Marine Science and Ocean Engineering, Number 111. Virginia Institute of Marine Science. Gloucester Point, VA. 102 p.

Coleman, J.M. and S.M. Gagliano. 1964. Cyclic sedimentation in the Mississippi river deltaic plain. Transactions, Gulf Coast Association of Geological Societies 14:67-80.

Culliton, T.J., M.A. Warren, T.R. Goodspeed, D.G. Remer, C.M. Blackwell, and J.J. McDonough. 1990. 50 years of population change along the nation's coasts, 1960-2010. National Oceanic and Atmospheric Administration, United States Department of Commerce. Rockville, MD., 41 p.

Davis, A.B. 1951. Galveston's bulwark against the sea. In Proceedings of the Second Annual Conference on Coastal Engineering. Texas A & M University.College Station, TX.

Davis, D.W. 1982. Economic and cultural consequences of land loss in Louisiana. Pages 140-158 In: D.F. Boesch (ed.), Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options. FWS/OBS-82/79. United States: Fish and Wildlife Service, Biological Services Program.

______ 1986. Venice and New Orleans: two sinking cities. Thalassas

4(1):49-56.

_____, J.M. McCloy, and A.K. Craig. 1987. Man's response to coastal change in the northern Gulf of Mexico. Resource Management and Optimization 5(1-4):257-297.

Dolan, R., R. Hayden, C. Rea, and J. Heywood. 1979. Shoreline erosion rates along the middle Atlantic coast of the United States. Ecology 7:603-606.

_____ and B. Hayden. 1980-1981. Templates of changes: storms and shoreline hazards. Oceanus 23(4):32-37.

_____ and H.G. Goodell. 1986. Sinking cities. American Scientist 74(1):38-47.

Fowler, L.C. 1981. Economic consequences of land surface subsidence. Journal of the Irrigation and Drainage Division, The American Society of Civil Engineers 107(1R2):151- 159.

Frayer, W.E., T.J. Monahan, D.C. Bowden, and F.A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950s to 1970s. State University, Department of Forests and Wood Sciences. Ft. Collins, Colorado. 31 p.

Gagliano, S.M., K.J. Meyer-Arendt, and K.M. Wicker. 1981. Landloss in the Mississippi River deltaic plain. Transactions, Gulf Coast Association of Geological Societies 31:295-300.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An ecological characterization study of the chenier plain coastal ecosystem of Louisiana and Texas. Vol. I: Narrative Report. FWS/OBS-78/9. United States Fish and Wildlife Service, Office of Biological Services. Washington, D.C. 302 p.

_____. 1980. Tidal marshes, the boundary between land and ocean. FWS/OBS-80/15. United States Fish and Wildlife Service. Washington, D.C. 12 p.

Ireland, R.L., J.F. Poland, and F.S. Riley. 1984. Land subsidence in the San Joaquin Valley, California. United States Geological Survey Professional Paper 437-1. United States Government Printing Office. Washington, D.C. 50 p.

Kerns, W.R., R.J. Byrne, and C.H. Hobbs. 1980. An economic analysis strategy for management of shoreline erosion. Journal Coastal Zone Management 8(2):165-184.

Kuhn, G.C. and F.P. Shepard. 1981. Should southern California build defenses against violent storms resulting in lowland flooding as discovered in records of past storms. Shore and Beach 49(4):3-10.

Leatherman S.P. and R. Dubois. 1983. Coastal environments of Maryland and Delaware. Pages 22-35 In: Association of American Geographers field trip guide. United States: The Association of American Geographers. Washington, D.C.

Marques, M.A. 1986. Guidebook symposium on man's impact on coastal environments, NE Spanish Mediterranean coast, 6-13 September. Barcelona, Spain: University of Barcelona. 134 p.

Maurmeyer, E.M. 1985. Wetland loss in the Delaware Bay. Pages 88- 94 In: Proceedings, Fifth Annual Gulf of Mexico Information Transfer Meeting. OCS Study/MMS-85/0008. Minerals Management Service, United States Department of the Interior. Metairie, Louisiana.

Mitchell, J.K. 1975. The rush to the shore: how to live with coastal erosion. Landscape Architecture 65(2):170-177.

Monte, J.S. 1988. United States of America: Maryland. Pages 581- 592 In: H.J. Walker, (ed.) Artificial Structures and Shorelines. Kluwer Academic Publishers. Dordrecht, Netherlands.

Morrissey, S. 1988. Estuaries: concern over troubled waters. Oceans 21(3):23-7826.

Nummedal, D. 1982. Future sea level changes along the Louisiana coast. Pages 164-176 In: D.F. Boesch, (ed.) Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options. FWS/OBS-82/79. United States Fish and Wildlife Service, Biological Services Program. Washington, D.C.

Orme, A.R. and A.J. Orme. 1988. United States of America: California. Pages 513-528 In H.J. Walker, (ed.) Artificial Structure and Shorelines. Kluwer Academic Publishers. Dordrecht, Netherlands.

Penland, S. and R. Boyd. 1981. Shoreline changes on the Louisiana coast. IEEE Oceans 81:209-219.

____, H.F. Roberts, S.J. Williams, A.H. Sallenger, Jr., D.R. Cahoon, D.W. Davis, and C.G. Groat. 1990. Coastal land loss in Louisiana. Transactions, Gulf Coast Association of Geological Societies 40:685-700.

Pirazzoli, P.A. 1983. Flooding ("aqua alta") in Venice (Italy): a worsening phenomenon. Pages 23-32 In: E.C.F. Bird and P Fabbri, (ed.) Proceedings of a Symposium held in Venice on Coastal Problems in the Mediterranean Sea.

: University of Bologna. Bologna, Italy.

Poland, J.F. 1981. Subsidence in the United States due to ground-water withdrawal. Journal of the Irrigation and Drainage Division, The American Society of Civil Engineers 107 (1R2):115- 135.

____ 1984. Case history n. 9.14. Santa Clara Valley, California, U.S.A. In J.F. Poland (ed.) Guidebook to studies of land subsidence due to ground-water withdrawal. Paris: United Nations Educational, Scientific and Cultural Organization. 305 pp.

Ramsey, K.E. and S. Penland. 1989. Sea-level rise and subsidence in Louisiana and the Gulf of Mexico. Transactions, Gulf Coast Association of Geological Societies 39:491-500.

Reyer, A.J., D.W. Field, J.E. Cassells, C.E. Alexander, and C.L. Holland. 1988. The distribution and areal extent of coastal wetlands in estuaries of the Gulf of Mexico. National Oceanic and Atmospheric Administration, United States Department of Commerce. Washington, D.C. 18 p.

Salinas, L.M., R.D. DeLaune, and W.H. Patrick, Jr. 1986. Changes occurring along a rapidly submerging coastal area, Louisiana, USA. Journal of Coastal Research, 2:269-284.

Turner, R.E. and D.R. Cahoon. 1987. Causes of Wetland Loss in the Coastal Central Gulf of Mexico. Vol. II: Technical Narrative. Final report submitted to Minerals Management Service. Contract N. 14-12-0001- 3252. OCS Study/MMS 87-0120. Minerals Management Service. Metairie, Louisiana 400 p.

Vaccaro, M.J. 1981. New Jersey seashore - ultimate destruction or salvation. Shore and Beach 49(4):34-37.

Valiela, I. and S. Vince. 1976. Green borders of the sea. Oceanus 19(5):10-17.

Walker, H.J. 1981a. The peopling of the coast. Pages 91-105 In: L.J.C. Ma and A.G. Noble, (ed.) The environment: Chinese and American views. Methuen and Company Ltd. New York, NY.

_____ 1981b. In defense of an island: Japan. Scientific Bulletin 6(1):1-9.

V. DEVELOPING COASTAL RESOURCES

Use and People's Perceptions of Waterfront Walkways. Three Case Studies in Wisconsin: Manitowoc, Sheboygan, and Milwaukee.

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Introduction

The Wisconsin Coastal Management Program (WCMP) first received funds earmarked for waterfront redevelopment projects in FY 1986. Since that year, on average, over 50% of the total monies available for coastal grants have been allocated for construction projects. Examples of eligible projects for construction grants are: improvements to waterfront parks; construction of waterfront walkways; boat ramp construction and rehabilitation; and other low-cost construction projects which provide public access to the waterfront.

Many of these grants have been allocated for developing walkways along the waterfront, which local communities feel are essential elements for waterfront development efforts. There has been some concern about the extent of use and the importance of walkways along the waterfront which are funded by the WCMP. Questions have been raised whether this is the best allocation of WCMP grants, or whether these funds might better be spent on other types of projects.

This study examined the extent of use and people's perceptions of three waterfront walkways built in Wisconsin with WCMP funding. Three sites were chosen for the research: Milwaukee; Sheboygan; and Manitowoc. The WCMP has allocated grants for construction of waterfront walkways at these three sites.

Methodology

Several research methods were considered for this study. The multiple case study method was felt most appropriate to analyze this problem. The multiple case study is a variation of the case study method. The case study method refers to the investigation of a particular unit. The case method employs as a unit of analysis a situation, an individual, or in our case, a walkway in a community. The analysis specifically refers to the series of events studied at the units of analysis at that particular time, in this case from July to September.

Interviews and structured observation proved to be reliable and useful techniques for gathering the data used in this study. The interviews for this research were conducted by a University of Wisconsin student who, in a face-to-face meeting, was able to encourage subjects and to probe more deeply into an issue. By asking leading questions, through a guided conversation, structured interviewing led to obtaining the information and data needed for this study.

Both walkway users and local merchants were interviewed. The main issues discussed with the users of the walkways during the guided conversation were: origin of the interviewees (residence); main reason for being at the location; how often the interviewee visited the site (# times per year); plans for their stay in the area; interviewee's awareness and opinion of the waterfront (especially of the walkway); perceptions of the walkway; having the walkway versus not having it, etc.

The main issues discussed during the guided conversation with the local merchants were: awareness of the waterfront; opinion of the walkways; how merchants felt the waterfront affected their business, etc. Similar to the interviews with the users of the walkway, interviews with the merchants were done on a random basis.

Observation is a tool that is complementary to interviewing, and very helpful in our case to determine the amount of use the walkways receive. Structured observation was used to obtain information about use of the facilities. The structured observation took account of those people using the facilities for any purpose. For example, recorded observations included the use of the walkways for walking, biking, jogging, watching boats, reading, taking pictures, skateboarding, etc.

Interviews and observation took place at the three locations (Sheboygan, Manitowoc, and Milwaukee). Interviews of walkway users and counts of the users took place at different segments of the walkways at different dates and different times. Interviews with the merchants were done with the businesses of the area. The interviews made by the field researcher were done on a random basis.

Results and Analysis of Data

Manitowoc

The waterfront walkway in Manitowoc is about 1.3 miles long. It starts at the busiest area of the waterfront, the Maritime Museum. The walkway runs along the waterfront of a recently-built hotel, the waterfront of the YMCA, through a small beach, along Manitowoc's marina, along Highway 42 through a park into a nature area, and ends at a main avenue almost perpendicular to Highway 42.

For the study, the walkway was divided into four segments.

Segment Number 1 (Museum Section)

This first segment includes the portion from the Maritime Museum to the waterfront section of the Inn on Maritime Bay Hotel. The Museum Section is approximately 1,400 feet in length.

Segment Number 2 (Marina Section)

This section includes the portion of the walkway from the YMCA to the end of the marina. This segment crosses a small beach near the YMCA and is approximately 2,30O feet in length.

Segment Number 3 (Shelter Section)

This section runs from the end of the marina to where the walkway crosses Highway 42, a length of about 2,200 feet. This portion of the walkway goes through a waterfront park which has a shelter, picnic amenities, a large parking lot, etc. Directly across from the picnic area is a breakwater which projects into Lake Michigan; the jetty is a major attraction of the area.

Segment Number 4 (Nature Section)

This portion of the segment starts on the west side of Highway 42. The walkway then goes by a picnic shelter and through a nature area, ending where the it meets Waldo Boulevard. This section is about 1,050 feet in length.

To obtain a better picture of how much use the walkway in Manitowoc receives, four site visits were scheduled. One site visit included the 4th of July weekend. The other three visits were randomly dispersed during the summer, with an attempt to sample every day of the week.

Observation of the use of the walkways was performed randomly and took place at all sections of the walkway at different times of day. Each count was recorded during a two-hour time period.

l) People's perceptions of the waterfront redevelopment.

* Visitors and residents alike stated that the waterfront redevelopment efforts are an asset to the community.

* Visitors are extremely impressed with the waterfront facilities in the community; they felt that these are major attractions and a reason for their continuing visits to Manitowoc.

* Long-time residents of the city expressed a special interest in the waterfront development. They have witnessed the transformation of the waterfront from an old, semi-abandoned commercial/industrial site, to the

focal point in the community for tourists.

* Other residents of the community supported expansion of the waterfront redevelopment efforts to other areas of the city.

* Merchants of the area feel that the waterfront redevelopment efforts are an attraction for the community which may bring additional potential shoppers to the city.

2) Use of the Manitowoc waterfront walkway.

Not all sections of the walk received the same use. Different attractions enticed people to a particular site. The area farthest from the major attractions of the community (the Nature Segment) was the least-used segment. In contrast, the most heavily used areas of the walk were where the tourist attractions were and at the lakefront park. This park was especially attractive because of the old breakwater located there, which people seem to particularly enjoy.

To give some idea of the use the walkway sections received during our entire research, we provide below information on the total number of people counted at each section and the length of the observation period.

Shelter section: 1,373 people in 16 hours of observation.
Museum section: 750 people in 12 hours of observation.
Marina section: 534 people in 16 hours of observation.
Nature section: 111 people in 14 hours of observation.

Sheboygan

Sheboygan's waterfront walkway is about 2500 feet long. The walkway runs along the Sheboygan River. It starts at the east side of Eighth Street and terminates at a shelter at the end of the waterfront park (Rotary Park). The walkway runs along the newly-remodeled waterfront shops, along where the charter and commercial fishing boats are berthed, along the Four Torches restaurant, and along a waterfront park.

During the field research, one portion of the walkway was still under construction. This portion is about 550 feet long, and goes from the west end of the newly-remodeled shops to where the walkway meets Eighth Street.

For our study, we divided Sheboygan's walkway into three segments.

Segment Number 1 (Shops Section)

This section of the walk is about 700 feet long, running from where the new walkway section was constructed in summer 1990 (the end of the shops to the west) to the end of where the charter sportfishing boats are berthed.

Segment Number 2 (Commercial Fishing Section)

This section is a stretch of about 600 feet which goes from two commercial fishing shops to the Four Torches restaurant. This section of the walk includes the area where the commercial fishing boats are berthed.

Segment Number 3 (Park Section)

This portion of the walkway runs from the Four Torches restaurant to the end of the waterfront park. This stretch of the walkway is about 600 feet long; it runs all along Rotary Park and ends at a shelter overlooking the water.

Three site visits were scheduled to Sheboygan, one on a regular weekend, one on two normal weekdays, with the last site visit scheduled for Labor Day weekend. Observation at all segments of the walkway was done randomly at different times of the day. Two-hour count periods were recorded at any given time, trying to alternate the times of the day at each of the walkway segments.

1) People's perceptions of the waterfront redevelopment.

* Sheboygan's waterfront walkway is confined to a relatively small area. People feel that the walkway is a major focal point for the community and one of the most important tourist attractions of the city.

* Most residents feel that the improvements to the waterfront are beneficial to the community because they are of high quality and attract tourists to the area.

* Long-time residents stated that they were aware of the tremendous transformation the waterfront has undergone, from an old shanty fishing area to a major tourist attraction.

* Residents feel that the city needs to expand the improvements to other areas of the waterfront which are unpleasant and appear to be underutilized.

* People suggested that skateboards and bikes be kept off the walk, as they were dangerous, especially to the elderly.

* Merchants of the area, especially those involved in seasonal

businesses, feel that the waterfront improvements are key in attracting visitors to the area.

2) Use of the Sheboygan waterfront walkway.

It appears that the areas of the waterfront walkway in Sheboygan which receive the most use are those which offer tourists things to see and do. These portions of the waterfront are at the shops and restaurant areas, which is also where the charter boats and other fishing activities take place. The least-used area of the walkway appears to be the segment farthest from the major tourist attractions. These are the same conclusions we reached from analysis of the Manitowoc data.

As with Manitowoc, in order to have an idea of the use each section of the walkway received during our research, we have provided below information on the total number of people counted at each section and the length of the observation period.

Commercial Fishing section: 2,260 people in 14 hours of observation.
Shops section: 2,157 people in 12 hours of observation.
Park section: 1,100 people in 12 hours of observation.

Milwaukee

The City of Milwaukee has developed a comprehensive strategic riverfront development plan. The main component of the plan is a walkway along the Milwaukee River in the downtown district, some segments of which have been completed. This is a long- term effort that involves constructing sections of the walkway at intervals, whenever funds become available.

The WCMP awarded the City of Milwaukee a grant for building an important segment of the riverfront walkway. This segment is located on the east bank of the Milwaukee River, from the Wells Street bridge north past the new Milwaukee Repertory Theater facilities to connect with a similar riverwalk that is part of the Milwaukee Center Development. The segment of the walk analyzed is about 475 feet long.

Milwaukee differs from the other communities analyzed. Its riverfront is in a downtown, urban setting, and may not represent as critical a component of the waterfront redevelopment efforts as in the two other communities, where the waterfront walkway was perhaps the major tourist attraction for the community. Milwaukee's walk is intended to provide more attractive waterfront access for the public, rather than to attract tourists to the city.

To be consistent with our previous analysis, we divided Milwaukee's riverfront area into two segments.

Segment Number 1 (Repertory Theater Section)

The first section of the walk goes from Wells Street to the end of the back of the Repertory Theater. This section is about 215 feet in length.

Segment Number 2 (Trammell Crow Section)

The second section of the walk goes from the end of the back of the Repertory Theater along the Milwaukee Center to Kilbourn Avenue, a stretch of about 260 feet.

We conducted three site visits to the City of Milwaukee, one on a weekend and two on regular weekdays. Segments of the walkway were observed randomly at different times of the day. With the exception of the first site visit (where on one day we had a count lasting one hour), our recordings were of two hours duration.

l) People's perceptions of the riverfront walkway.

* Milwaukee's riverfront walkway is still in the early stages of development. People interviewed felt that the improvements made so far enhance Milwaukee's downtown.

* People felt that the riverfront improvements should continue and be expanded, since there are many areas along the riverfront that are still unpleasant.

* In general, people were enthusiastic about the riverfront improvements; however, they also stated that other amenities (such as green areas, benches, etc.) along the riverfront were needed as part of the waterfront redevelopment efforts.

* Many of the people were deeply concerned about the quality of the water in the Milwaukee River. They felt that it was very important to have a clean river to complement the waterfront improvements.

* In general, area merchants thought the riverfront improvements were an asset to the community.

2) Use of the Milwaukee Riverfront Walkway.

The data gathered shows a clear distinction of day and time when the riverfront walkway receives the most use. In general, we found that the walkway receives its heaviest use during lunch time on regular weekdays. At other times (for example, the evening) and on other days (the weekends), we noticed a definite decline in walkway usage.

As with Manitowoc and Sheboygan, in order to have an idea of the use each section of the walkway received during our research, we provide below information on the total number of people counted at each section and the total hours of observation.

Repertory Theater section: 452 people in 11 hours of observation.
Trammell Crow section: 292 people in 9 hours of observation.

Conclusions

Waterfront Walkways Use

The three waterfront walkways analyzed in this research have major differences from one another. Manitowoc's and Sheboygan's walkways are a focal point for the community and an important element in their waterfront redevelopment efforts, but they differ in length. Length makes a big difference in the amount of use a walkway receives. Sheboygan's walkway is shorter than Manitowoc's; therefore more concentration of people occurs. Also, most of Sheboygan's major waterfront attractions are concentrated along the waterfront walkway, while this is not the case in Manitowoc.

Milwaukee's riverfront is a different situation. Milwaukee is a large city and the riverfront is just an additional attraction to the community. The riverfront is also in the early stages of development and may eventually become a major attraction for the community. However, at this time, it represents an additional feature for Milwaukee's downtown.

These differences notwithstanding, it is possible to draw some conclusions from our observations. In all of the communities, the waterfront walkway facilities are extensively used. The main difference in use depends on the location of a particular segment of the walkway. Certain segments of the walkway are more heavily used depending on the attractions in this area. In general, the more attractions provided, the more use received by a particular segment. The segments furthest from the major attractions, received the least use.

Significance of the Walkways

The waterfront improvements, specifically the waterfront walkways in all of the communities, are highly appreciated by the users of the facilities. Most people interviewed showed much interest in the waterfront redevelopment efforts of the communities. People in general are supportive of walkway development. People using the waterfront walkways and merchants of the area thought that the waterfront improvements are indeed an important asset for the community.

Communities are experiencing an economic revitalization due, in part, to the waterfront improvements, which in turn encourages people to visit the community. Many of those interviewed had read or heard of the waterfront improvements. People feel that all the improvements to the waterfront enhance the communities' attraction.

Breakwaters for Erosion Control, Waste Management, and Wave Energy

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Abstract

This paper describes a low-cost construction system that can build fixed or floating concrete breakwaters anywhere in the world with portable equipment operated by local, unskilled labor. The breakwater consists of large concrete caissons, tanks, or rectangular boxes lined with impermeable, corrosion-resistant laminated ferrocement that can serve as repositories for dredge spoils or toxic waste. The tanks or caissons may have any diameter, height, or wall thickness and can be slip-formed downward to any depth without the use of heavy equipment or complicated forms.

The seaward face of the breakwater is thickened to resist impact, configured to concentrate wave energy for generating electricity, and may contain several rows of open cells that can absorb overtopping waves and be used for mariculture. The breakwater can form a dike to protect beaches or wetlands from storm waves and provide a highway around congested traffic areas ashore, or it may be expanded to create a barrier island. Where erosion control cannot await completion of a permanent dike, a floating concrete breakwater can be built and installed in a few weeks, then relocated as dike building proceeds.

The actual cost of some laminated concrete pontoons produced in a floating formwork is provided, from which the cost of floating or fixed breakwaters can be estimated.

Introduction

Shoreline protection devices, new waste disposal sites, and alternate energy sources are needed immediately. Constructing these separately by the usual methods is expensive. By combining them into one project and using the construction method described here, all three objectives can be met for less cost than beach preservation or waste management alone.

Background

In 1970, Lockheed Missiles & Space Company in Sunnyvale, California, proposed to encapsulate San Francisco's waste in laminated ferrocement boxes and sink them offshore. The boxes were to be 80 feet long, 40 feet wide, and 25 feet high with a capacity of 80,000 feet^3. A nearby ferrocement company quoted a price of \$14,450 for each box, in lots of 260 units. This represented \$0.18/ft^3 of enclosed space or \$1.17/ft^2 of wall area.

Encapsulating waste for 18 cents/ft^3 was considered economically attractive, but the Lockheed proposal lost out to a landfill operator and the company abandoned the project.

Landfill sites are no longer cheap or plentiful, so it is time to reconsider the encapsulating concept. Instead of sinking the boxes in deep water, they could be sunk in a row offshore to form a breakwater with their seaward face strengthened and configured to concentrate wave energy for generating electricity. The concept is environmentally acceptable because laminated ferrocement is impermeable to water and can incorporate barriers to prevent escape of any gas or liquid emanating from toxic or nuclear wastes. The mortar in ferrocement can have a high pozzolanic content and a low water/cement ratio to provide long-term durability. The Romans used pozzolanic mortars in harbor works that have resisted seawater for over 2000 years. Ferrocement can deflect much more than conventional concrete without opening cracks, and this ductility makes it suitable for earthquake-prone areas. If any leaks do occur, the tops of the containers can be removed and the contents relocated.

Ferrocement is defined by the American Concrete Institute as "a form of reinforced concrete using closely spaced multiple layers of mesh and/or small diameter rods completely infiltrated with mortar" (ACI, 1988). It has been used for boat hulls since it was first developed in 1848 and is known to most civil engineering students as a material for concrete canoes. The material is widely used for tanks, silos, housing, and boats in countries where labor is cheap. Thousands of ferrocement boats are built annually in China, from small river craft to ships carrying 500 passengers (Wang, 1981). Ferrocement was used for large roof spans in the Turin Exposition Hall, the Rome Sports Palace, and several aerodromes (Nervi, 1956), but construction methods were so labor-intensive that rising wages finally limited its use to structures like the Sydney Opera House and the Amman Mosque where cost was secondary. Mechanized laminating methods are now available that eliminate most of the labor formerly required.

When marine structures are built in a shipyard or graving dock, expensive double forms are needed and the construction facility represents a major investment that also limits size. Two or more inches of cover must be included in the design to protect the reinforcing from corrosion, so concrete structures are heavier and may cost more than their steel counterparts. Laminating methods permit using a low-cost, single surface form, building directly on the water without shipyard support, and decreasing weight with corrosion-resistant ferrocement used alone or as a protective sheath on conventional concrete. Enough boats, tanks, and pontoons have now been built with the laminating process to show that costs can be less than half that of counterparts in steel or cast-in-place concrete (Iorns, 1983).

Two specific examples of laminated construction in floating formwork can be cited. Twenty-six pontoons were built at the Port of Sacramento, California, in 1965, each of which was 60 feet long, 6 feet wide, 3 feet deep, weighed 12 tons, and sold for $1080, including overhead and profit. The material in each unit cost $310 and the average labor cost was $100. At 1990 prices, with ready-mix fine-aggregate concrete at $75/yd^3, rebar at $500/ton, welded wire fabric at $750/ton, and unskilled labor at $15/hour, the material and labor cost for each such pontoon would be about $1200. The unit costs would be $100 a ton, $1.11/ft^3 of volume, $1.07/ft^2 of wall and deck area, and $20/lineal foot of length. These pontoons were designed for the attachment of finger piers to hold boats up to 60 feet in length and could serve as a floating breakwater in relatively sheltered waters.

In 1970, a floating fuel dock was built for Chevron Oil Company and installed in San Francisco Bay. Its pontoon was 80 feet long, 24 feet wide, 5 feet deep, weighed 118 tons, and sold for $12,400. Costs were $4950 for material and $2710 for labor. At 1990 prices, the total cost for labor and materials for such a pontoon would be about $15,000. Unit costs would be $127/ton, $1.56/ft^3, $3.07/ft^2 of hull and deck area, and $187.50/lineal foot along its 24-foot width. This fuel dock was well-reinforced and could serve as a design guide for larger floating breakwaters.

Materials

Any cement and fine aggregate meeting ASTM specifications can be used for laminating either ferrocement or conventionally-reinforced concrete. High strength is achieved by keeping the water/cement ratio below 0.4 and the cement/aggregate ratio above a level that completely fills all voids in the aggregate. Several proprietary admixtures are available to lubricate the mix for pumping.

Conventional ferrocement is usually reinforced with layers of welded or woven wire fabric tied to a framework of rods; the amount of reinforcing is limited by the need to force mortar through the armature. In laminating, the reinforcing is embedded after the mortar is in place, so any type or concentration of reinforcing can be used. Service experience and laboratory tests show that expanded metal and welded wire fabrics are the most cost-effective reinforcing (Iorns and Watson, 1977).

Equipment

Several manufacturers make suitable spray equipment for the production of either laminated concrete or ferrocement. The portable mortar mixers and spray rigs used in the plastering trades are suitable for thin ferrocement sections. Thicker sections are laminated with small-line wet-mix shotcrete equipment. Massive sections may be built by filling a ferrocement form with concrete delivered by high-capacity concrete pumps.

Construction

Both fixed and floating breakwaters can be built with laminated ferrocement or concrete and configured to collect wave energy. Floating breakwaters cost less and are faster to build, but permanent breakwaters are preferred wherever water depths permit. Laminating techniques in combination with downward slipforming from a floating platform can now produce large, concrete caissons, tanks, or massive gravity structures anywhere in the world and at any depth. This makes fixed breakwaters economically feasible in depths previously considered unsuitable.

A sloping beach with calm water is best for starting construction, but the process can be adapted to any water frontage. Wakes of passing vessels and wind waves of less than one foot can be tolerated without special provisions. If building must take place in an exposed location, the method described in Iorns (1990) for constructing and launching floating bridge or airport modules through heavy surf can be used.

Construction starts with the assembly of a waferboard form on the water. A polyethylene film on the outside keeps water out and another film inside facilitates release and recovery of the form materials. The materials and labor total slightly less than $\$1/ft^2$, in place. A layer of ferrocement costing $\$1/ft^2$ is then laminated onto the form to create a corrosion-resistant, watertight sheath for the main structure. Layers of fine-grain concrete and welded wire fabric or rebar mat are now built up to design thickness. At 20-city average prices reported by the Engineering News Record in 1990, each inch of added thickness costs 20 cents/ft^2 for the concrete, and between \$1 and \$2 for the included reinforcing, depending on its type and amount.

Configurations

Figure 1 is a slightly modified version of an existing wave power-extracting caisson breakwater module being evaluated at Sakata Port in Japan (Goda, 1989). The breakwater is 80 feet from front to back and 88 feet high. Each module is 65 feet wide. The wall area of the module is approximately 36,000 ft^2 and the volume is 450,000 ft^3, of which about 350,000 ft^3 can be used for waste. The same construction system developed for the Lockheed boxes can be used, but the $\$1.17/ft^2$ cost of wall area must be raised to \$3 to allow for price increases since 1970 and for strengthening of the seaward face. Thus adjusted, the breakwater module in Fig. 1 would cost about \$180,000 or \$2,800/lineal foot and 40 cents/ft^3 of waste capacity. This does not include the skirt options that are designed to prevent wave scour from undermining the structure. They can be built as integral parts of the module or laminated separately in a floating form and deployed as needed.

Mariculture pens are shown in Fig. 2, but their design and placement may vary widely. Where prevailing wave conditions do not justify recovering wave energy, the pens may be placed seaward of the breakwater. Otherwise, the pens may be placed as shown behind the energy collectors to trap overtopping storm waves. The pens add very little to the cost of the breakwater, but greatly increase its base area and stability.

According to Hagerman (1990), two wave power plants were built in Norway to compare the resonating oscillating water column concept with a tapered channel arrangement that causes waves to overflow into a reservoir. A low-head turbine is actuated by the outflow from the reservoir. Both systems produced electricity, but the oscillating water column plant was destroyed in a violent storm. The tapered channel plant has now been operating for over five years and similar projects are underway in Indonesia and Australia. The cost of all these projects might be substantially reduced with laminated concrete.

Floating Breakwater

Now that downward slipforming can place fixed breakwaters at low cost in depths never previously thought possible, the need for floating breakwaters is diminished. Their chief use will be to provide emergency erosion control or a temporary shelter for starting a fixed breakwater or some other large structure. When required, they can be produced rapidly in any length, width, or molded depth by the horizontal slipforming methods developed for floating bridges and airports (Iorns, 1990). Their design and construction present no problem but mooring them may.

Mooring

Massive plough- or claw-type reinforced concrete anchors can contain buoyancy compartments that are flooded to place them or injected with air to retrieve them. They can be built on-site in floating forms and installed without divers or heavy equipment.

Conclusion

A technology is now available which permits economical construction of fixed or floating breakwaters anywhere in the world with portable equipment operated by unskilled, local labor. The breakwaters can have any length, width, or depth and can be ballasted with dredge spoils or toxic waste. Their seaward face can be configured to provide for mariculture or to concentrate wave energy for generating electricity. They may also be used to halt beach erosion and support an offshore highway for bypassing congested traffic on shore.

References

ACI. 1988. Guide for the Design, Construction, and Repair of Ferrocement (549.1R-88). American Concrete Institute, Detroit, MI., 27 p.

Goda, Yoshima, et. al. 1989. Field Verification Experiment of a Wave Power Extracting Caisson Breakwater. Pages 35-42 In: Proceedings of the First International Conference on Ocean Energy Recovery (ICOER '89), Honolulu, HI, American Society of Civil Engineers.

Hagerman, George, Personal Communication, October 16, 1990.

Iorns, M.E. 1983. Cost comparisons: ferrocement and concrete versus steel. Concrete International, 5(11):45-50.

_____. 1990. Floating Airport Cost Reduction. Proceedings of Floating Airport San Diego Workshop, University of San Diego, 16 February 1990, 6 p.

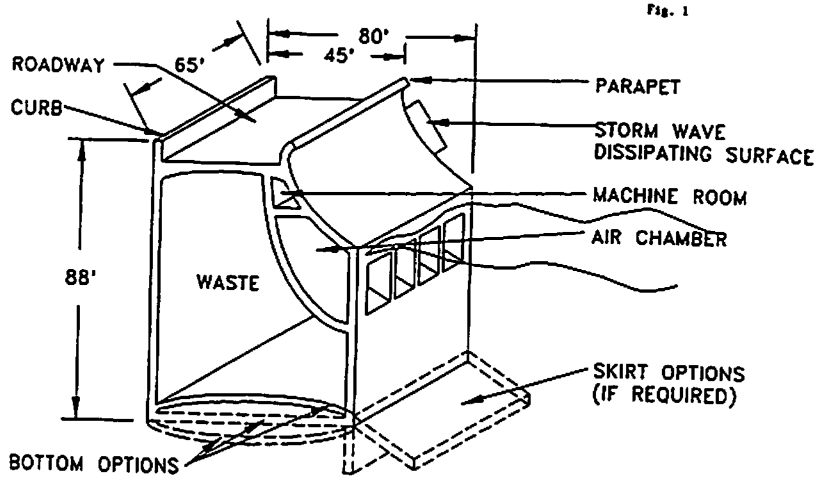
_____ and L.L. Watson. 1977. Ferrocement boats reinforced with expanded metal. Journal of Ferrocement, 7(1):9-16.

Nervi, P. L. 1956. Structures. W. F. Dodge Co., New York, NY, 118 pp.

Wang, K-M. 1981. The Application of Ferrocement Boats in China. Pages 3-47 In: Proceedings of the RILEMM/ISMES International Symposium on Ferrocement, Bergamo, Italy, July 1981.

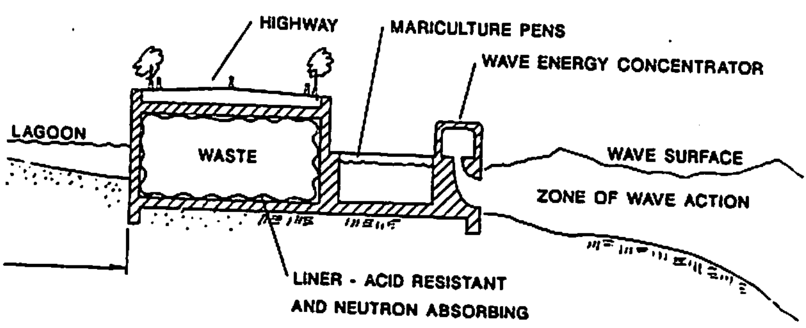
ENERGY GENERATING BREAKWATER MODULE

Fig. 1



MULTIFUNCTION DIKE

Fig. 2



Assessment of Offshore Sand Bodies for Coastal Projects

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Abstract

The U.S. Atlantic and Gulf of Mexico continental shelves contain large surficial sand bodies. Resources contained in these sand bodies could be available for regional metropolitan construction and coastal beach nourishment projects. An assessment is required before utilization of the offshore sand bodies can occur. Such an assessment can be viewed generally as comprised of five major, dependent areas: geological; engineering; environmental; multiple-use; and economic. Geological assessment consists of geochemical, geophysical, sedimentary petrological, and geomorphic subareas. This paper discusses some of the fundamental concepts for geological assessment.

Introduction

Occurring as shoals, deltas, relict beach ridges, and buried channel deposits, offshore sand bodies represent potential sources of sand for a variety of coastal needs. Coastal development coupled with coastal erosion has had escalating impacts on many coastal areas. Consequently, coastal planning is receiving more attention from scientists, planners, and the public (Culliton et al., 1990). More research is being focused on the causes and processes of coastal erosion, as well as on protective measures. Beach replenishment and protection projects, and the construction industries of cities such as Boston, Norfolk, New York, and Houston, require large volumes of quality sand.

One method to combat coastal erosion is beach nourishment, especially for relatively small areas of ecological or commercial value. Nourishment is one of a variety of methods used to abate, at least temporarily, coastal erosion. This approach is not a permanent solution and it generally requires periodic reapplication to maintain planned objectives. Reapplication schedules are site-specific and their frequencies can range from annual to decadal. Beach nourishment projects require large amounts of economically attainable sand. Such sand must be available in large volumes, meet rather exact sedimentary petrological criteria (Williams, 1987), and be available in environmentally safe areas.

Recently, Ocean City and the State of Maryland sponsored a beach nourishment project for Ocean City. The project was designed for beach replenishment and hurricane protection. Utilizing a portion of a linear shoal in state waters, the project substantially extended the width of the shoreface and beach. A restoration project in Miami Beach involved over 16 million $yard^3$ of sand and extended over a period of seven years to create more than 10 miles of new recreational beach. Significant successful beach replenishment projects have been completed in Florida, New Jersey, and other areas. The Minerals Management Service of the U.S. Department of the Interior, through a Gulf of Mexico Federal-State Task Force with Louisiana, Texas, Mississippi, and Alabama, is currently evaluating the potential of a large shoal off Louisiana as a source of beach replenishment sand for the Isles Dernieres, a barrier island chain experiencing rapid erosion.

In view of land use pressures, environmental concerns, and depletion of onshore deposits, marine sand bodies offer an alternative to onshore sources for commercial projects. Marine sand has long been utilized by the construction industries of Japan and the United Kingdom. Since 1955, over 300 million tons of marine sand have been supplied in the United Kingdom. Marine sand from the North Sea used in Great Britain meets a wide variety of industry concrete specifications (BACMI, 1987).

Geological Setting

The Gulf of Mexico and Atlantic continental shelves are submerged regions of low relief, sloping seaward to a shelf-break zone. Shelf sediments are generally derived from fluvial, barrier island, and residual relict or reworked sources. Modern processes include Holocene sea level changes, wind-wave currents, and long-shore and tidal currents that operate as the shoreface retreats in response to the transgressing sea and sediment budget.

Northeast of Long Island, New York, extensive sand deposits are associated with marine processes linked to and following Pleistocene glaciation. Between Long Island and Cape Lookout, North Carolina, fluvioglacial sources contributed enormous volumes of sediments to the shelf. South of North Carolina, sands are generally derived from Piedmont fluvial input and erosion of Tertiary shelf outcrops.

Offshore between Long Island and southern Florida, barrier islands dominate the coast, while the shelf possesses a great number of linear shoals. Shoals are abundant in water depths less than 200 feet, with most shoals located in water depths less than 100 feet. Shoals are linear but are arcuate nearer inlets and capes (Williams, 1986). Most shoals are oriented diagonally (20° to 30°) to the coast, but a great number are aligned parallel to the coast (Duane et al., 1972). Shoals off New England probably represent relict features maintained by tidal processes. Shoals composed of transgressive Holocene sands overlie late Pleistocene and early Holocene transgressive sediments.

Gulf of Mexico continental shelf sediments off Texas, Louisiana, and Mississippi are products of deltaic sedimentation since the late Mesozoic. Heavy sediment discharge from the Mississippi River coupled with shelf processes and sea-level fluctuations during the Quaternary represent the principal factors accounting for the character of the northern portion of the Gulf of Mexico shelf. Modern sediments in the region are composed of material from abandoned deltas, remnants of ancient barrier islands, and sediments discharged from the Mississippi. Sand bodies include shoals, relict deltas, channels, buried beaches, and submerged barrier islands. Sixty-nine sand resource targets offshore Louisiana were identified using data from research programs at the Louisiana Geological Survey, in cooperation with the U.S. Geological Survey, the Minerals Management Service, and the Louisiana Department of Natural Resources (John et al., 1989). Other sand bodies have been identified offshore of Texas, Mississippi, Alabama, and Florida.

Assessment

Assessment of a sand body as a resource incorporates five major but interdependent areas: geological; engineering; environmental; multiple-use; and economic. Generally, a geologic assessment is initiated first to provide basic data and information necessary for the other areas. The dimensions, extent, quality, and quantity of the deposit are established from the geological assessment.

This paper examines some of the fundamental factors and methods of geological assessment of an offshore sand deposit. This assessment can be divided into four major interrelated subareas of analysis: geochemical; geophysical; petrological; and geomorphic. Based on the geological assessment, decisions can be made concerning project feasibility or alternative approachs.

Reconnaissance allows preliminary area delineation, details bathymetry, and obtains surface samples and information concerning regional oceanographic processes. Bathymetry distinguishes geomorphic features such as shoals from the surrounding shelf surface. Surface sampling consisting of grab samples and shallow cores permits determination of surface textural characteristics. Such samples are usually small in volume and generally only provide preliminary information about the bottom surface sediments.

Surface penetration by a grab sampler is usually less than 0.3 m in unconsolidated sandy sediments and generally less than 2.0 m by most gravity corers. Surface sampling plans are generally based on grids but are highly variable and often project-specific. Based on bathymetric charts, shallow seismic lines, and surface grab samples, vibracores verify seismic and geological reconnaissance information. Vibracores provide representative samples of the sand body with depth. Sampling grids for coring operations are variable but spacing between coring locations ranges from less than a kilometer to a few kilometers. The deciding factor may include the amount of known information and perceived deposit homogeneity.

Geochemical

Geochemical analysis determines the chemical constituents and their concentrations in the water column, sediment, and interstitial fluids. Most important is the detection of potentially hazardous materials. Certain heavy metals could be present in an active or inactive state under specific geochemical conditions. If these geochemical conditions change (eg. redox potential), inactive heavy metal chemical species may change, become active, and possibly enter the marine food chain. During sediment sampling, if concentrations of clay or organics are encountered, a geochemical analysis, usually including atomic absorption analysis, would be required of the water column, clay fluids, fine-grained sediments, and organics. Heavy metals in interstitial waters associated with clay and organic sediments have been routinely detected by atomic absorption analysis in the part per million range.

Heavy metals at potentially hazardous (to the biota) concentrations have been reported in sediments of rivers, harbors, and bays. Sources of the metals are industrial and sewage discharges, urban and highway runoff (Corps of Engineers, 1987). An important consideration is the solubility of the specific constituents. Soluble forms of certain elements and compounds are available to the biological food chain. The potential of a heavy metal as a contaminant depends greatly on its form and availability rather than simply the concentration in the sediment. Heavy metals may be stable in a slightly soluble form in dredged material containing excessive sulfide. However, application of the dry oxidized material may increase the solubility of the heavy metal sulfides. Under oxidizing conditions, the pH level and heavy metal hydroxyl and oxide formation are the governing factors of solubility of heavy metals. Commonly occurring heavy metals include copper, chromium, nickel, cadmium, boron, lead, mercury, zinc, and chromium.

Crucial to assessing dredged material is determination of the types and amounts of contained contaminants. Over 90% of the total volume of material dredged from U.S. Coastal waters is considered acceptable for disposal via a wide range of disposal alternatives. But, dredged material from certain bays, lakes, and rivers may contain contaminants if the deposit is near areas of intensive agriculture or industrial operations. Such contaminants may include heavy metals, sewage wastes, pesticides, or petroleum products (Corps of Engineers, 1987). The U.S. Environmental Protection Agency has established limits for pollutants in water and sediments as well as guidelines and standards for approved testing methods (USEPA, 1986).

Sedimentary Petrology

A sedimentary petrology study provides data on the nature and properties of the sediments and constituents. Offshore sands are predominately quartz; other components include shells, carbonates, heavy minerals, and feldspar minerals. Nearly all offshore sands contain at least some species of the heavy minerals (specific gravities greater than 2.85). Common heavy minerals found in the sands of the Atlantic shelf include ilmenite, rutile, zircon, and monazite. Over 90 mineral species have been identified in the surficial sediments of the U.S. continental shelves. Although most occur in small concentrations, many heavy minerals are present in potentially economic concentrations (Grosz and Escowitz, 1983). Heavy mineral deposits with economic potential have been described in offshore Virginia waters (Berquist and Hobbs, 1988). Associated heavy minerals may ultimately influence the feasibility of a sand mining project feasibility, representing a potentially valuable co-product (Rowland, 1989).

Sedimentary petrological analysis includes the statistical parameters of the sediment size distribution, i.e. mean grain size, sorting, skewness, and kurtosis. This analysis describes in quantitative terms the size distribution parameters and is the basis for inferential analysis of the sediment. Most sediments exhibit log-normal distributions, reflecting the natural environment, although perfectly normal distributions are found on rare occasions. Sediment size distributions are routinely obtained by rapid sediment analyzer (RSA) systems which apply Stokes Law to fall velocity differentials of the various sand particle sizes through water. Data are converted to phi designations or millimeter equivalents, allowing calculation of statistical parameters. Phi is defined as the negative logarithm to the base two of the particle diameter. The phi designation scale is commonly used by geologists because of the log-normal sediment size distribution of natural sediments (Folk, 1973). The phi scale reflects the sediment distribution (finer distinctions in the smaller size categories) in a manner that is superior to the millimeter scale, especially for analysis of natural hydraulic processes.

Critical sediment statistical parameters are the mean and median grain size, sorting, skewness, and kurtosis. Median grain size gives an estimate of the average particle size and is used in the description of the distribution. Mean grain size is an alternative measure of the average grain size. Statistically, the median is based on ranked values of distribution not taking into account the true values. The mean uses the actual values and is generally a more sensitive measurement. Sorting is a measure of the dispersion, an expression of the standard deviation from the mean. It provides an indication of the transporting agent's ability to segregate load according to size. Environments with efficient sorting include beaches and many uniform regions of a continental shelf. Kurtosis is a statistical measure of the peakedness of the size distribution curve and is related to sorting and non-normality of the curve. A poorly-sorted sediment exhibits a relatively flat particle size distribution, with no asymmetry. Skewness measures the asymmetry or non-normality of the distribution. Skewness may be either positive or negative. Positive skewness indicates a greater relative abundance of fine material in a distribution than would be expected in a normal distribution; a negative skewness indicates a greater relative abundance of coarser size material. Statistical analysis of sediment parameters enables characterization of the sediments, sedimentary and geomorphic processes, and ultimately the resource potential of the sand body.

Geophysical

Geophysical surveys of offshore sand bodies include high-resolution, shallow, seismic profiling and side-scan sonography. Often, geophysical surveys utilize two instrument systems: side- scan sonar and sub-bottom profiler. Very accurate navigation and position-finding is crucial for interpretation of the side-scan imagery and the high resolution profiles. LORAN-C is the standard navigation system used in U.S. nearshore waters. A PC with an appropriate microprocessor can supply the necessary real- time latitude and longitude, speed, and heading. Accurate navigation controls are necessary to construct sidescan mosaics, to determine the scale of the sidescan images, and to allow precise positioning.

Advanced side-scan sonar can produce almost planimetrically correct images of the sea floor. Side scan systems are mounted in a "fish" towed behind the ship. Transducers project an acoustic beam sideways to the sea floor at an angle, rather than vertically down under the ship as in a conventional depth recording. System resolution depends on factors such as frequency; range varies with factors such as depth to the seafloor. Bottom features such as shoals, sand waves, and channels are discernible by side-scan sonar. Return signal strength is directly related to the bottom characteristics. Strong images are a result of bottom bed forms or objects oriented so that the acoustic signal is reflected directly toward the transducer. Light areas result from poor backscatter caused by absorption of the acoustic energy, by fine-grained, softer sediments, or by shadow zones associated with bottom relief.

Seismic reflection methods are employed to obtain sub-bottom, high-resolution sediment profiles. An acoustic signal is generated that penetrates the bottom sediment surface. Reflections of the acoustic pulse transmitted to the seafloor are recorded and analyzed. Penetration of the seafloor is determined by the frequency and energy level of the acoustic source. High-resolution, shallow penetration systems are more appropriate for sand body exploration and analysis, as better quality images are obtained from materials and features on or near the seafloor surface. Sub-bottom profile systems are generally composed of a multi-frequency transceiver, a towfish carrying transducers and associated cables, and a recorder. Profiles are generated with either 3.5, 5.0, or 7.0 kilohertz (kHz) frequencies. Another channel, often fixed at 200 kHz, provides accurate data for bottom tracking and water depth. High-resolution, shallow seismic profiles provide information about the nature and variations of the sediment, potential obstructions (buried boulders or debris), faults, slumps, and the presence of clay or peat beds. Seismic data must be correlated with the vibracore information. Dimensions of the sand body can thus be estimated and gross volumes of the deposit calculated.

Geomorphic

Regional geomorphology may assume a determinant role in a geologic assessment. Many shelf sand bodies are surficial features in water depths less than 100 feet. Because of their depth and prominence on the seafloor, such sand bodies may be an integral part of the processes shaping the coastline. Geomorphic features may function as natural wave attenuation structures. In some cases, particularly closer to shore, seafloor alteration can result in increased wave energy transmitted by wave refraction. A possible result could include accelerated coastal erosion and altered long-shore transport processes. However, many shelf sand bodies are located offshore at depths sufficient to negate problems associated with wave refraction.

Wave refraction occurs as waves from deeper open water transverse depths less than about half their wavelength. Waves are transformed in response to the seafloor. Transformation ultimately terminates as the wave reaches the beach and releases energy. The first transformation is referred to as refraction by decreasing depth. Waves approaching the coast at an angle orient to the bottom contours as a result of wave refraction. Wave sections reaching shallower water first advance more slowly than sections in deeper water, as the wave bends to the shoreline. Refraction continues as long as the bottom relief is present. Waves focus toward the shallower regions; energy in those areas increases. The opposite effect is exhibited in deeper water regions where waves diverge and energy is minimized. Refraction effects depend on the angle of incidence of the incoming waves. Small angle changes may cause significant changes in wave intensity at certain points along a coast and may accelerate unanticipated shoreface changes.

From a physical perspective, sand bodies located a distance offshore may be better candidates for use than similar bodies nearer shore. Computer models can analyze the relational impact seabed morphology changes would have on local wave and currents. Computer models assess amounts and geometric patterns of sand removal such that any removal can be undertaken in an environmentally responsible manner. Many offshore sand deposits are of such enormous volume that one deposit could theoretically supply many times the volume of material needed for a host of coastal projects.

Summary

The U.S. continental shelves have numerous surficial sand bodies. Classification of these bodies incorporates linear shoals, arcuate shoals, relict and buried channels, remnants of barrier islands, and former deltas. With depletion of onshore sand resources and the increasing demand for large volumes of acceptable quality sand, these offshore deposits are a potential alternative to diminishing terrestrial sources. Offshore sand can be used for beach nourishment projects, especially in environmentally or economically important coastal areas. Metropolitan areas located near the coast could also utilize offshore sand for the local construction industries.

An assessment of an offshore sand deposit must be conducted before development of the deposit can proceed. This assessment will consist of five fundamental areas: geological; engineering; environmental; multiple-use; and economic. The geological assessment furnishes crucial input to other areas of the assessment and includes geochemical, geophysical, petrological, and geomorphic studies.

* Geochemical analysis characterizes the deposit's chemical environment. The presence or potential for certain chemical conditions and constitutents is determined. Contaminants such as heavy metals, residue from industrial wastes, or pesticides can be dealt with in an effective and environmentally safe manner.

* Geophysical assessment develops information concerning the properties, variations, homogeneity, and extent of the sand body.

* Sedimentary petrological assessment is fundamental to the geological assessment. Petrology contributes basic statistical data and analysis of the nature and properties of the seabed material. Critical measurements include sediment size distribution parameters, heavy minerals, and associated sediment constituents such as shell fragments, silt, and clay.

* Geomorphic assessment is conducted to determine the nature of the regional shelf processses. By applying information on the processes and geomorphology to simulation modelling, possible methods or options can be formulated to utilize the sand deposit in an environmentally-sound manner.

References

Berquist, C.R. and C.H. Hobbs. 1988. Study of Economic Heavy Minerals of the Virginia Inner Continental Shelf. Virginia Division of Mineral Resources Open-File Report 88-4., 149 p.

British Aggregate Construction Materials Industries (BACMI). 1987. Marine Dredged Aggregates: A Technical Appraisal. London, United Kingdom.

Culliton, T.J., M.A. Warren, T.R. Goodspeed, D.G. Remer, C.M. Blackwell, and J.J. McDonough, III. 1990. 50 Years of Population Change along the Nation's Coasts 1960-2010. National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. 41 p.

Duane, D.B., M.E. Field, E.P. Meisburger, D.J. Swift and S.J. Williams. 1972. Linear shoals on the Atlantic Inner Continental Shelf, Florida to Long Island. In: Swift, D.J.P., D.B. Duane, and O.H. Pilkey (eds.), Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Rossi, Stroudsberg, PA.

Folk, R.L. 1973. Sedimentary Petrology. Hemphill Press, Austin, TX. 170 p.

Grosz, A.E. and E.C. Escowitz. 1983. Economic heavy minerals of the U.S. Atlantic continental shelf. Pages 231-242 In: Tanner, W.F. (ed). Proceedings: Sixth Symposium on Coastal Sedimentology. Florida State University, Tallahassee, FL.

John, C.J., S. Penland, K. Ramsey, and C.G. Groat. 1989. Preliminary evaluation of sand resources, offshore Louisiana. Pages 1-6 In: Proceedings: OCEANS '89 Vol.1.

Rowland, T.J. 1989. Sand and placer mineral development potential offshore Virginia. Pages 2808-2819 In: O.T. Magoon, H. Converse, D. Miner, L.T. Tobin, and D. Clark (eds.), Coastal Zone '89, Volume 3.

U.S. Army Corps of Engineers. 1987. Beneficial Uses of Dredged Material. Engineer Manual, EM 1110-2-5026.

U.S. Environmental Protection Agency. 1986. Environmental Protection Agency Manual 1986a. Washington D.C.

Williams, S.J. 1986. Sand and gravel deposits within the United States Exclusive Economic Zone: resource assessment and uses. Pages 377-386 In: Offshore Technology Conference, 18th Annual OTC Conference, OTC 5197 Houston, TX.

_____. 1987. Geologic Framework and Sand Resources of Quaternary Deposits Offshore Virginia, Cape Henry to Virginia Beach., U.S. Geological Survey Open-File Report 87-667., Reston, VA. 60 p.

Physical Model Testing of Harbor Improvements at Olcott Harbor, New York

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Introduction

Olcott Harbor is located on the southern shore of Lake Ontario (Figure 1) at the mouth of Eighteenmile Creek. It is a small hamlet in Niagara County in the town of Newfane, New York, situated about 18 miles east of the mouth of the Niagara River. Eighteenmile Creek is about 14 miles long and drains an area of approximately 85 mi^2.

The existing federal navigation project at Olcott Harbor was authorized by the Rivers and Harbor Act of 1913 and provides for parallel jetties at the creek mouth located 200 ft apart. The east and west jetties are 850 and 873 ft long with crest elevations (el) of 6 and 7 ft, respectively. They are concrete-capped, vertical sheet-pile structures. The project also includes a 12'-deep, 140'-wide entrance channel extending lakeward from the shoreward ends of the jetties to the -12 ft contour in Lake Ontario.

Olcott Harbor has been fully developed with boat docks and facilities on both banks of the creek. The harbor has a mooring capacity of 134 vessels and can accommodate boats up to 68 ft in length. Major economic activity in Olcott is centered in commercial business enterprises, especially marine-related businesses. Krull Park, a 329-acre county park, is situated about 1,300 ft east of the harbor entrance. It provides recreational facilities for swimming and picnicking.

During storms with winds from the northerly quadrant, waves entering between the jetties are reflected back into the entrance channel. This situation, combined with waves overtopping the jetties, results in extremely rough conditions in the harbor entrance. Local residents report that boating in the entrance channel is frequently more difficult than in the open lake. This situation is particularly dangerous for transient vessels seeking refuge during storms. Also, due to a crowded harbor, visiting craft have difficulty finding mooring space.

The harbor is exposed to northerly storms. Waves entering between the jetties cause vessels to break loose from their moorings, resulting in damage to themselves, other boats which they strike, and harbor facilities. Individual storm damages have exceeded $20,000 (U.S. Army Engineer District, Buffalo, 1978). A regional analysis of boating needs on Lake Ontario and in Niagara County indicates an immediate need for more than 500 additional berths for permanently based vessels at Olcott Harbor and a demand for an additional 300 moorings by 1996.

The Coastal Engineering Research Center (CERC) of the U.S. Army Corps of Engineers conducted a physical model investigation of Olcott Harbor to study wave, current, creek flow, and shoaling conditions for the existing harbor configuration, and to determine the optimum improvement plan that would provide adequate protection at minimal costs (Bottin and Acuff, 1990). Tests were conducted to determine the impact of the proposed improvements on current patterns and temperature conditions as creek waters move into Lake Ontario (Bottin, 1990).

The Model and Test Conditions

The model was constructed to an undistorted linear scale of 1:60 (model:prototype) and operated in accordance with Froude's model law (Stevens et al., 1942). It reproduced approximately 7,000 ft of the New York shoreline of Lake Ontario and included the existing harbor entrance and lower 3,000 ft of Eighteenmile Creek (Figure 2). Underwater bathymetry was reproduced in Lake Ontario to an offshore depth of -24 ft low water datum (lwd) with a sloping transition to the wave generator pit el of -60 ft. The total area reproduced in the model was approximately 13,930 ft^2, representing about 1.8 mi^2 in the prototype.

Model spectral test waves with peak periods ranging from 5.7 - 7.4 seconds and significant heights ranging from 4.0 - 11.0 ft were reproduced by an 80'-long, unidirectional spectral wave generator from five test directions. Resistance-type wave gauges and an automated data acquisition and control system were used to obtain wave height data at selected locations in the model, and a coal tracer material was used to indicate the qualitative movement of sediment on the shorelines adjacent to the harbor entrance. A water circulation system reproduced steady-state flows through the creek channel and harbor area that corresponded to selected prototype creek discharges (1,500 - 5,100 cfs). To study temperature distributions in the harbor, heated water was introduced into the creek to represent discharges for the spring and fall seasons and temperatures at various locations were recorded with thermistor probes during the tests. Still-water levels of +2.8 and +4.0 ft lwd were selected for use during most model tests. The lower value was used in conjunction with test waves that occur during the fall and winter seasons; the higher value was used with test waves that occur during the spring and summer seasons. The design lake levels selected are equivalent to the 10-year frequency annual mean lake level for the particular season plus a short-period peak rise having a 1-yr recurrence interval.

Tests and Results

Prior to testing various improvement plans, comprehensive tests were conducted for existing conditions to establish a baseline from which to evaluate various breakwater plans. Results of wave height tests for existing conditions indicated rough and turbulent wave conditions in the entrance. Wave heights up to 6.5 ft were measured in the entrance under boating season conditions. Visual observations revealed very confused wave patterns between the jetties due to reflection from the vertical wall structures. Tracer tests indicated that sediment will move easterly or westerly along the shorelines on each side of the harbor entrance depending on the direction of wave approach. Tracer material was not deposited in the jettied entrance under any of the wave conditions tested. Water surface elevation tests for existing conditions revealed that the maximum rise in elevation would be only 0.24 ft for the 100-yr creek discharge (5,100 cfs), and that maximum current velocities in the lower reaches of the creek would be 3.5 fps for this extreme event.

Tests were conducted for 23 test plan variations of two basic harbor configurations. One configuration provided a mooring area to the east of the existing entrance. The second configuration provided mooring areas on both the east and west sides of the existing entrance. Variations consisted of changes in the lengths and crest elevations of the proposed breakwaters. For an improvement plan to be acceptable, maximum wave heights were not to exceed 3.0 ft in the proposed entrance, or 1.0 ft in the proposed mooring areas, for wave conditions occurring during the boating season (spring, summer, and fall).

The first harbor configuration consisted of a detached 1,100'-long dogleg west breakwater (elevation +15.3 ft), a 1,650'-long detached east breakwater (elevation +16.2 ft), a 340'-long east spur breakwater (elevation +12.7 ft), and channel dredging (elevation -12 ft to -9 ft). Tests revealed that wave heights in the entrance and mooring areas were well within the established criteria for boating season wave conditions. As a result of the model tests, the east and west breakwaters were reduced to +14.5 ft in elevation, the length of the east breakwater was reduced by 125 ft (removed from the shoreward end of the structure), and the length of the west breakwater was reduced by 350 ft (50 ft removed from the lakeward end and 300 ft from the shoreward end of the structure). This configuration is shown in Figure 3.

Based on test results for the first harbor configuration, the detached east and west breakwaters of the second configuration were reduced to elevations of +14.5 ft and the east breakwater length was reduced by 125 ft. The plan consisted of a detached 1,570'-long dogleg west breakwater, a 270'-long west spur breakwater, a 1,525'-long detached east breakwater, a 340'- long east spur breakwater, and channel dredging. Tests indicated that 50 ft of breakwater length could be removed from the shoreward end of the west breakwater (Figure 4) and acceptable wave conditions would be achieved during the boating season. The opening between the attached and detached west breakwaters resulted in minor shoaling in the mooring area in the western portion of the harbor. However, installation of a sill between the structures, and extension of the attached breakwater, or a spur on the attached structure, would alleviate this shoaling.

Model tests indicated that openings between the attached breakwater spurs and the detached breakwaters will provide wave-induced current flow through the harbor and should enhance circulation. Also, the construction of the proposed harbor plans will have minimal impact on water surface elevations and current velocities in the lower reaches of Eighteenmile Creek. Comparisons of existing conditions and the new breakwater plans revealed similar trends in the entrance and lake with regard to temperature variations. The movement of the creek plume into the lake and along the shorelines was similar on a regional basis and varied only slightly in a localized area at the entrance.

Acknowledgements

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References

Bottin, R. R., Jr. 1990 . Current and Temperature Effects at Eighteenmile Creek as a Result of Harbor Improvements at Olcott Harbor, New York; Hydraulic Model Investigation. Technical Report CERC-90-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________ and H. F. Acuff, 1990. Olcott Harbor, New York, Design for Harbor Improvements; Coastal Model Investigation, Technical Report CERC-90-1, U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS.

Stevens, J. C., et al. 1942. "Hydraulic Models," Manuals of Engineering Practice, No. 25, American Society of Civil Engineers, New York, NY.

U.S. Army Engineer District, Buffalo. 1978. Feasibility Study of Olcott Harbor, New York, Buffalo, NY.

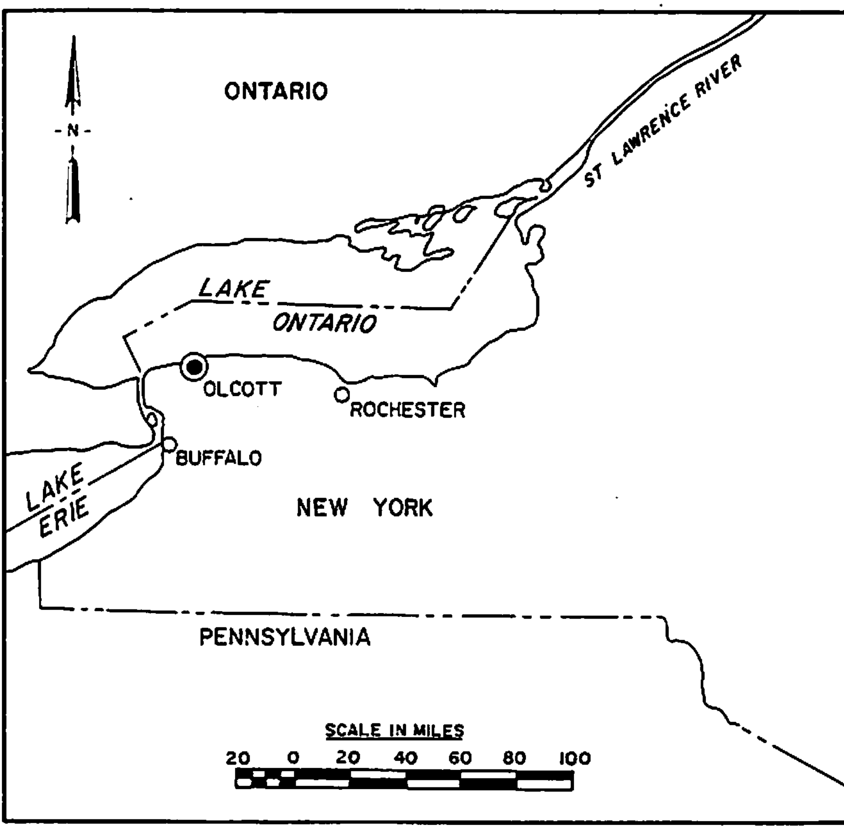
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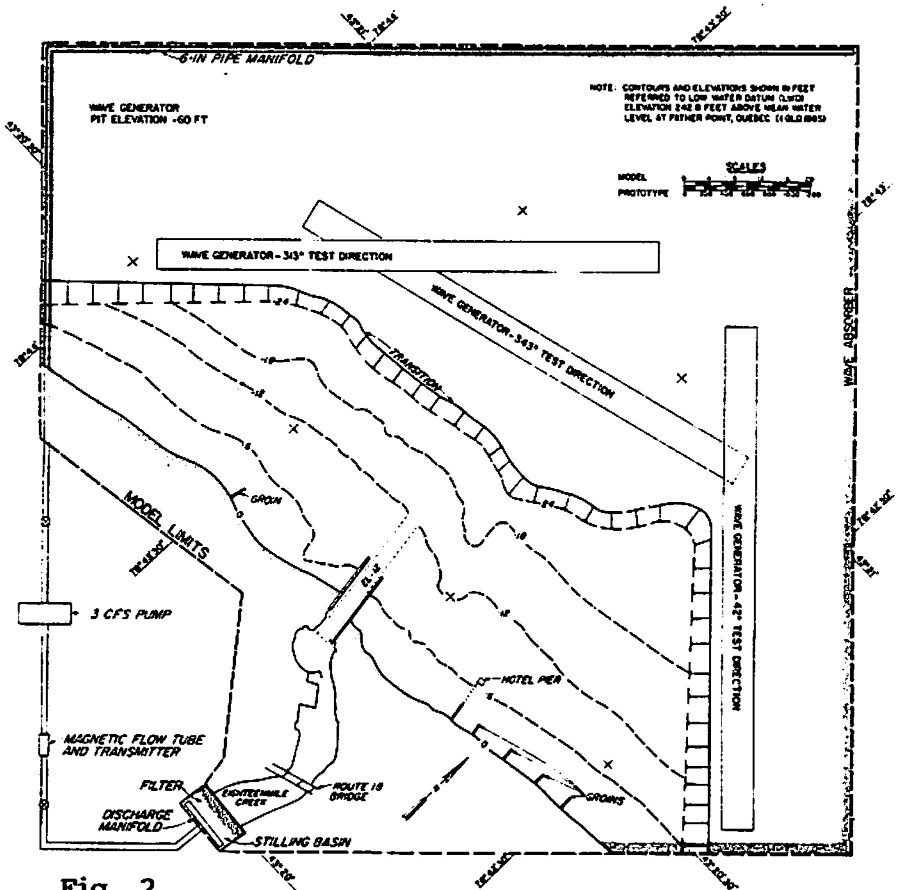
Fig. 1


6-IN PIPE MANIFOLD
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SCALES
MODEL
PROTOTYPE
WAVE GENERATOR - 313° TEST DIRECTION
WAVE GENERATOR - 343° TEST DIRECTION
TRANSITION
WAVE ABSORBER
WAVE GENERATOR - 42° TEST DIRECTION
MODEL LIMITS
GROIN
HOTEL PIER
3 CFS PUMP
MAGNETIC FLOW TUBE
AND TRANSMITTER
FILTER
DISCHARGE
MANIFOLD
STILLING BASIN
EIGHTEENMILE
CREEK
ROUTE 18
BRIDGE
GROINS

Fig. 2

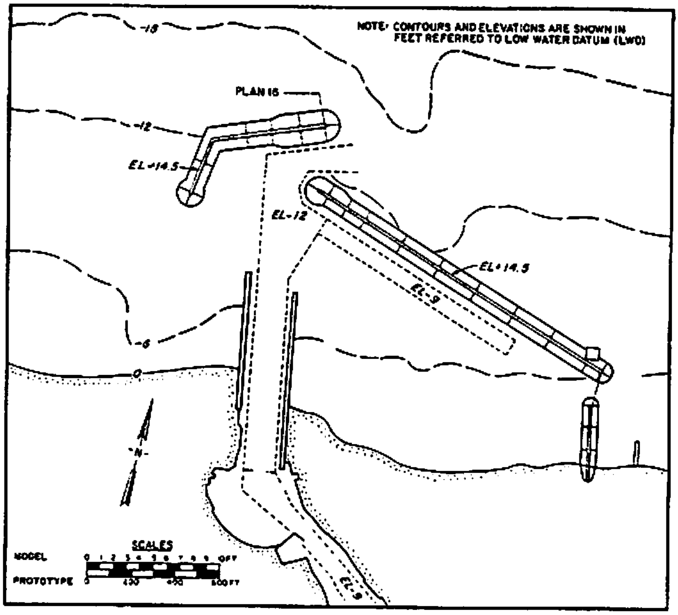

Figure 3. Optimum breakwater configuration with mooring area east of the entrance.

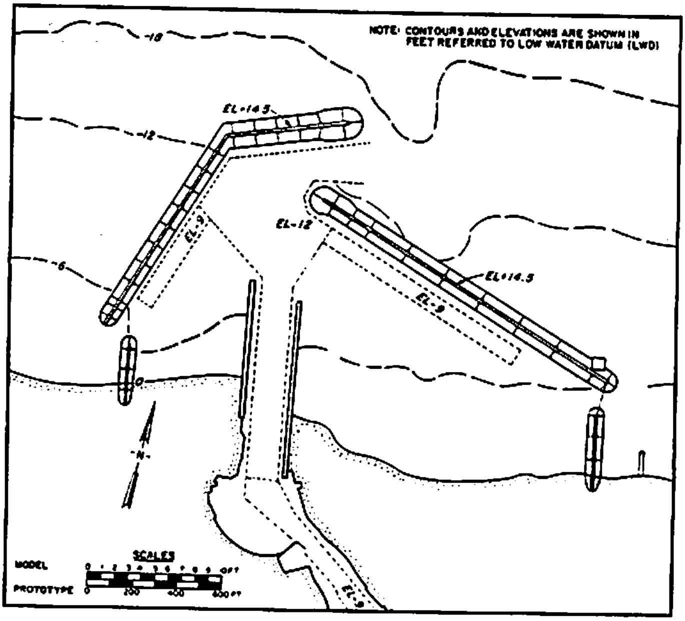

Figure 4. Optimum breakwater configuration with mooring areas on both sides of the entrance.

The Deployment of Floating Breakwaters: Design Guidance

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Introduction

Moored, floating breakwaters are widely used in rivers, reservoirs, estuaries, and along the coast to provide protection from wind waves and ship-generated waves. They are often used to protect moored vessels in small craft harbors. Other uses include protection of recreational swimming areas, fish rearing pens for aquaculture, landing areas for sea planes, and dredging and other temporary construction operations. Floating breakwaters have many advantages over fixed breakwaters: they are more adaptable to water level fluctuations such as those that occur in reservoirs and tidal areas; they are relatively cheaper for deep water installation; they are mobile and easily relocated; and they interfere less with water circulation and fish migration.

However, many floating breakwater installations have been unsuccessful owing to the designer's failure to fully appreciate their limitations. They are kinetic structures and thus prone to frequent damage at connecting joints between units and at mooring line connectors. Unanticipated wave-induced forces can cause anchor and mooring line failures which,in turn, can cause a floating breakwater to break loose and damage nearby vessels, piers, etc. While serious, these design concerns can be overcome and should not limit floating breakwater deployment. A third limitation, which has not been fully appreciated (as demonstrated by several unsuccessful installations), is that the performance of a floating breakwater is extremely dependent on the period of the incident waves. This, in turn, sets strict limits on where floating breakwaters can be deployed in terms of the wind speed and duration, and particularly the wind fetch to which they are exposed.

Floating Breakwaters

The primary purpose of a floating breakwater is to prevent the transmission of incident wave energy. This can be accomplished by reflecting energy seaward, usually by virtue of a vertical face that is held relatively stable to the water particle motion in the incident waves. It can also be accomplished by turbulent dissipation of the kinetic energy in the incident waves - either by causing wave breaking over the top of the structure or by generating turbulence as water particle motion in the waves is broken up by the structure. Figure 1 shows schematic diagrams of the most commonly used generic groups of floating breakwaters. The prism group includes interconnected concrete boxes often filled with flotation material and axially connected by flexible connectors. Prism floating breakwaters often see dual usage as marina docks. The catamaran group is a variation on the prism group that has greater stability to wave agitation for the same breakwater mass. It also has slightly better energy dissipation characteristics owing to flow separation at the structure's additional corners. The most common types of flexible assembly floating breakwaters are those constructed of scrap tires - particularly the Wave Maze (Noble, 1969) and the Goodyear Module type (Giles and Sorensen, 1979). Fluid-filled bags have also been used. Other types seeing limited use include rigid rafts, inclined planes having one end resting on the bottom, and A-frame breakwaters. For more details on the various types of floating breakwaters see Kowalski (1974) and Hales (1981).

Wave Mechanics

The relationship between the wave period (T), wave length (L) and water depth (d) is given by the dispersion equation (see Sorensen, 1978)

$$L = (0.16gT^2\tanh(6.28d/L)) \qquad (1)$$

where g is the acceleration of gravity. (Note: when $d/L > 0.5$, the tanh (6.28d/L) term equals unity and the wave length depends only on the wave period.) For a given water depth and wave height, a shorter period wave will have a shorter length as given by Equation 1. For shorter waves in a given water depth, the water particle motion will be concentrated closer to the water surface. This is demonstrated in Figure 2. For the shorter period wave, the particle orbits decay exponentially to die out at a depth equal to about half the wave length. For the longer wave, the particle orbits are larger and eliptical, they extend to the bottom, and they have horizontal dimensions that change little with depth. For the former (L = 2d), about 80% of the wave kinetic energy is concentrated in the upper 30% of the water column; for the latter (L = 20d), the kinetic energy is essentially uniformly distributed over the water column. This demonstrates why a given floating breakwater would be much more effective against the shorter period waves. The transmission coefficient (Kt) for a floating breakwater, defined as the transmitted wave height divided by the incident wave height, generally increases nonlinearly with an increase in incident wave period.

Storm-generated wind waves have a spectrum of wave heights and periods commonly represented by the significant wave height (Hs) and the significant period (Ts). Hs is the average of the highest one-third of the waves in a wave record and Ts may be taken as the average period of these one-third highest waves. For deep water, the wind-generated Hs and Ts depend primarily on the wind speed (U) and the distance over which the wind blows, i.e. the fetch (F) or the wind duration (td). Forecasting curves for Hs,Ts = fct(U,F or td) are given in the Shore Protection Manual (U.S. Army Coastal Engineering Research Center, 1984).

A floating breakwater at a given location and having a particular orientation will have a certain fetch. Assuming sufficient wind duration (usually the case for practicable floating breakwater installations) the generated wave height and period, and consequently the breakwater effectiveness, will strongly depend on the wind speed. Higher wind speeds will generate higher waves and longer wave periods which will increase the transmission coefficient for these waves. From a different point of view, for a typical design wind speed (e.g. 40 or 60 m.p.h.), the longer the fetch the lower the effectiveness of the floating breakwater.

For a given water depth, the heights of waves generated by a moving ship depend primarily on the ship speed and bow geometry. The generated wave periods, on the other hand, depend primarily on the ship speed. Typical measured ship wave characteristics are given in Sorensen (1966), and available methods for predicting ship wave characteristics are summarized in Sorensen (1989).

Floating Breakwater Deployment

Guidelines for the deployment of floating breakwaters can be developed from: 1) allowable wave heights for moored vessels and other uses; 2) the wave transmission characteristics of the common classes of floating breakwaters; and 3) the ranges of wind speed, fetch, and duration that will generate waves consistent with the limitations presented by the first two factors.

The allowable wave height in the lee of a breakwater deployed to protect moored vessels is somewhat dependent on the size, hull geometry, mooring arrangement, and orientation of the vessels as well as on the incident wave period. Given this, some general wave height criteria have been established. The U.S. Army Corps of Engineers (1984) recommends that maximum significant wave height be limited to 1 foot in berthing areas and 2 feet in anchorage areas and mooring areas for large fishing vessels. The Canadian Small Craft Harbors Directorate (1985) gives specific guidance for allowable maximum significant wave heights for fishing harbors as follows: 1) for all recreational and fishing boats up to 15 meters (49 ft) long -- in the harbor entrance 1 meter (3.3 ft), mooring basin 0.5 meters (1.6 ft), and berthing areas 0.25 meters (0.8 ft) and 2) for fishing boats exceeding 15 meters length -- in the harbor entrance 1 meter, mooring basin 1 meter, and berthing areas 0.5 meters.

The author is not aware of published allowable wave heights for the other floating breakwater usages mentioned in the Introduction. Large dredges may be able to economically operate in slightly higher seas. For our purposes, we can use 2 feet as the maximum allowable significant wave height in the lee of a floating breakwater.

Figure 3 shows the transmission coefficient for selected floating breakwaters representative of the (1) prism, (2) catamaran, and (3) flexible assembly groups. Kt is plotted as a function of the ratio of the breakwater dimension in the direction of wave propogation (the width, W) divided by the length of the incident wave. The data are all based on monochromatic waves tests in wave tanks. Breakwater 1 is a concrete box having a width of 16 feet and a draft of 3.5 feet, tested in water 25 feet deep (Hales, 1981). Breakwater 2 is a catamaran breakwater having pontoons 3.5 feet wide with a 4.65 foot draft, and a total width (W) of 21 feet (Hales, 1981). The water depth for the catamaran tests was also 25 feet. Breakwater 3 is a tire breakwater made up of four Goodyear modules to yield a width of 42 feet (Giles and Sorensen, 1979). The test water depth was 13 feet. These three breakwaters were all moored with a line fore and aft (see Figure 1). Other mooring line arrangements or tautnesses would somewhat alter the transmission coefficients.

Given our allowable two foot wave height in the lee of the breakwater and the transmission coefficient for a selected point on one of the curves (Figure 3), the required maximum incident wave height can be calculated for the selected point. The selected point on Figure 3 also yields a value of W/L from which the wave length and (from Equation 1) the incident wave period can be calculated. This allowable wave height and period pair can then be used to determine the wind speed, fetch, and duration that will generate this wave (from the forecasting curves in the Shore Protection Manual). This was done for a series of points on the three curves in Figure 3 and plotted. The result is Figure 4, which gives the maximum allowable wind speed as a function of fetch and some required durations for selected points. For example, considering the tire assembly breakwater, a 60 mph wind blowing for 25 minutes or longer can only have a fetch of just under two miles; a longer fetch would result in waves in the lee of the breakwater that exceed the allowable two-foot wave height.

Naturally, these curves only apply for the allowable wave height in the lee of the breakwater, the selected breakwaters types and geometries, and the tested water depths considered here. However, since the selected breakwater types and conditions are quite typical of most installations to be found in practice, the curves generally give a fair representation of the general limits on floating breakwaters to be found in most situations. For another design situation, one could go through similar calculations to find the particular wind speed versus fetch and duration limitation curves, but they would be very similar to Figure 4.

The dominant point demonstrated by Figure 4 is the limited fetch to which floating breakwaters can be exposed. For example, for a 60 mph design wind speed the fetch should not exceed 2 to 3 miles. This would be a river, or a small to medium lake or estuary section. Any larger body of water would be an unsuitable location to use a floating breakwater.

A plot similar to Figure 4, developed for a given design situation, also allows a good comparison (along with consideration of costs, ancillary uses, and aesthetics) of the relative effectiveness of the different breakwaters considered. The tire assembly has a much poorer Kt versus W/L curve but, owing to its greater width, has a relatively better U versus F curve.

Typical intermediary Hs and Ts values for the waves considered in developing the curves for Figure 4 were 3 feet and higher, and greater than 3 seconds, respectively. Ship-generated wave periods for common ship speeds (e.g. < 20 knots) are less than 3 seconds and related wave heights rarely reach 2.5 feet (Sorensen, 1966). So, the three example breakwaters considered here would be quite effective for protecting against ship-generated waves.

Other Design Considerations

Wave-induced horizontal loads on floating breakwaters are primarily dependent on the incident wave height. Floating breakwaters must be moored to adequate anchors to resist these loads. Information on mooring loads is available from wave tank experiments on common types of floating breakwaters (e.g. see Giles and Sorensen, 1979; Hales, 1981; and Kowalski, 1974). The most common types of mooring line anchors used for floating breakwaters are dead weight anchors such as concrete blocks and pile anchors. Screw and embedment anchors are also used. A brief review of design practice for these types of anchors and references to more detailed design guidance for anchors are given by Giles and Eckert (1979).

Inter-breakwater and mooring-line connectors typically include chains and elastic members to dampen load peaks and act as bumpers. There is little in the literature on connector design (see Hales, 1981), with most designs proceeding from experience and common sense judgement.

Conclusion

This paper gives a brief overview of some of the key factors in floating breakwater design, with an emphasis on evaluating site wind wave conditions to see if a floating breakwater is appropriate at the site. It is hoped that this will prevent the future misuse of floating breakwaters in inappropriate places, as well as provide some initial guidance for their design.

References

Canadian Small Craft Harbors Directorate. 1985. Guidelines of Harbor Accommodation. Government of Canada, Ottawa.

Giles, M.L. and J.W. Eckert. 1979. Determination of Mooring Load and Transmitted Wave Height for a Floating Tire Breakwater, C.E.T.A. 79-4, U.S. Army Coastal Engineering Research Center, Ft. Belvoir, VA.

_____ and R.M. Sorensen. 1979. Determination of mooring loads and wave transmission for a floating tire breakwater. Proceedings, Coastal Structures 79. American Society of Civil Engineers, pp. 1069-1085.

Hales, L.Z. 1981. Floating Breakwaters: State-of-the-Art Literature Review. T.R. 81-1, U.S. Army Coastal Engineering Research Center, Vicksburg, MS.

Kowalski, T. (ed.) 1974. 1974 Floating Breakwaters Conference Papers, Marine Tech. Rept. 24, Univ. of Rhode Island, Kingston, RI.

Noble, H.M. 1969. Wave maze floating breakwater, Proceedings, Civil Engineering in the Oceans II, American Society of Civil Engineers, pp. 929-942.

Sorensen, R.M. 1966. "Investigation of Ship-generated Waves" Tech. Rept. HEL 12-1, Univ. of California, Berkeley, CA.

_____. 1979. Basic Coastal Engineering, Wiley & Sons, N.Y.

_____. 1989. Port and Channel Bank Protection from Ship Waves. Proceedings, Ports 89, American Society of Civil Engineers. pp. 393-401.

U.S. Army Coastal Engineering Research Center. 1984. Shore Protection Manual, 4th Edition, U.S. Government Printing Office, Washington, D.C.

U.S. Army Corps of Engineers. 1984. Hydraulic Design of Small Boat Harbors, Engineer Manual 1110-2-1615, Washington, D.C.

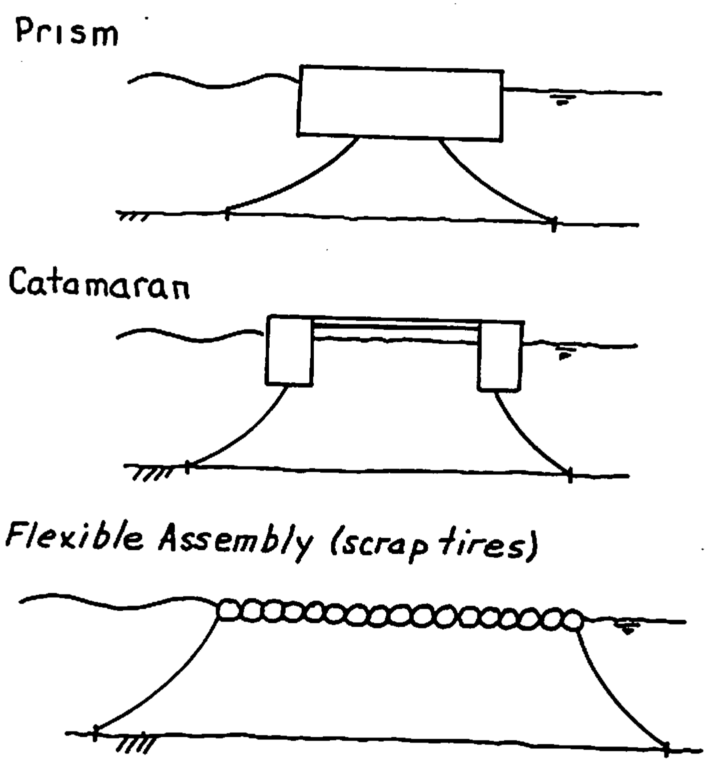

Figure 1

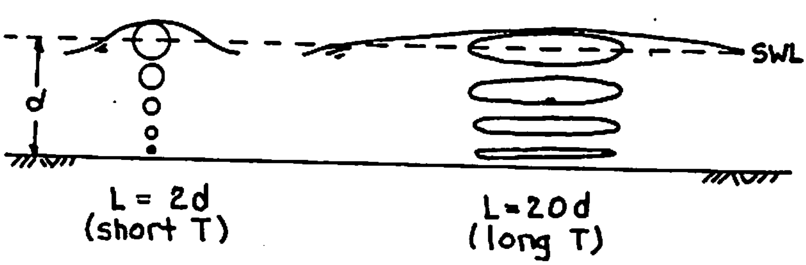

Figure 2

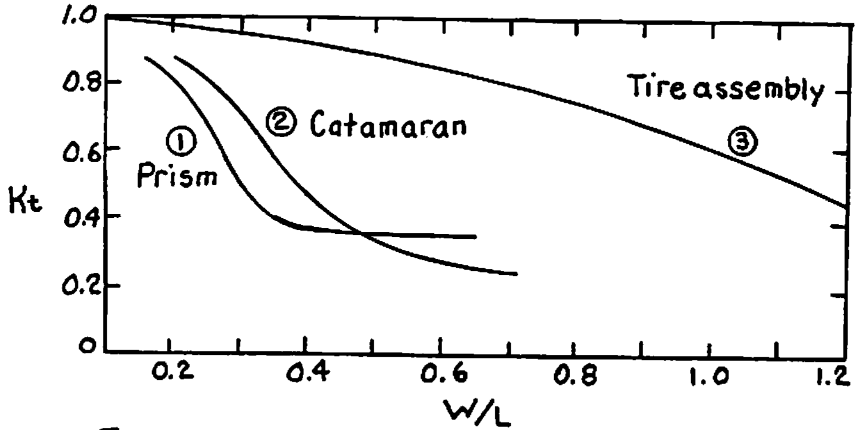

Figure 3

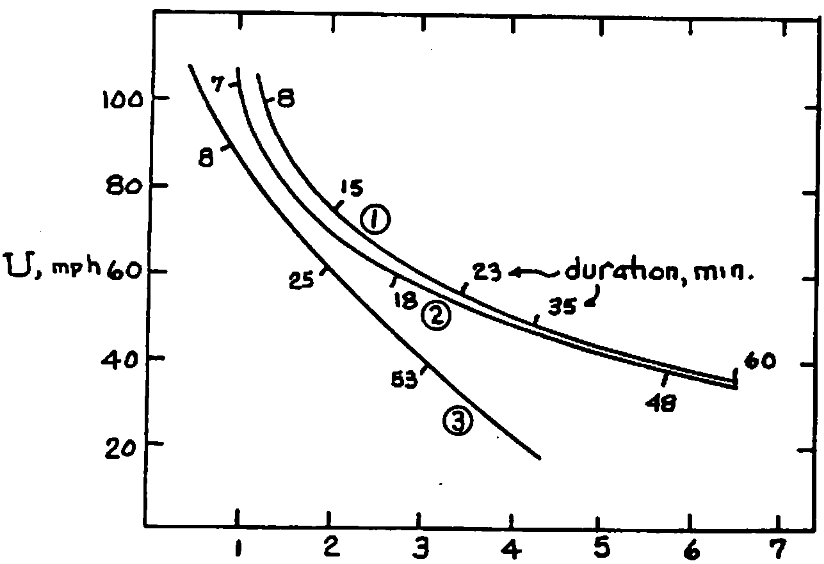

Figure 4

The Exxon Valdez Oil Spill: What Can Coastal States do to Prevent Future Spills?

Virgil F. Keith
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Abstract

The grounding of the EXXON Valdez on Bligh Reef in Prince William Sound and the subsequent spilling of over ten million gallons of Alaska North Slope crude, in less than five hours, suggests that the construction of oil tankers be re-examined with respect to a design which could reduce both the number and magnitude of oil spills. This paper focuses on variations of double hulls with respect to design, spill prevention, effectiveness, and cost.

Double hulls provide the highest probability of surviving damage, either from a collision or grounding, with no loss of cargo. The arrangement provides spaces both below the cargo tanks and on the sides solely for the carriage of ballast water when the tanker is in the ballast condition. These tanks are empty when the tanker is loaded. In the loaded condition, the empty ballast tanks also act as the first line of defense in the event of structural damage to the cargo tanks. Therefore, double hulls, in addition to providing the highest probability of preventing oil spills, also act to reduce the magnitude of an oil spill in the event of damage to a cargo tank by containing oil released from the inner cargo tanks.

Both the type I double hull and the type II double hull require a minimum distance between the inner and outer bottom of 1/15 of the beam (B/15) of the vessel or 19.7 feet, whichever is smaller. By starting with the IMO-required ballast volume and subtracting the volume required for a B/15 double bottom, the volume remaining for each side can be determined. The calculations show that the minimum distance between the inner and outer sides is approximately 1/15 of the tanker's beam, or the same separation as the double bottom. In other words, a suggested design for a compromise double hull oil tanker would be a type II (B/15) design with a minimum separation between the inner and outer hulls of 1/15 of the beam of the vessel or 6.56 feet (2.0 meters), whichever is larger. The 6.56 feet (2.0 meters) minimum separation is necessary to maintain the effectiveness of the two hulls in preventing the release of cargo.

Would this oil tanker be as effective in protecting the environment as a type I double hull? The answer with respect to groundings is yes! The answer with respect to high-energy collisions is no! However, since the cargo carrying capacity is not reduced, the overall number of oil tankers or traffic density will not increase. In addition, with proposed Vessel Monitoring

Systems (VMS), vessel traffic separation lanes, and designated anchorages, the probability of high-energy collisions could be reduced through operational control of these vessels in U.S. waters.

Introduction

The grounding of the EXXON Valdez on Bligh Reef in Prince William Sound and the subsequent spilling of over ten million gallons of Alaska North Slope crude, in less than five hours, suggests that the construction of oil tankers be re-examined with respect to a design which could reduce both the number and magnitude of oil spills. This paper focuses on engineering subsystems in ship design, many of which are in use, but not required, on today's modern tankers.

Specifically, improvements in tanker design are suggested in the following areas:

- Double Hulls;
- Centralized Bunker Tanks;
- Automated Cargo Control System;
- Auxiliary Thrusters;
- Precise Navigation Display System; and,
- Improved Lifeboats.

Double Hulls

Oil tankers with double hulls have cargo and bunker tanks surrounded with a complete and protective second hull. Double hulls are required on chemical tankers and liquefied flammable gas carriers to provide the maximum amount of protection to the cargo tanks. This design provides the highest probability of surviving damage, either from a collision or grounding, with no loss of cargo. The arrangement provides spaces both below the cargo tanks and on the sides solely for the carriage of ballast water when the tanker is in the ballast condition. These tanks are empty when the tanker is loaded. In the loaded condition, the empty ballast tanks also act as the first line of defense in the event of structural damage to the cargo tanks. Therefore, double hulls, in addition to providing the highest probability of preventing oil spills, also act to reduce the magnitude of an oil spill in the event of damage to a cargo tank by containing oil released from the inner cargo tanks.

Title 46 of the Code of Federal Regulations, Subpart 153.230 defines a type I double hull; Subpart 153.231 defines a type II double hull. In general terms, a type I double hull requires the spacing between the inner and outer bottom to be 1/15 of the beam of the vessel or 19.7 feet, whichever is smaller. In the case of the EXXON Valdez with a beam of 166 feet, this would equate to a spacing of 11.06 feet. With respect to the spacing between the inner and outer sides of a type I double hull vessel, Subpart 153.230 requires 1/5 of the beam or 37.74 feet, whichever is smaller. Again using the EXXON Valdez as an example, the minimum distance would be 33.2 feet. While this type I double hull is the most effective design with respect to reducing oil pollution from collisions, groundings, and rammings, it results in a 25 to 30% loss of cargo carrying capacity due to the excess ballast capacity between the inner and outer hulls. This loss in carrying capacity would require an increase in the number of tankers to transport the same volume of oil with an attendant increase in the number of tanker accidents.

In reviewing the requirements for a type II double hull as specified in Subpart 153.231, the spacing between the inner and outer bottom is exactly the same as a type I double hull (1/15 of the beam of the vessel or 19.7 feet, whichever is smaller); however, the minimum required spacing between the inner and outer sides is reduced to 76 centimeters or approximately 30 inches. In the case of the type II double hull, the designer does not have sufficient space to meet the ballast requirements. A design between a type I double hull with excess ballast capacity and a type II double hull with insufficient ballast capacity could be considered. This type II (modified) double hull design would use the ballast capacity as presently required by the International Maritime Organization (IMO) and the U.S. Coast Guard (USCG) and adjust the separation between the inner and outer hulls so that the tanker carries only the required ballast capacity. With only the required ballast between the inner and outer hulls, the cargo carrying capacity is not affected.

Since both the type I double hull and the type II double hull require a minimum distance between the inner and outer bottom of 1/15 of the beam of the vessel or 19.7 feet, whichever is smaller, it appears logical that the type II (modified) double hull tanker should start with a double bottom, as required for the type I and type II double hulls. By starting with the IMO-required ballast volume and subtracting the volume required for the double bottom, the volume remaining for each side can be determined. The calculations reveal that the minimum distance between the inner and outer sides is nearly 1/15 of the tanker's beam, or the same separation as the double bottom. In other words, a suggested design for a compromise double hull oil tanker would be a type II (B/15) design with a minimum separation between the inner and outer hulls of 1/15 of the beam of the vessel or 6.56 feet (2.0 meters), whichever is larger. The 6.56 feet (2.0 meters) minimum separation is necessary to maintain the effectiveness of the two hulls in preventing the release of cargo.

Would this oil tanker be as effective in protecting the environment as a type I double hull? The answer with respect to groundings is yes. The answer with respect to high-energy collisions is no. However, since the cargo carrying capacity is not reduced, the overall number of oil tankers or traffic density will not increase. The probability of a high-energy collisions could be reduced through operational control of these vessels in U.S. waters. Figure 1 is a schematic of a nominal 70,000 deadweight ton crude carrier with a B/15 double hull, and Figure 2 is a schematic of a nominal 250,000 deadweight ton crude carrier with a B/15 double hull.

Centralized Bunker Tanks

Any crude carrier will normally transport crude oil one way and return to the loading port in the ballast condition. It is, however, important to recognize that in addition to transporting crude oil one way, the oil is handled twice (loaded and discharged) and that the ship's bunker tanks contain fuel oil on both legs of the trip. The bunker capacity of a crude carrier can exceed 1,000,000 gallons. This 1,000,000 gallons of bunker capacity is one of the reasons that, while primary concern should be with a loaded tanker, a tanker in ballast should not be disregarded.

The increased efficiency of the diesel engine has led to today's lower exhaust gas temperatures and thus to a decrease in the performance of the exhaust gas boilers. The steam generated by these boilers is essential for heating the fuel bunkers. If fuel is stored in tanks with sides in contact with the sea, the amount of available steam is not sufficient for heating purposes, and expensive fuel has to be consumed in the oil-fired boiler to balance the shortage. However, if the fuel tanks are installed in a central position in the ship, forming block tanks whose sides are not in contact with the sea, then even the reduced amount of steam produced by the exhaust gas boiler is enough to heat the fuel.

The block tank system means more than just energy saving. In this case, fuel economy measures coincide with measures to reduce oil pollution. The four bunker tanks are arranged athwartships, above the inner bottom and between the inner sides. In a fashion similar to the cargo tanks, the spaces directly below in the double bottom and outboard in the double sides would be used exclusively for ballast water. An elevated overflow tank is installed in the center of the tanks. Since all stiffeners of the tanks are placed outside, the tanks have smooth sides and floors, a point which is relevant to fuel deterioration.

Another advantage of centralized bunker tanks is the simplification of the pipeline systems. The filling line of the bunker tanks is a single line in the athwartship direction with manifolds on both ship's sides, and one connection to each of the tanks directly through the deck. The overflows of the tanks are connected with short bends to the central overflow tank. Overfilling of the tanks is reduced due to their position and the overflow tank. Tank level alarms and remote control, pressure-actuated valves are provided in both the cargo handling system and the bunkering system.

Space is provided below the center tanks for the remote controlled fuel transfer pumps are located. The fuel oil from the tanks flows into these pumps, which in turn deliver it via a pressure pump directly to the engine room. This avoids suction problems and the installation of a pipe duct in the double bottom can be avoided.

The block tanks simplify not only the fuel system but also the ballast system. Since the ballast tanks surrounding the centralized bunker tanks have the same trimming moment as the bunker tanks, trim adjustments for fuel consumption are a direct 1:1 ratio.

Today's shipboard bunkering and fuel problems can be solved, in large part, with centralized bunker tanks. Figure 3 illustrates the centralized bunker tanks. Furthermore, this arrangement protects the environment by reducing the probability of oil spills from collisions and groundings due to the double hull configuration.

Automated Cargo Control System

An automated cargo control system will increase ship safety, decrease vessel turnaround time, reduce paperwork requirements, and decrease the probability of an oil spill. With this type of system, many existing problems are solved by using state-of-the-art system technology. Basically, data and control signals are transmitted between a cargo control console, two central computers, and various system subpanels.

The cargo control console replaces all conventional tanker's remote control mimic board. The system includes multiple color cathode ray tubes (CRT'S), operation keyboards, and one main system keyboard. Having this hardware, the operator will be able to monitor the following functions simultaneously.

- ballast piping valve lineup;
- ballast and bunker tank levels;
- cargo piping and vacuum-retaining valve status;
- cargo and ballast pump status; and,
- cargo tank levels.

By having multiple CRT'S, the operator can give the option to view drafts, trim and stress, cargo venting/IGS system lineup, and scheduling information.

The cargo operations keyboards will help the operator perform the task of manually opening and closing valves, and control the speed of cargo, ballast, and bunker transfer pumps. By having three keyboards, the operator will be able to control various systems simultaneously on the different screens.

Special functions such as loading plan simulations, onboard calculations, and engine room flooding calculations will be able to be performed under "Systems Keyboard," which has full alphanumeric capability.

Each computer on the main cargo system can independently perform all operations in which the subpanels provide an additional level of redundancy. For example, if the control for the cargo is lost, the operator has the capability to control all cargo-related systems directly from the subpanels. In the backup mode, the operator can manually control all valves and pumps in a conventional manner.

In automatic mode, the system is designed to control the discharge or loading of the ship. For instance, when discharging in automatic control mode, the operator either inputs a new discharge plan or specifies a previously saved discharge plan. The simulation also provides a complete schedule for cargo, ballast, and bunker transfer. If the simulation is acceptable, the operator will engage the system to automatically line up the cargo lines and start the pumps. From this point on, the system gradually increases the overall cargo pumping rate until either the maximum present discharge manifold pressure, maximum present transfer rate, or the cargo pump system capability is reached. The system then automatically monitors the manifold pressure or transfer rate, and controls the system to maximize the discharge rate throughout the operation. At the same time, pumping rates for each cargo tank are also individually controlled such that all tanks will finish up at exactly the same time (or in sequence if so desired by the operator). Automatic ballasting, crude oil washing, stripping, and line draining operations are also provided.

During automatic operations, the operator must acknowledge certain key steps before the computer will proceed. Examples of computer-controlled actions which must first be acknowledged by the operator include opening of manifold valves, starting cargo or ballast pumps, closing tank fill valves, and initiating crude oil washing, stripping, and line draining sequences.

The system also provides the following alarm-monitoring and error-checking functions, essential for maximizing safety:

- comparison of actual cargo transfer rates to pre-set limits;
- comparison of actual manifold pressures to pre-set limits;
- comparison of actual measured vessel draft and trim to that calculated by the on-line system;
- display of "time to full" or "time to empty" warning messages for all cargo and ballast tanks;
- calculation of longitudinal trim and stress;
- comparison of actual valve lineup to desired valve lineup;

and,

- displays the status of the cargo tank vacuum-retaining valves.

In order to reduce paperwork requirements, the system can automatically generate most of the documentation required for every voyage. The onboard computer in the vessel control center can transfer data to a shoreside computer for customs, immigration or the company's needs through onshore satellite communication (SATCOM), to further expedite vessel clearing. Figure 4 is a graphical representation of the automated cargo control system.

Auxiliary Thrusters

Berthing accidents account for approximately 5% of tanker oil spills. The magnitude of these oil spills is generally much smaller than the oil spills resulting from collisions or groundings. However, they occur in locations which suffer from frequent spills. Location, frequency, and magnitude must all be considered when evaluating the effects of oil spillage on water and marine life.

Figure 5 illustrates the turning moments versus speed of a 70,000 deadweight ton tanker. With the rudder alone, at a full 35 degrees, the turning moment at nine knots is approximately 43 million foot pounds, whereas the turning moment at two knots is less than 4 million foot pounds -- a reduction of over 90 percent. It is also shown that a 1500 BHP auxiliary thruster develops an average of 12 million foot pounds at berthing speeds -- speeds below two knots. By combining the forces produced by the ship's rudder and the auxiliary thruster, a combined average turning moment of nearly 15 million foot pounds is produced at speeds below two knots. This is nearly four times the moment from the rudder alone.

The auxiliary thruster is hydraulically powered and designed for ice operations. The thruster's intake is at the bottom of the tanker and the port and starboard discharge nozzles are above the intake. This design varies from the standard single tunnel thruster which tends to become ice-bound on the intake side of the thruster. This auxiliary thruster also acts as a backup device in the event of the loss of the propeller since the discharge nozzles are directed 15° aft of the perpendicular to the centerline of the tanker. This means that an oil tanker with twin diesel engines powering a single propeller could lose one engine and the propeller and still drive the hydraulic unit with the remaining engine. The auxiliary thruster would increase the tanker's resistance in the water by approximately 1% at 14 knots. This added resistance would equate to a speed loss of approximately 0.05 knot.

Precise Navigation Display System

A precise navigation display system is a computerized navigation and piloting system intended for use aboard vessels that navigate in harbors, along shores, and in coastal waters. It combines accurate positioning, radar, and electronic charts on a single multi-color display, usable in full daylight without a hood. Its electronic charts are accurate replicas of NOAA charts, stored internally in its own memory, including various scales and areas of coverage. Pre-computed routes for all intended journeys are maintained as an aid to piloting along the way and in maneuvering in harbors.

The system consists of a shipboard computer of medium performance, available off-the-shelf, a color monitor, and a special control box. It can obtain radar targets for its display from a digital radar and positioning from LORAN-C, GPS, and/or a satellite navigation system. A digital, raster scan radar, a gyrocompass or fluxgate compass, and a LORAN-C receiver capable of connection to the computer are integral parts of the system.

The electronic charts of the system form the background of its displays. Various scales can be selected and they change automatically as the vessel moves along its track. The chart displays contain accurately placed aids to navigation, including buoys, fixed lights, and day beacons. Shorelines, channel edges, major depth contours, principal hazards, and obstructions are all incorporated on the charts. A symbol representing the vessel moves in accordance with position determined by LORAN-C or GPS. A track of the vessel's previous positions is maintained and can be recorded. Radar images of other vessels, buoys, other aids to navigation, and the shoreline are combined with the electronic chart, and tracks of moving vessels are visible. Radar echoes from buoys indicate whether or not they are at their charted locations. The charts can be used for voyage planning; setting waypoints automatically plots track lines and labels them with the courses and distances between the selected points. Labeled tracklines can be recorded for subsequent and repeated use. The bearing, distance, and time to reach selected buoys or waypoints can be continuously displayed. Any position can be entered and marked on the chart display. The ships position is continuously displayed and can be color-coded with respect to being in safe waters.

Improved Lifeboats

An oil tanker could be equipped with free-fall lifeboats. Free-fall lifeboats are completely enclosed, easily accessible from the stern of the tanker, and designed for use in rough seas or seas covered with burning oil. These lifeboats are launched in a free-fall mode from a ramp. They are equipped with a radio to transmit position data by an integrated navigation memory system. Distress signals are automatically transmitted on shipping and air distress frequencies. These free-fall lifeboats are used extensively in the North Sea and have recently been fitted on two merchant vessels in the United Kingdom. The use of improved lifeboats would permit the tanker's crew to stay with the ship in the event of a severe casualty. By staying with the ship until the last possible moment, the crew might be able to prevent an oil spill or minimize the amount of oil spilled in U.S. waters.

Effectiveness

The procedure for applying the system modifications factors is shown in Figure 6. The distribution of spill incidents is derived from worldwide tanker spill incidents which are contained in ECOTANK, a proprietary database developed and maintained by ECO, Inc., of Annapolis, Maryland. The modification is then compared to these spill incidents by accident type to determine if the modification has an effect or not. If the modification has an effect, that effect is quantified and the spill incident data reduced accordingly for that accident type. Quantification of the effect was determined through interrogation of the extensive literature of systems and engineering analysis of vessel accidents, and real-time simulation of vessel operations. This process continues through all accident types and system modifications for each group of system modifications, as developed for crude carriers operating within Prince William Sound. These results are presented in Figure 7, which shows the oil spill incidents remaining after application of each group system modification.

Table 1 provides the results of the effectiveness methodology in tabular form. Group I modifications will have an effectiveness of 14% in reducing accidents, while Group II modifications have a combined effectiveness of 41%. The effectiveness of improved tanker design is found to be 55%. The cumulative reduction in oil spills due to the combination of the three groups is approximately 77%. These reductions are shown graphically in Figure 8, which also provides some guidance on the timeframe in which those reductions take place. Group I modifications are expected to affect the oil spill rate in the immediate future, while Group II and Group III modifications will take place over a longer time period as systems are acquired and installed and new vessels are constructed and placed in service.

Figure 9 shows the improvement in port safety and the increase in cost per gallon of oil transported to achieve that safety, for U.S. ports. Port safety is equated to reduction of oil spills due to marine transportation system modifications. Increased cost and improvement in port safety are shown for the effects of Group I modifications, Group I and Group II modifications combined, and Group I, II, and III modifications combined. It should be emphasized that the increased cost and reduction in risk impact different groups of people, with the benefits of risk reduction -- economic, environmental and social -- being shared by groups that may or may not carry the burden of the costs. The above discussion indicates that a substantial reduction in risk is achievable with a comparably small increase in cost.

Cost of Improved Tankers

Figure 10 illustrates the increased cost of improved tankers based on the improved 70,000 deadweight ton crude carrier and the improved 250,000 deadweight ton crude carrier. Both of these crude carriers incorporate the engineering subsystems discussed within this section, with cost data verified by U.S. shipyards, and are governed by the following factors:

- Single ship bid from U.S. shipyard (Nov. 1989) with a 1992 delivery;
- Service speed is 14 knots;
- Designed for ice operations;
- Main propulsion - diesel engine(s); and,
- Hydraulic unit for auxiliary thruster and cargo pumps.

Figure 10 also shows that the construction cost of a 70,000 deadweight ton, single hull tanker, is approximately $85 million, whereas the cost of an improved B/15 double hull tanker (separation between the inner and outer hulls is the tanker's beam divided by 15), of the same deadweight, is $93 million. This $8 million increase in construction cost equates to a cost increase of 9.4% for the 70,000 deadweight ton crude carrier. The cost of a 250,000 deadweight ton, single hull tanker, is approximately $175 million, whereas the cost of an improved B/15 double hull tanker, of the same deadweight, is approximately $192 million, a cost increase of 9.8 percent.

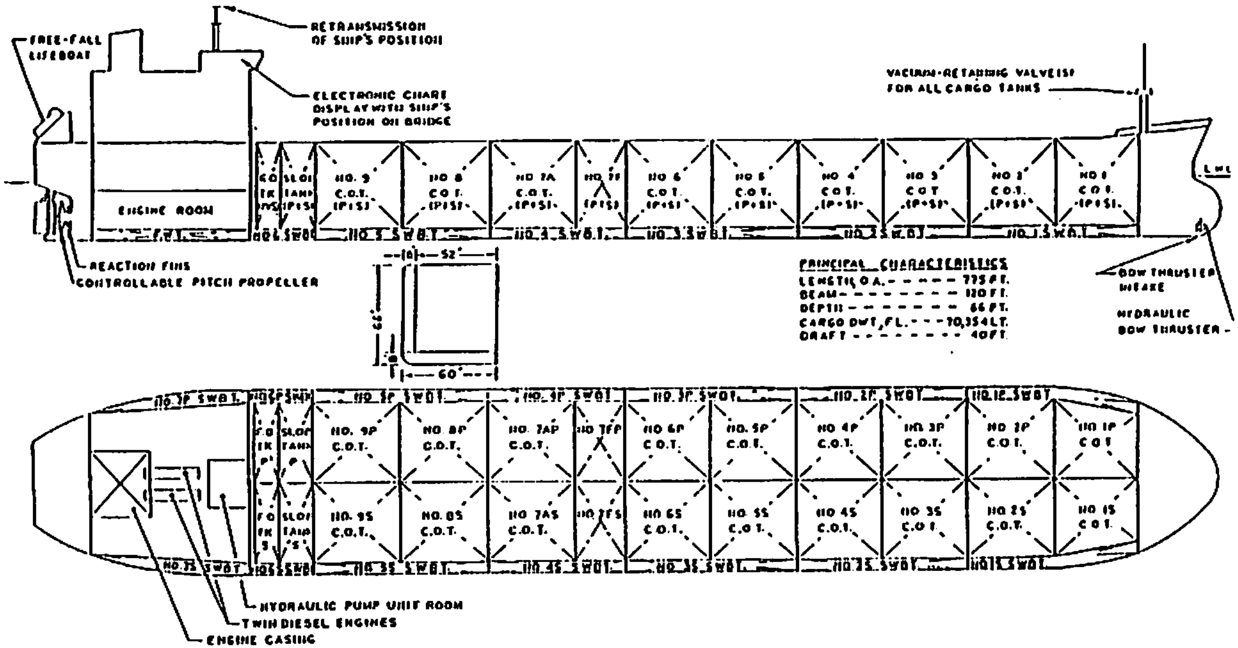


FIGURE I

70,000 DWT CRUDE CARRIER

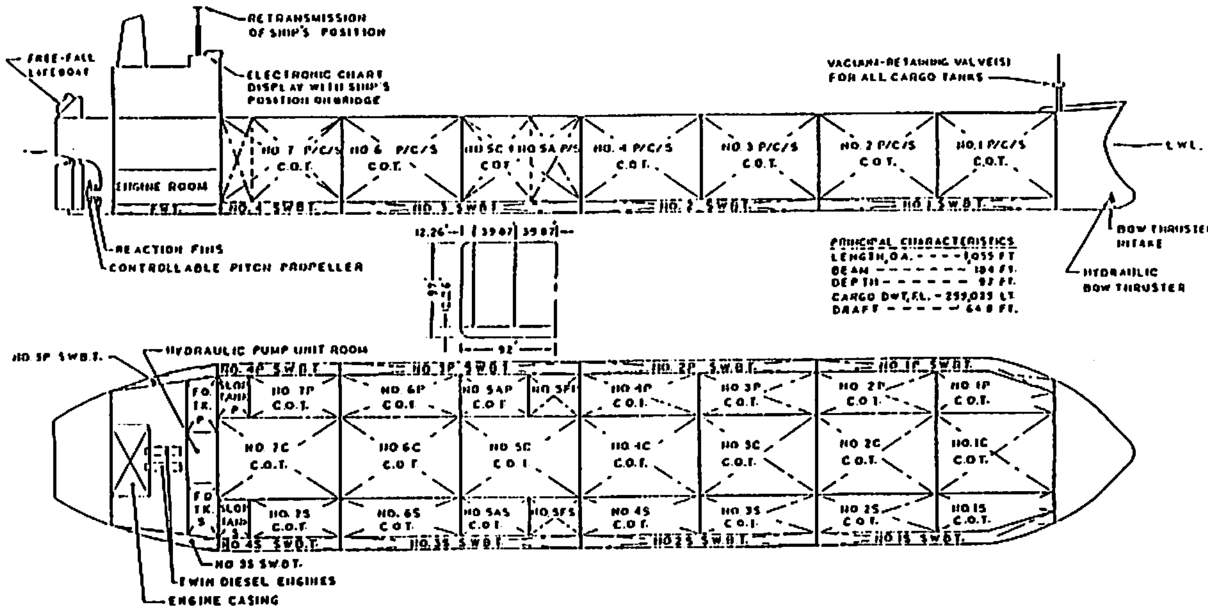
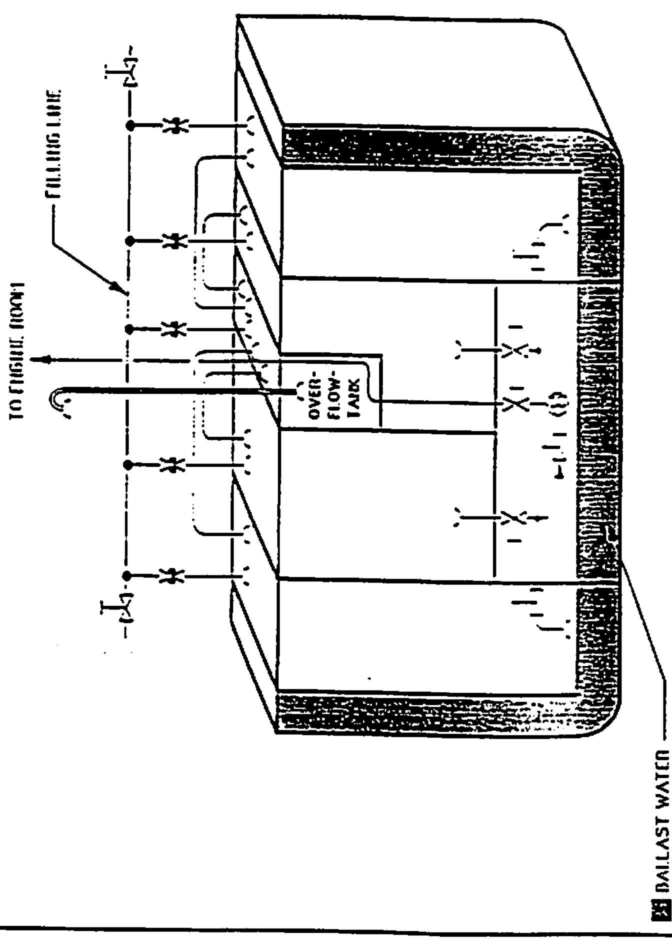


FIGURE 2

250,000 DWT CRUDE CARRIER



CENTRALIZED BUNKER TANKS

FIGURE 3

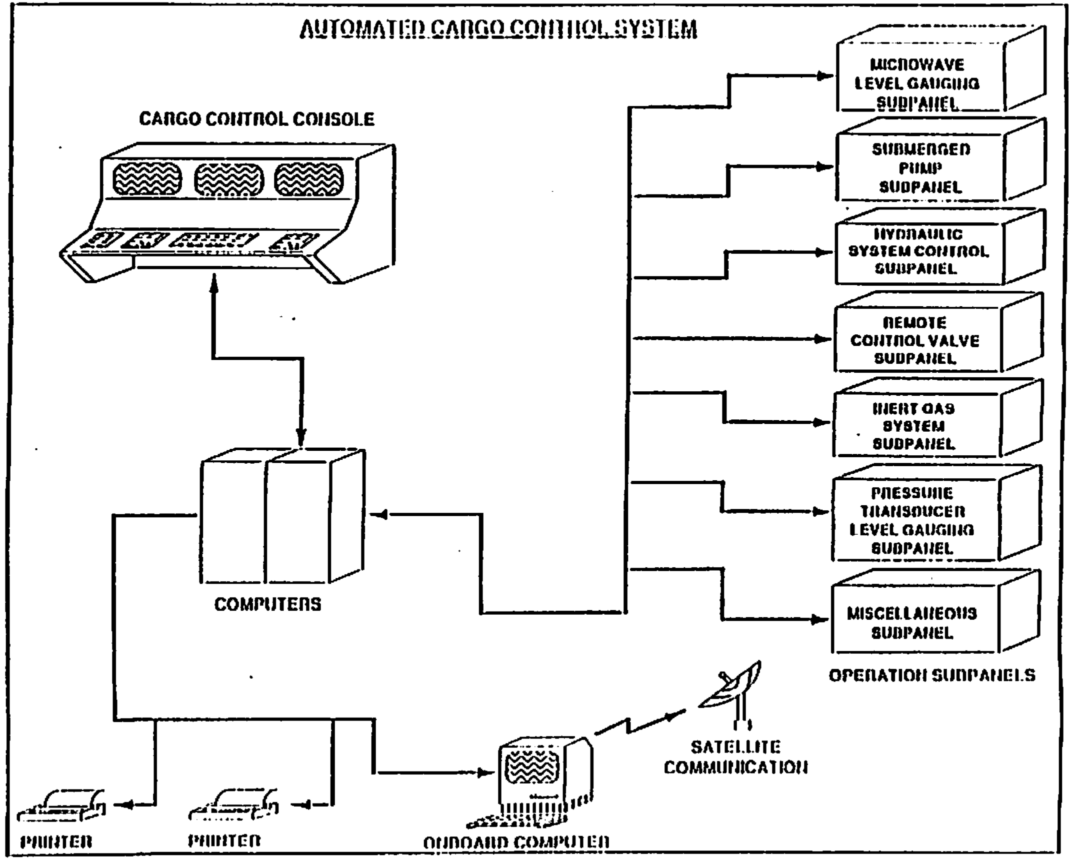

AUTOMATED CARGO CONTROL SYSTEM
CARGO CONTROL CONSOLE
COMPUTERS
MICROWAVE LEVEL GAUGING SUBPANEL
SUBMERGED PUMP SUBPANEL
HYDRAULIC SYSTEM CONTROL SUBPANEL
REMOTE CONTROL VALVE SUBPANEL
INERT GAS SYSTEM SUBPANEL
PRESSURE TRANSDUCER LEVEL GAUGING SUBPANEL
MISCELLANEOUS SUBPANEL
OPERATION SUBPANELS
SATELLITE COMMUNICATION
PRINTER
PRINTER
ONBOARD COMPUTER

FIGURE 4

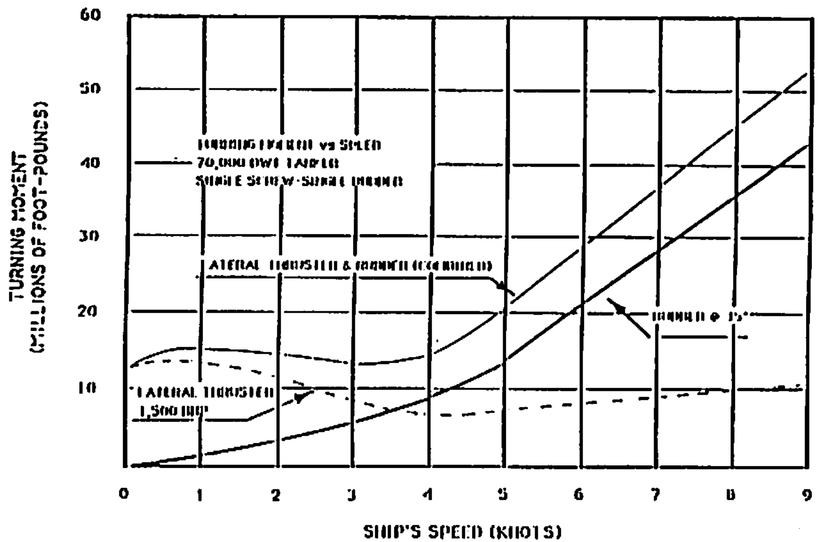

TURNING MOMENT
(MILLIONS OF FOOT-POUNDS)
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
SHIP'S SPEED (KNOTS)
1,500 HP

FIGURE 5

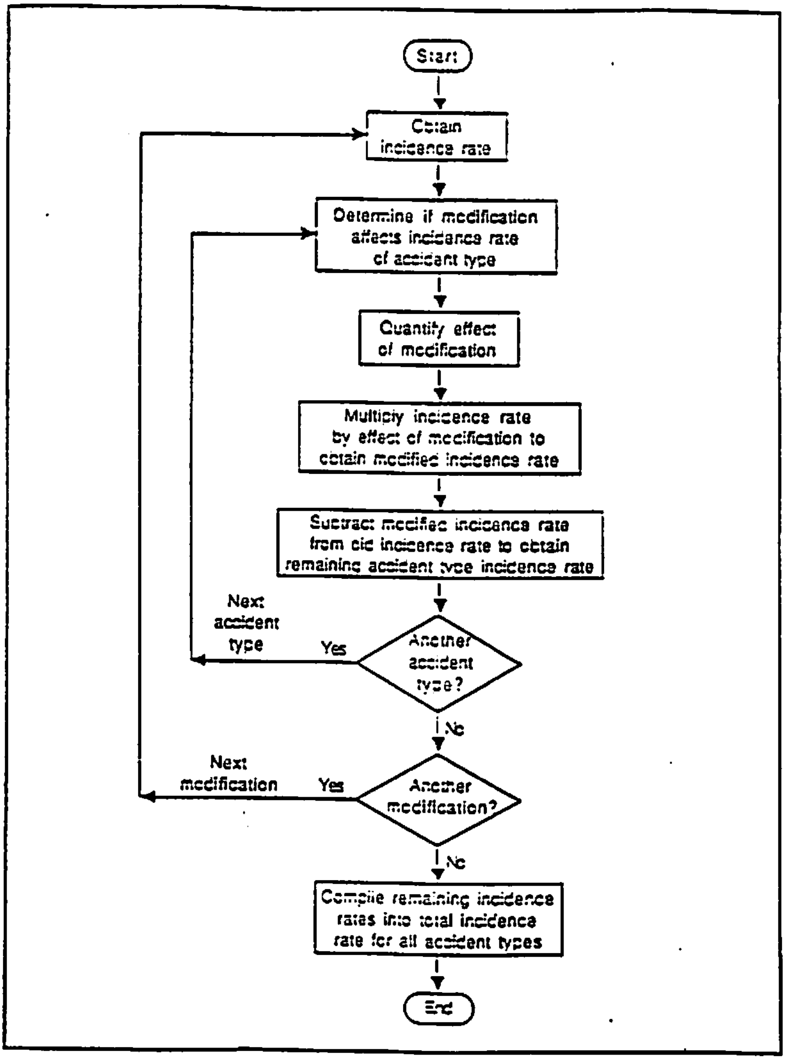
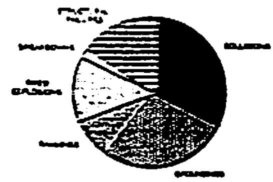


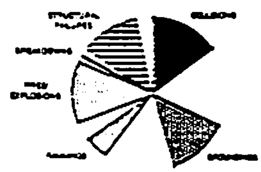
FIGURE 6 EFFECTIVENESS METHODOLOGY

EXISTING



GROUP I MODIFICATIONS

GROUP I and II MODIFICATIONS



GROUP I, II and III MODIFICATIONS

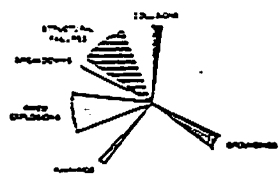


FIGURE 7 TOTAL OIL SPILLS REMAINING AS RESULT OF GROUP MODIFICATIONS

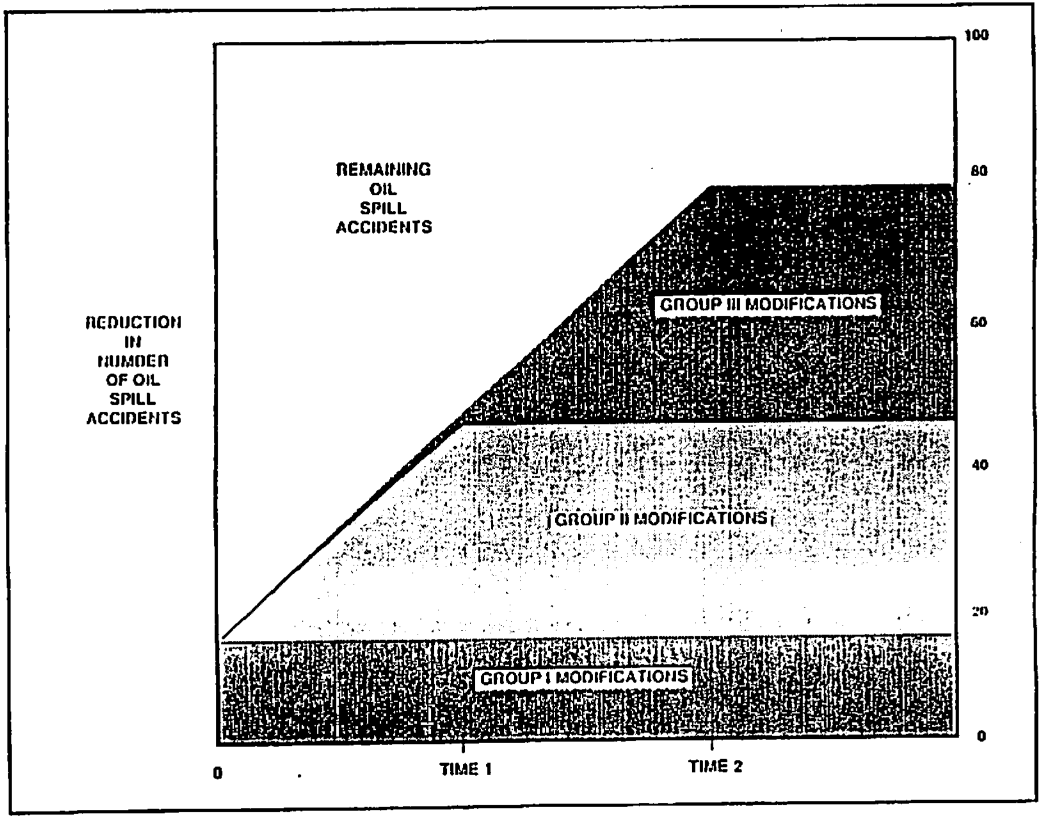


FIGURE 8 REDUCTION IN SPILL INCIDENTS BY ACCIDENT TYPE DUE TO SYSTEM MODIFICATIONS

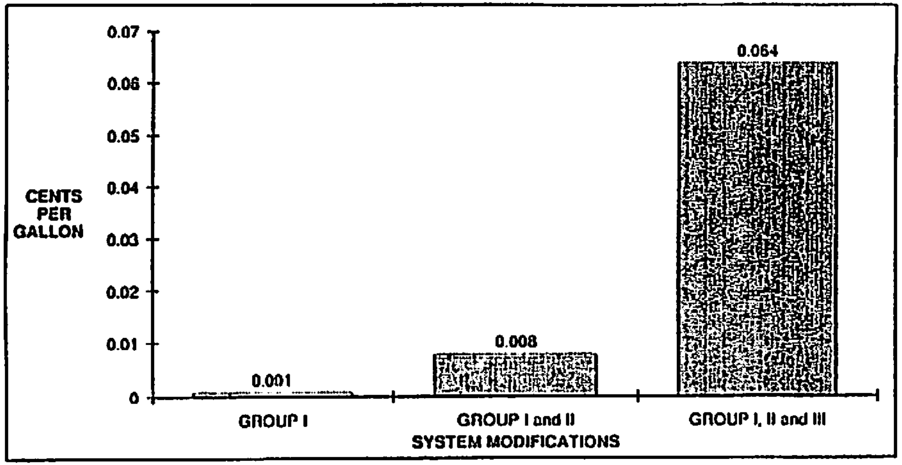


FIGURE 9 EFFECTS OF SYSTEM MODIFICATIONS ON THE REDUCTION OF OIL SPILL ACCIDENTS

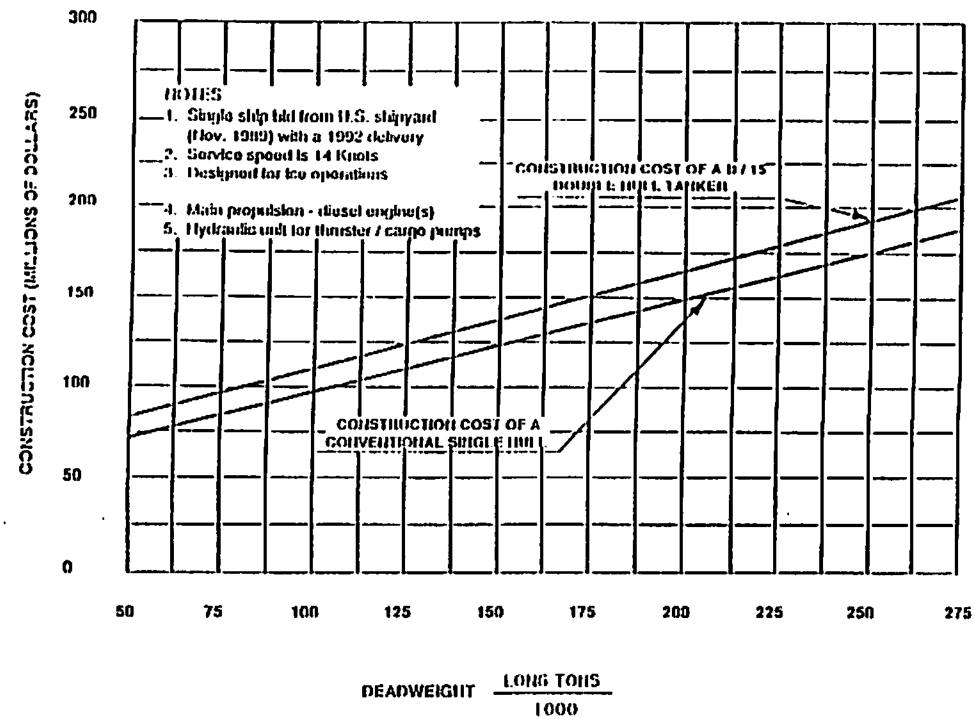


FIGURE 10 COST OF MARINE TRANSPORTATION SYSTEM MODIFICATION PER BARREL FOR U.S. PORTS

TABLE 1 OIL SPILL REDUCTION DUE TO MARINE TRANSPORTATION SYSTEM MODIFICATIONS

SYSTEM MODIFICATION	REDUCTION IN OIL SPILLS (per cent)	CUMULATIVE REDUCTION (per cent)
GROUP I		
Mandatory Drug and Alcohol Testing Emergency and High-risk Navigation Area Training Port Restrictions/Port Closure System Two Person Watchstanding Requirement Improved Loading/Unloading Procedures Local Spill Cleanup/Prevention Involvement Spill Response Equipment Coordination	14	14
GROUP II		
Vessel Monitoring System Traffic Separation Lanes with One-Way Traffic Designated Anchorage Areas Emergency Response/Pollution Control Vessels Improved Loading/Unloading Designs	41	49
GROUP III		
Improved Tanker Design	55	77

Innovative Means of Acquiring and Enhancing Coastal Public Access

Paul C. Ticco
National Oceanic and Atmospheric Administration

Securing and maintaining coastal public access, both lateral movement along the shore and perpendicular access to the shore, has been and continues to be a fundamental objective of coastal zone management. Increases in coastal population (over one-half of the U.S. population currently resides in a coastal county), together with competing public and private demands for the use of desirable coastal lands, demonstrate the need for adequate and expanded coastal public access. However, many factors including conflicting public and private uses, recent Supreme Court decisions, concerns over regulatory takings and just compensation, physical or geological barriers, and scarcity of funds have impeded or prevented the acquisition, development, and enhancement of coastal public access sites.

In principle, the general public has a legal right, through the Public Trust Doctrine (PTD), to access and enjoy the coast. This body of federal and state law vests original title to trust lands and living resources in a state in trust for all people; and establishes a mandated privilege of the public to use and enjoy navigable waters, shorelands, and submerged lands for the traditional purposes of commerce, navigation and fishing (Slade, 1990). However, the PTD, as developed by common law and judicial representation, grants no right to the public for perpendicular access to public trust lands over privately held land. For lateral access, although the majority rule is that the PTD does not provide public rights of access along the dry sand area above the public trust shorelands, a growing number of states are finding that the public's full exercise and enjoyment of their public trust rights also requires limited access to this area (Slade, 1988).

Furthermore, although recreation is not a right historically covered by the PTD, some states are including public uses such as recreation and environmental preservation in their interpretation of the PTD. There is little doubt that the right of public access to the shore is expressed in both common law and state practice.

Despite the authority of the Public Trust Doctrine, coastal states have had to utilize several alternative methods to expand their coastal public access opportunities. Most of these states have developed federally-approved coastal management plans through the Coastal Zone Management Act of 1972, as amended (CZMA). Section 303(2)(D) of the CZMA declares that state coastal zone management programs should provide for "public access to the coasts for recreational purposes." To address this policy, Section 305(b)(7) of the CZMA requires states to develop plans that protect and provide access to "...public coastal areas of environmental, recreational, historical, aesthetic, ecological, or cultural value." The CZMA, thus, clarifies a participating coastal state's responsibilities toward providing and maintaining coastal public access.

However, the CZMA is limited in its implementing specificity and funding. Therefore, although each coastal state has a different pattern of shorefront ownership, there are a number of means, some common and some innovative, that states may use to address the need for or improve the quality and quantity of coastal public access. These include direct financial techniques, the use of various grant programs, the acquisition of new sites, public access inventories and mapping efforts, and the preservation, improvement, and more efficient utilization of existing sites. Examples are discussed below:

1. Public Access Guides/Surveys/Maps/Inventories

Almost every coastal state has produced a public access guide that provides information on shoreline access sites, increases public awareness and appreciation of the coastal environment, and may be used by land-use decisionmakers to identify, designate, and develop access sites. Excellent examples can be found in California, Hawaii, Maryland, Michigan, Oregon, and Washington. As a complementary effort, coast-wide public access surveys and mapping efforts aid both state and local coastal managers. The Territory of Guam, for example, has inventoried its entire coastline and published a guide emphasizing public recreation sites.

2. Land Acquisition and Easements

Perhaps the most advantageous means that states may use to provide, protect, and preserve coastal public access is through the actual acquisition (through direct purchase or contribution) of land. This approach provides the least number of use conflicts and boundary disputes. One method of acquiring land is through use of the CZMA. The 1980 amendments to the CZMA created Section 306A to provide states with federal funds for purchasing land and completing low-cost construction projects aimed at increasing coastal public access and revitalizing deteriorating waterfronts. Most of these funds are channelled through the state to local governments, with additional local and/or state funds added to complete the project.

The first three years of Section 306A funding (FY 1985-1987) produced an expenditure of $14.5 million for over 350 public access projects. This represented 13% of all federal CZMA Section 306 (coastal management plan implementation) funds. Eight percent of the Section 306A projects (with a cost of $4.6 million) went to land acquisition projects. These acquisitions included everything from small, low-cost beach access lots to large, expensive environmentally sensitive areas (Proceedings, 1989). The remaining funds were used for low-cost construction projects (piers, waterfront parks, coastal pathways, waterfront revitalization) that also aided public access. By 1988, the CZMA had provided a total of $17,501,224 in Section 306A funds to states, to which were added $18,271,391 in non-federal matching funds for these projects (Biennial Report, 1990). Some of the states that have used Section 306A funds extensively are California, North Carolina, Oregon, Washington, and Michigan. Unfortunately, Section 306A funds are inadequate to meet the growing costs of public access and coastal recreational site acquisitions. Therefore, some states have acquired property for coastal public access through direct state purchase programs. The Maryland Greenways Program, for example, was developed to acquire, protect, and preserve greenways.

Despite its obvious appeal, land acquisition is often not feasible because of financial limitations of prospective buyers or the unwillingness of a private landowner to sell. In these cases, easements (agreements between private landowners and a government and/or public trust entity in which a private landowner agrees to certain conditions) have been successful alternatives. The landowner may enjoy a significant financial gain, while the government and/or public trust entity will obtain valuable lands for public access (Draft OCRM Bulletin, 1990).

3. Financial Means - Bonds, Taxes and Fees

Coastal states may accumulate significant revenue or acquire land to be used for providing public access through the use of state bonds, taxes, and fees. Some examples include: Michigan, which collects revenue from various taxes and fees for its Public Access Site Program; California, which has acquired land for public access through state bonds; and New York, which derives most of its state appropriations from bonds (such as revenue bonds) or taxes. Examples of various homeowners taxes that have been used for New York coastal issues include real estate transfer, mortgage reporting, real property gains, and lands gains taxes. Furthermore, state lotteries, cigarette and liquor taxes, and fees on recreational vehicles may all be used to raise funds for acquiring and maintaining parks and recreation areas.

4. Permits

State and local governments may also increase public access through use of their permitting processes. Development permits may be designed that specify requirements for public access or open space within the actual development project. The federal consistency provisions of the CZMA under Section 307 may also be used by states as a coastal public access tool by requiring federal activities (including those development projects affecting public access) to be consistent with the appropriate state coastal management program.

5. Trust Funds

Some examples of trust funds that have been used to increase coastal public access include the American Heritage Trust Fund and the Michigan Natural Resources Trust Fund, which was created expressly for acquiring land for recreational uses and for the protection of land based on its environmental or aesthetic qualities.

6. Coastal Public Access Site Development/Maintenance

Various means also exist to enhance existing coastal public access sites. These include vegetative planting (an effective method of protecting dunes and marshes while limiting shoreline erosion) and beach nourishment, which buffers eroding areas and helps build up existing beaches. Despite the high cost and unpredictability of success associated with beach nourishment, it is a popular choice for many areas, especially those heavily dependent on tourism revenue.

7. Miscellaneous Means of Acquiring or Enhancing Coastal Access

Miscellaneous means of acquiring or enhancing coastal public access include using non-profit groups, volunteers, or prisoners for site maintenance assistance, using arts or music projects to raise funds and increase public awareness, and providing a tax return check-off box to give citizens an opportunity to support environmental causes. Maryland's Chesapeake Bay Trust Fund receives funding in this way, allowing state taxpayers to make a voluntary contribution to Bay programs.

Effective State Efforts

Utilizing many of the above-mentioned techniques, coastal states have been effective in acquiring or enhancing coastal public access sites. A sample of these (OCRM Technical Bulletin 101, 1988) follows:

- The San Francisco Bay Conservation and Development Commission has increased the number of miles open for public access to the Bay from four to one hundred through a combination of new permit conditions and public acquisition;

- In 1987, Michigan prepared a Linked Riverfront Parks Master Plan for the City of Detroit that eventually created new parks and coastal recreation opportunities, and stimulated housing, office, and commercial retail development;

- In New York City, a total of 33 miles of previously inaccessible waterfront has been opened to the public;

- In Hawaii, public access guides that include an inventory of existing access sites, recommendations for purchasing additional sites, and original techniques to increase access have been prepared and widely distributed.

- In North Carolina, over 100 public access sites have been opened along the state's ocean and estuarine shoreline.

Obstacles - "Takings"

Despite these successes, many obstacles exist to coastal public access. One of these is expressed in two recent Supreme Court cases that concern the specific issue of constitutional "takings." In Nollan v. California Coastal Commission (1987), the Court, by a 5-4 vote, struck down, as an unconstitutional "taking," a California Coastal Commission requirement that public access to and along the coast must be provided as a condition for granting a coastal development permit. In First Evangelical Lutheran Church of Glendale v. County of Los Angeles (1987), the Court found that a private landowner may recover damages when a state government has "taken" private property through the use of a state land use regulation.

The cumulative effect of these cases may be to discourage planners from using creative land use planning techniques, such as development exactions, to obtain coastal public access sites and other public benefits.These decisions may also leave planners less inclined to adopt measures that restrict development for the sake of public safety or environmental protection because they may be forced to purchase the property or pay damages if successfully sued for a "taking" (Eichenberg, 1987). A net decrease in coastal public access may result.

Despite this scenario, most of the recent news for local governments has been promising as appellate courts have favored damage awards in only a few cases. Others have upheld restrictive land-use controls, including some based solely on aesthetic considerations (Kelly, 1989). In sum, the future rulings of many more cases will determine the actual impact of these two Supreme Court decisions.

Conclusion

In conclusion, as coastal population continues to rise, and coastal use conflicts increase in severity, the importance of providing socially satisfactory coastal public access will also magnify. Local and state governments must meet this challenge by using several means at their disposal, including federal government grant programs, state financial methods, and legal challenges, to increase and enhance public access to the Nation's coastlines.

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References

Eichenberg, T.K., 1987. Supreme court rules against public beach access. Oceanus, 30(3):83-86.

Kelly, E.C. 1989. The Quiet Evolution Continues, Journal of Planning Literature, Vol. 4, No. 2, Ohio State University Press.

NOAA. 1988. Coastal Management: Solutions to Our Nation's Coastal Problems-Technical Bulletin No. 101, Office of Ocean and Coastal Resource Management, NOAA, Department of Commerce, Washington, D.C.

_____. 1989. Proceedings of the National Coastal & Estuarine Program Managers' Meeting, Office of Ocean and Coastal Resource Management, NOAA, Department of Commerce, Washington, D.C.

_____. 1990a. Biennial Report to the Congress on Coastal Zone Management - Fiscal Years 1988 and 1989, Office of Ocean and Coastal Resource Management, NOAA, Department of Commerce, Washington, D.C

_____. 1990b. Draft OCRM Public Access Bulletin, August 20, 1990, Office of Ocean and Coastal Resource Management, NOAA, Department of Commerce, Washington, D.C., Unpublished.

Slade, D.C. 1988. Making the Public Trust Doctrine Work - First Draft Compilation, National Public Trust Study, Coastal States Organization, Washington, D.C.

_____. 1990. National Public Trust Study - State Compilation Outline, Coastal States Organization, Washington, D.C.

The Economical/Ecological Aspects of Small-Craft Harbor Construction

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Introduction

This paper will examine the various environmental and ecological considerations which must be taken into account when planning and constructing a small-craft harbor. "Small-craft" as used in this context follows the U.S. Coast Guard general guidelines of recreational and commercial vessels up to 100 gross tons and approximately 90 feet in overall length (Code of Federal Regulations, 1983). Accordingly, some of the design considerations and construction techniques associated with bulk cargo terminals and container ports, etc. will not be addressed here. Design aspects will be spoken to only where there are clear environmental/ecological ramifications associated with various options. This paper may serve as a generic overview, realizing that there are many site-specific variables associated with any form of shoreside development such as icing, tidal fluctuations, storm protection, and access. Specific areas to be addressed are siting, construction methods, the environmental effects of harbor structures, and mitigation techniques. A properly designed small-craft harbor can serve to minimize adverse environmental/ecological impacts and, in some cases, serve as an enhancement mechanism.

Harbor Siting

Proper siting is perhaps the single most important element in project development. The ideal location should be on a sheltered body of water which is deep enough to require no or minimal dredging. There should also be excellent vessel and vehicle access to adequate upland facilities with proper drainage and/or access to sewerage facilities. The physical hydrology of the site should be such that minimum erosion or siltation would result from construction of bulkheads, breakwaters, and piers. The basin should be well-flushed to maintain water quality and there should be no shellfish beds, wetlands, endangered or threatened species, or sites of archeological or cultural significance which might be impacted by harbor construction or use. In the real world, satisfying all the above requirements may be nearly impossible given the increased demand for shoreside property and possible developmental conflicts. It should be remembered that harbor impacts can also be positive since concentration of shoreline development occurs rather than scattered private docks. Harbors can also contribute to the diversity of shoreside habitat by providing substrate for fouling communities (Chmura and

Ross, 1978).

The various types and sizes of boats to be accommodated will affect the choice of harbor location and design considerations. Deeper access channels and harbor depths are required for larger power boats and sailboats with fixed keels. These types of vessels also require relatively straight access channels with broad turns and few shoreline hazards as well as proximity to open waters. Turning areas within the harbor can be smaller for outboards, double screw power boats, and sailboats because they need less room to turn than single screw power boats. These considerations will affect dredging and submerged area use (Rogers et al., 1982). The fastest growing market segment in boat sales is the 35-40 foot length range. The impact of this trend toward larger boats will be a reduction in the number of boats which can be berthed in a given area of protected water. Since aisle space and maneuvering areas also increase with the size of boats served, the spatial requirements per boat increase significantly. This translates to more harbor infrastructure costs allocated to each boat (Klancnik, 1990).

Proper flushing of the harbor basin should be considered in the siting phase of harbor development. Relevant considerations include location relative to other water bodies, ambient water quality, biological activity, total volume and expected harbor activity, and type and volume of discharge. For most cases, a two-four day flushing time is satisfactory (Boozer, 1979). Flushing time as used here indicates the amount of time required for a complete exchange of water between the harbor basin and surrounding waters to occur. This is important for dilution and dispersal of pollutants, prevention of siltation, and to maintain water quality. Harbors located within a confined area with one or two relatively narrow openings will have flushing characteristics considerably different from those located directly on larger bays or river shorelines. Areas with poor natural circulation, such as dead-end canals, should be avoided. There are formulae available for estimating the flushing characteristics for various water bodies. Variables used in these approximations include tidal cycle and range, surface area, non-tidal freshwater inflow, desired dilution factors, depths at low and high tides, salinities, and river discharge where applicable (Heinen, 1985).

Habitat loss for various species of flora and fauna must also be taken into consideration during the siting process. At one time, salt marshes were considered prime spots for harbor development because they tend to be found on sheltered shorelines. It is now known that salt marshes contribute to primary production, provide wildlife habitat and nursery grounds, and serve as a buffer zone between open waters and uplands to absorb the impacts of storm surges and rainwater runoff. Social values for natural marshes have been estimated at $50,000 to $80,000 per acre with some estuaries performing waste assimilation work of even higher value (Gosselink et al., 1974). A recent study in Florida which examined the commercial and recreational fisheries value associated with coastal wetlands, determined that the capitalized retail value averaged about $6,000 dollars per acre statewide (Bell, 1989). As a result of this awareness of the value of coastal marshes and wetlands, most coastal states in the U.S. have mandatory guidelines which must be followed to minimize impacts to these areas from any type of coastal development. This is particularly true in the southeast Atlantic and Gulf of Mexico regions, where the majority of the nation's coastal marshes and wetlands are located (NMFS, 1983).

Another environmental/ecological factor which must be considered during the siting process is the existence and proximity of shellfish beds. Shellfish are highly susceptible to siltation episodes which might occur during dredging operations and accelerated runoff due to upland construction. Bivalve shellfish are filter feeders and are, capable of concentrating pollutants, potentially making them unfit for human consumption. Oysters have been shown to exhibit pollutant levels 40 times higher than ambient waters (Loosanoff, 1965). The National Shellfish Sanitation Program (NSSP) Manual of Operations clearly states that pollution from boats is a public health problem requiring special consideration for proper classification of shellfish growing areas. This is due to aspects such as petroleum hydrocarbon spills, leachate from toxic-based bottom paints, and incidents of fresh fecal pollution which has a different pathogen-to-coliform ratio than municipal sewage (Heinen, 1985). In the absence of more stringent state guidelines, harbors should be located at least 1,000 feet from shellfish harvesting areas (NMFS, 1983). Therefore, it is important to check the NSSP classification for shellfish growing areas in the proposed harbor area if shellfish are present. The classification listings and charts are available from marine resource management agencies in shellfish producing states.

Soil characteristics is another facet of siting which should be examined carefully. If the proposed site does not have access to existing or incipient sewerage infrastructure, the soil needs to be able to support an adequate septic system. Soil type and composition also are major factors in the amount of runoff which occurs during rainfall events. Such runoff can increase pollutant loading, create turbidity and concurrent reduced biological production, and enhance siltation rates into the harbor basin necessitating more frequent dredging. Soil scientists should be consulted to determine permeation rates and building support capabilities. Test pilings are often driven during the siting process to see if waterbottoms are conducive to piling acceptance and support. This is particularly important in areas where pilings and other structures might be affected by icing conditions (Wortley, 1984).

Construction Methods and Mitigation Techniques

Dredging and dredged material disposal

Nearly all harbor development projects will require some dredging operations. Factors influencing the amount of material which must be dredged are controlling water depths, tidal range, size of vessels to be accommodated, distance to main navigation channels, and siltation rates. Like all other activities associated with harbor development, the environmental impacts associated with dredging are site-specific. Negative environmental impacts associated with dredging and disposal operations include short term increases in turbidity, temporary reductions in dissolved oxygen content, burial of organisms, disruption of existing benthic communities, creation of stagnant water conditions, and resuspension of pollutants (Chmura and Ross, 1978).

Most of the negative aspects of dredging operations can be eliminated or minimized. Indeed, in some cases dredging can be used to enhance the environmental quality of a water body in some cases by increasing flushing rates. Harbor basin design features that promote flushing are basin depths that are not deeper than connecting waters and gradually increase toward open water, basins with few vertical walls and gently rounded corners, and even bottom contours with no pockets or depressions (Heinen, 1985). Increased turbidity and burial of organisms by siltation can be minimized by the proper use of hydraulic cutter-head dredges, filters, and silt screens as opposed to unscreened mechanical dredging. The work should be scheduled so as to have the least impact on certain life stages of the surrounding biota such as fish larvae or oyster spat when such sensitive resources are present. The duration and areal extent of these impacts are a direct function of material particle size and the flushing rate (Burrage, 1988). Where possible, dredged channels should follow the course of existing channels and slips for boats with deep drafts should be built in naturally deep water. The harbor should not alter tidal circulation patterns, salinity regimes, or change related nutrient, aquatic life, and vegetation distribution patterns (NMFS, 1983).

Dredged material disposal is sometimes the hingepin on which all other components of harbor development revolve. All dredged material should be viewed as a potentially reusable resource, and all disposal plans should include provisions for access to such resources. Permanent, upland disposal sites or approved open- water sites should always be sought in preference to wetland disposal. Areas containing submerged vegetation and regularly flooded emergent vegetation should not be used as disposal sites. Dredge material from marinas should be placed on upland areas or existing diked disposal areas, when possible. Open-water and deep-water sites can be considered if beneficial uses of the dredged material are identified or if it is not economically or environmentally feasable to dispose upland. Disposal dikes should be shaped and stabilized immediately to minimize erosion and dike failure and, where possible, outfalls should be positioned to empty back into the dredged area (NMFS, 1983).

There are potential beneficial uses for dredged material provided such material is not contaminated. In undeveloped and relatively unpolluted areas, dredging has no significant affect on water quality whether diked or undiked confinement techniques are used. It follows that new habitat can sometimes be created from dredged material. There are many opportunities to restore or create wetlands with development projects, both private and public. In water bodies where wave energy is weak, artificial salt marshes can be created by planting dredged material with suitable species (Clark et al., 1980). In areas where there is no choice but to damage or remove wetland areas, this may serve as a viable mitigation technique. After identifying the major possible impacts of small-craft harbors on wetlands, Giannio and Wang (1974) stated that the major impact would be in the areas of biological production and water quality control. They suggest two methods of matching the biological production of a marsh in a harbor development:

> "The first method requires that dredge spoil from harbor construction be placed in estuarine waters in such a way that a new marsh re-establishes itself on the organically rich material. The second method involves tailoring the environment to make it attractive to biological production by fouling communities, an alternative to marsh grass as a source of food. The harbor is made attractive by flushing out pollutants with each tidal cycle, maintaining high water quality by waste collection, and providing a surface on which the organisms can prosper and multiply." (Giannio and Wang, 1974).

Both of these enhancement techniques can be achieved by using proper dredging and dredged material disposal techniques. Other mitigative measures for dredging impacts include dredging during colder months when dissolved oxygen concentrations are higher, confining discharges to the smallest practicable deposition zone to protect adjacent substrates, maintaining the same elevation as marshes and other contiguous areas to promote natural tidal flooding and flushing, and situating dredged material islands on the windward side of the dredged channel or basin (Heinen, 1985).

Bulkheads

Bulkheads are vertical, walled structures built parallel to the shoreline to protect it from erosion or to provide boat docking convenience. Bulkheads are usually made of stone, concrete, sheet metal, or wood. The most severe effects of bulkheads occur when they are constructed within or along the shores of wetlands and used to hold fill deposited on the wetland. As well as preventing free water circulation to any wetland behind it, a bulkhead can also prevent the natural seepage of groundwater into local waters. The vertical face of the bulkhead protects the upland by taking the brunt of wave energy, but in so doing, it creates reflection waves which disturb sediments and encourages scouring at the base of the bulkhead. Reflected waves may also result in increased harbor maintenance costs and discomfort for boaters (Chmura and Ross, 1978). Bulkheads, where absolutely necessary, should be built no closer to the water than the annual high water mark and preferably further landward (Clark et al., 1980).

Where possible, sloping (3:1) rip-rap, gabions, or other types of revetments should be used in place of vertical seawalls or bulkheads (NMFS, 1983). Revetments are often preferable to vertical bulkheading from a biological perspective because they provide more surface area for fouling organisms. The biota associated with these structures includes assemblages of barnacles, mussels, tunicates, sponges, amphipods, and algae. This biomass, although lower in organic content than marsh grass, is a more important source of nutrient material for other aquatic species since only 45% of the marsh production ever enters the water (Nixon et al., 1973).

Placing revetments as far upland as possible not only helps to avoid alterations to shallow intertidal and wetland areas, but also provides a vegetated buffer to filter stormwater runoff between upland facilities and the waterway. Where vertical bulkheads are necessary, they should contain weep holes, covered with a filter cloth to retain sediments and permit groundwater flow into the harbor. Problems with floating debris accumulation, shoaling, and flushing can be avoided by using rounded corners instead of sharp turns. Vegetated revetments are currently recommended as a means of maintaining a vegetation fringe along the shoreline while protecting the upland (Heinen 1985).

Breakwaters and jetties

Most but not all harbor locations will require the construction of some type of breakwater or jetty or both. These structures are designed to attenuate wave energy either from naturally occurring wind-generated waves or vessel wakes. They may or may not be connected to the shoreline and are usually oriented to provide the most effective wave reduction given the specific characteristics of the harbor site. They are generally linear structures which extend into the water and provide sheltered conditions for vessels and the harbor facilities by dissipating wave energy. They may be composed of a wide variety of materials and constructed to either sit on the bottom or float on the surface.

Since breakwaters and jetties provide calm water, they may also increase the amount of shoreline available for wetland establishment. Breakwaters and jetties are also sites where fouling communities can establish themselves. However, these structures can also have the undesired environmental/ecological impacts of creating erosion and deposition at unplanned areas if proper mitigation techniques are not utilized. In particular, the construction of bottom-based jetties may cause detrimental impacts on adjacent property if longshore or river currents exist. The reduced wave activity and concurrent sediment transport caused by breakwaters and jetties can lead to sediment deposition on the high energy side of the structure and erosion on the low energy side due to lack of trapped sediment to renourish those areas (Heikoff, 1976). Fortunately, breakwater designs exist which can provide the necessary wave reduction requirements while minimizing the negative aspects of increased siltation and erosion and maintaining desired flushing characteristics. Circulation often can be maintained by providing openings in solid (bottom-resting) breakwaters at both ends or between the structure and shore.

Alternatively, floating breakwaters can be used. Although floating breakwaters are only effective for wavelengths shorter than twice the width of the breakwater and are not effective on open coasts, they offer certain advantages over fixed breakwaters. Construction cost is nearly independent of water depth and they can be used over soft or unstable bottoms which preclude the use of fixed structures. They can be easily relocated if necessary, have minimal potential interference with fish migration and shoreline processes, and can reduce benthic habitat modification (Heinen , 1985). Many types of floating breakwaters are available for evaluation given specific harbor siting parameters. One type which was in vogue in the mid-1970's is the floating tire breakwater. This type of floating breakwater exhibits many of the desirable qualities of others, but has some of the same limitations. Maintenance requires time and money not typically invested in conventional breakwaters. They cannot be moved year round in coastal areas experiencing severe icing conditions and they do not provide the degree of wave protection of conventional (bottom-resting) breakwaters. They can be a hazard to navigation and a source of liability if not effectively marked (DeYoung, 1978). Modern marine technology has advanced to the point where floating breakwaters can now be designed and constructed to provide totally effective protection against the heavy wave action a large body of water or commercial ship traffic often produces. The new technology involves floating structures developed on sound engineering and physical principles to reduce wave forces by as much as 90%. The designs use offset reflecting surfaces to provide a mechanism for wave forces and stillwater forces to directly oppose each other (Sethness and Moore, 1989).

Piers and access routes

Piers and access routes can have detrimental effects on wetlands and submerged areas within the harbor basin by blocking light penetration and water flow. As happens with bulkheads and breakwaters, water flow may be altered, especially if piers are supported by solid bases. Wood, a major component of many piers, pilings, and docks, is usually treated with a preservative which discourages the establishment of fouling organisms and marine borers. To be effective, these preservatives must be of a poisonous nature and of low water solubility which results in a slow leaching rate (Chmura and Ross, 1978). Depending upon tidal ranges at the harbor site, piers may be built over or float on the water. They should be built long enough to reach deeper water in order to minimize the amount of required dredging in the basin.

The potential environmental/ecological impacts of piers and pier construction can be avoided or reduced by using alternative materials such as concrete-filled steel-reinforced PVC, plastics, or other materials. Highly refined (grade one) creosote or alternative preservatives which minimize chemical leaching should be used when wood is used as a construction material. Docks and piers can be elevated as high as possible, oriented in a north- south direction, and minimized in width to allow for maximum sunlight penetration. Solid structures which block water circulation should be avoided (Heinen, 1985).

Traditionally, floating piers have used polystyrene and styrofoam billets or metal barrels to maintain buoyancy. These materials have limitations. Metal barrels are subject to rusting, particularly in marine environments. Polystyrenes and styrofoam are subject to attack by wave action, burrowing by marine animals, abrasion, and degradation from chemicals or fuel in the water around dock areas. The byproduct of this deterioration is small plastic particles which are aesthetically unappealing and hazardous to aquatic life. One very successful method to overcome these floating dock problems is the use of glass fiber reinforced concrete docks. These docks completely encapsulate larger single blocks of polystyrene with glass reinforced concrete. This type of floating dock system has the added advantage of being able to be left in the water year round in areas with potential icing conditions (Schirren, 1989).

During construction, the installation of piles may affect the surrounding soil mass. Driven piles, used predominantly in small-craft harbors, develop the greatest uplift resistance. This is the reason test piles are routinely emplaced during the siting phase of project development. Piles in sandy soils behave much differently than in soils with a higher clay component. The importance of soil tests of both upland and waterbottom areas cannot be overemphasized (Wortley, 1984). Piling and substrate displacement can affect benthic and fouling communities.

Access routes which must cross wetland areas, both vehicular and pedestrian, should be elevated so as not to restrict, impede, impound, or otherwise interfere with natural water flows. Essentially, the cross-sectional area of a body of water should not be effectively reduced by abutments, support piers, pilings or other structures. When possible, existing upland areas should be used for these access routes (Clark et al., 1980).

Parking areas and support facilities

Because harbors are directly adjacent to the waterbodies they service, the effects of surface runoff must be given high priority during the design of upland support facilities. This runoff may contain pollutants and may increase turbidity in the harbor basin and surrounding waters, decreasing biological productivity. The runoff may be naturally induced by rainfall or artificially induced by activities such as boat and equipment washing and lawn watering.

Some of the support facilities associated with small-craft harbors include launching ramps, fuel docks, hull and engine repair shops, sales rooms for boats, engines, and accessories, open or enclosed dry-land boat storage, boat haul out facilities (such as a travel lift), restrooms and shower rooms, and restaurants. Often there are also bait and tackle shops, laundry facilities, and propane gas and bulk ice facilities. The general design rule for parking lots is two spaces per vessel. Most of these support facilities are non-porous and contribute to runoff potential (Chmura and Ross, 1978).

Space for these support facilities must be allocated during the siting phase of project development. Some larger facilities have missed an opportunity to capitalize on the extra income generated by support services by not looking farther than the harbor basin during the siting and design phase. Some structures which can potentially contribute greatly to runoff-associated problems are probably unnecessary for modern harbor development. A current example is the continued development of covered slips which are indigenous to the south and rarely found on the Atlantic or Pacific coasts. The cost of developing covered slips is clearly substantially greater than that incurred for open slips. The primary reason for constructing them in the past was to prevent the hot sun from warping wooden boats. Today, however, fiberglass has substantially replaced wood. In addition, the covered slip has reduced flexibility because it cannot be used for sailboats, vessels with high superstructures such as tuna towers, or vessels with fixed outriggers such as trawlers (Crompton and Ditton, 1975).

An effective harbor design and stormwater management plan is essential to maintaining water quality within the harbor. Stormwater runoff impacts can be mitigated through proper control measures incorporated during harbor design. Vegetated buffers such as marsh, mangrove or other natural vegetation on the site should be maintained between land and water areas. Clearing should be kept to a minimum. Erosion and sediment controls should be installed before upland construction begins. Porous surfaces such as crushed stone or shell should be used whenever possible, particularly in parking areas. Soil percolation rates are the governing factor here and a stormwater collection and discharge system may have to be installed if percolation rates are low. When outfalls are necessary, they should be located in areas with high flushing rates. Efforts should be made to retain at least the first inch of rainfall and route runoff through swales, wetlands, retention and detention ponds, or other systems that will increase retention time to concentrate potential pollutants, decrease runoff velocity, increase infiltration, and allow suspended solids to settle and remove pollutants (Boozer, 1979). For upland hydrologic systems, all components should be conserved in as near the natural condition as possible. The components needing protection include creeks, streams, swales, sloughs, and other permanent and temporary surface channels as well as all marshes, swamps, and other permanent and temporary wetland units. In addition, all existing ponds, lakes, and other stillwater areas that are connected permanently or intermittently with the shorelands systems should be maintained. A topographic profile of the harbor site, particularly the upland portion, can be a valuable tool in establishing a stormwater retention site in the event natural basins are not present. Natural drainage patterns should be protected wherever practicable (Clark et al., 1980).

Fuel docks and launching ramps are the primary sources for small spills of oil and fuel. Spills at fuel docks can be minimized by using fuel pumps with back pressure automatic cut- off valves. Cut-off valves should be available at the fuel dock and elsewhere in the harbor. Under EPA regulations that took effect in December 1988, small-craft harbor owners were given ten years to add corrosion protection to existing steel tanks and piping and to install protection against spills and overfills. All systems must be tested for leaks and replaced or repaired if problems are found. Owners are also required to install new leak detection systems by 1993. Storage tanks installed after December, 1988 must meet new requirements for spill and overfill prevention, corrosion protection, and leak protection. The intent of these regulations is to prevent fuel or other contents held in steel tanks from leaking into the ground (Kleevic, 1990).

If the harbor is in an area where public sewer service can be obtained, this service should be used. Where septic tanks are used, they should be located in suitable soils far enough from the harbor basin and adjacent waters and designed with sufficient capacity to prevent the leaching of nutrients or contaminants. Wastes from vessel pumpouts should be handled separately as the chemical disinfectants used can destroy the bacteria necessary to decompose wastes in onshore treatment facilities (Heinen, 1985).

Boat ramps should be given special consideration during the siting and design phase of the project. According to the latest statistics over half of all boats in the United States, an estimated total of 5,987,000, are transported on trailers (NMMA, 1989). Space should be left in the ramp area for adequate maneuvering of vehicles with trailers. The ramp(s) should slope no more than 12% and the breakover angle (change in slope from horizontal) should be no more than 6°. This will minimize discharge of exhaust in or near the waterway and avoid the adverse aesthetic and environmental impact of tow vehicle tire material being left on the ramp (Hauf and Boaz, 1970). Ramp sites should be located along shorelines containing minimal wetland vegetation and adjacent to waters of adequate navigational depths. They should be restricted to areas that do not require dredging to gain access to navigable waters where feasible. When boat ramps are built in proximity to grassbeds, channel routes should be clearly marked to avoid damage to the grassbeds by propellers and propwash (NMFS, 1983).

Summary

The need for more small-craft harbors is evident. In the State of Florida, there is a shortfall of 90,000 slips and moorings. In Michigan, a study indicated a shortfall of 29,000 slips and moorings and a resultant loss of 15,000 new boat sales representing approximately $40 million in lost economic opportunity (Gilmour, 1989). These are not isolated or extreme situations. The demand for boating facilities is expected to expand as upward trends in income levels and leisure time combine with technological developments in vessels which make equipment more reliable, more mobile, and less costly.

Some national trends experienced in the 1980's will continue through this decade. It is expected that boat registrations will remain at a relatively stable rate of 650,000 boats per year and that new major facilities (i.e., more than 250 berths) to be built each year will remain in the 150 to 200 marinas per year range. The reason these rates have not increased along with the popularity of boating is that natural harbors and other environmentally suitable sites have already been developed (Klancnik, 1990).

Addressing potential environmental/ecological impacts of small-craft harbor construction in the coastal zone necessitates a concise and current knowledge of biological interactions, water chemistry, hydrology, geology, engineering practices, and economics. The placement of a shoreline structure in a coastal environment can result in habitat loss due to construction and/or consequences subsequent to placement. It must be remembered that all facets of small-craft harbors are site-specific.

While construction and placement of harbors can alter the natural environment, the addition of harbor structures can also provide habitat that can be beneficial in less productive environments. Structures such as revetments, breakwaters, and piers can act as artificial reefs and supply substrate for animal colonization. The tradeoffs in species diversity and biological production are important considerations in any small craft harbor project. The environmental/ecological aspects of small-craft harbor construction are an important part of the overall project planning and implementation process.

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References

Bell, F.W. 1989. Application of Wetland Valuation Theory to Florida Fisheries. Report Number 95. Florida Sea Grant College. Gainesville, FL. 118 p.

Boozer, A.C. 1979. A Review of the Impacts of Coastal Marine Siting, Construction, and Activities as Related to Water Quality Considerations. South Carolina Department of Health and Environmental Control, Bureau of Field and Analytical Services, Division of Biological and Special Services. Colombia, SC. 30 p.

Burrage, D.D.(ed.) 1988. The Mississippi Oyster Industry: Past, Present, and Future. Proceedings of a Conference Held in Biloxi, Mississippi, December 1-2, 1988. MASGP-88-048. Mississippi/ Alabama Sea Grant Consortium, Ocean Springs, MS. pp. 30-34.

Chmura, G.L. and N.W. Ross. 1978. The Environmental Impacts of Marinas and Their Boats, A Literature Review with Management Considerations. University of Rhode Island Marine Memorandum 45. Kingston, RI. 32 p.

Clark J., J.S. Banta, and J.A. Zinn, 1980. Coastal Environmental Management; Guidelines for Conservation of Resources and Protection against Storm Hazards. Prepared for Council on Environmental Quality. Washington, D.C. 161 p.

Crompton, J.L. and R.B. Ditton, 1975. A Feasibility, Management and Economic Study of Marinas on the Texas Gulf Coast. Texas A & M University, College Station, TX. TAMU-SG-76-201. 51 p.

DeYoung, B. 1978. Enhancing Wave Protection with Floating Tire Breakwaters. New York State College of Agriculture and Life Sciences, Information Bulletin 139, Physical Sciences, Sea Grant I. Stony Brook, NY. 29 p.

Giannio, S.P. and H. Wang. 1974. Engineering Considerations for Marinas in Tidal Marshes. College of Marine Studies, University of Delaware, Newark, Delaware.

Gilmour, G. 1989. Marina Development. Marina Dockage Vol. 4 No. 2. July/August. Van Zevern Publications, Inc., Skokie, IL. pp. 16-17.

Goodwin, R.F. (ed.) 1989. Boating & Moorage In the '90s. Proceedings of a Conference, October 19-21, 1988, Everett, Washington. WSG-WO-89-1. Marine Advisory Services, Washington Sea Grant Program, College of Ocean and Fisheries Science, University of Washington, Seattle, WA. 201 p.

Gosselink, J.G., E.R. Odum, and R.M. Pope. 1974. The Value of the Tidal Marsh. Publication No. LSU-SG-74-03, Center for Wetland Resources, Louisiana State University, Baton Rouge, LA. 30 p.

Hauf, H.D. and J.N. Boaz. 1970. Architectural Graphic Standards. John Wiley & Sons. New York, NY.

Heikoff, J. M. 1976. Politics of Shoreline Erosion: Westhampton Beach. Ann Arbor Science Publishers, Inc. Anne Arbor, MI.

Heinen, E.T. 1985. Coastal Marinas Assessment Handbook. Environmental Protection Agency, Region IV, Atlanta, Georgia.

Klancnik, F.A. 1990. Planning marinas for the 1990's. Marina Dockage Vol. 3, No. 1. January/February Van Zevern Publications, Inc., Skokie, IL.

Kleevic, G. 1990. Latest EPA guides for fuel tanks. Marina Dockage Vol. 3, No. 3. May/June. Van Zevern Publications, Inc., Skokie, IL.

Loosanoff, V.L. 1965. The American or Eastern Oyster. U.S. Fish and Wildlife Service, Circular 205. Washington, D.C. 36 p.

National Marine Fisheries Service. 1983. Guidelines for Proposed Wetland Alterations in the Southeast Region of the U.S. National Marine Fisheries Service Southeast Fisheries Center, St. Petersburg, FL. 13 p.

National Marine Manufacturers Association. 1989. Statistical and Research Department 1989. Boat and Motor Dealer, 1989 Market Manual. Van Zevern Publications, Inc., Skokie, IL. pp. 37.

National Shellfish Sanitation Program. 1989. U.S. Dept. of Health and Human Services Public Health Services, Food and Drug Administration, Washington, DC. 317 pp.

Nixon, S.W., C.A. Oviatt, and S.L. Northby. 1973. Ecology of Small Boat Marinas. Marine Technical Report, Series No. 5, University of Rhode Island. Kingston, RI. 20 p.

Rogers, J.E., R.H. Golden, and G.S. Halpern, 1982. Developing a Marina in New Jersey: A Handbook. Prepared for the New Jersey Department of Environmental Protection, Division of Coastal Resources, Rockville, MD.

Schirren, C. 1989. New glass fiber reinforced concrete makes the grade for docks. Marina Dockage Vol. 2 No. 1. Van Zevern Publications, Inc., Skokie, IL. January.

Sethness, D. and W. Moore 1989. New floating breakwaters use state-of-the-art dockage technology. Marina Dockage Vol. 2 No. 3. May/June. Van Zevern Publications, Inc., Skokie, IL.

Wortley, C.A., 1984. Great Lakes Small-Craft Harbor and Structure Design for Ice Conditions: An Engineering Manual. University of Wisconsin Sea Grant Institute. WIS-SG-84-426. Madison, WI. 227 p.

______, Code of Federal Regulations, 1983. Title 46, Parts 166 to 199, Office of the Federal Register National Archives and Records Service, General Services Administration, Washington, D.C.

Port Development--Its Relationship to our Coastal Experience

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Introduction

As we attempt to address such broad and ominous topics as coastal experience and port development, I am struck by how diverse our panel topics are; not to mention the broad mandate and issues that the whole conference is addressing. As I strive to give you what is sometimes a different perspective from the more mainstream coastal topics, I am reminded of the last conference which focused specifically on ports and harbors, and symbolically was held in our country's oldest port city, Boston. I think it would be safe to say that when coastal conferences are being planned and topics for workshops being organized, the word "port development" is often omitted. The first call for papers for this conference, in fact, did not list "port development" as one of its themes.

I give this preamble as an example of some of the difficulties we all face in integrating planning of the various aspects of port and coastal development. Historically, ports and their governing bodies were usually seperate entities and were not thought of as part of the process for coastal and harbor development. I hark back to the 1988 Coastal Society conference because of its commitment and forward thinking in bringing the theme of ports to the mainstream of the Society and for making that theme an integral part of the coastal experience and coastal planning.

Not only does the conference cover a broad canvas, but port development is a complex concept and I propose that it includes almost all aspects of landside and coastal issues that our major coastal cities face. Because the image of a port is usually oriented to the water and the image of a harbor is landbased, our thinking and planning for the future of our port cities need to mesh this image; otherwise we will not understand their relationship and how best to work in tandem on our shared issues.

It has been my experience, even with a captive audience with heightened coastal awareness, that the least understood part of our coastal world is the working port. Often a port signifies many and conflicting uses to a region and the citizenry of that region. It is different than a harbor, yet interrelated. First and foremost it is a public resource, a source of commerce and the livelihood to thousands of people who work in the maritime industry. It is the maritime entrance to a city and a place for recreation, and to some, a view to be developed. In Boston, the port evokes images of sea-faring adventurers, the Boston Tea Party, and the center of colonial America.

Background

Port cities developed during the colonial period because of the geography and natural deep water harbors in the region. Boston and Philadelphia became the historic and commercial centers of colonial America because of their natural harbors and their relatively short sailing times to England compared with other colonial cities. The quest for new trade routes led to both the economic growth of the new country and eventually contributed to the degradation of the coastal waters. Much of our country's development can be traced through the history of water transportation. Our coastal heritage parallels the development of the nation's trade and gives us the framework for understanding where we have been. But managing our coastal and marine environment for the future must be carried out in a very different manner.

In the early 1700's, three of the preeminent port cities were Boston, Philadelphia, and Charleston. In 1990, there are 188 deep-water commercial seaports along the United States coastal waters and 1,435 navigable waterways, harbors, and riverways whose usage and quality are interrelated. While commercial seaports comprise only 2% of America's shoreline, or approximately 1,650 miles of the coast, they are the keystone of international trade (Hershman, 1988). Approximately 50% of the US population lives near a coastal city and in the year 2000, 80% of the population will be along the water's edge, placing even greater demands on coastal and port cities.

Traditionally, port development has been shared by public and private entities. Channel dredging is the responsibility of the U.S. Army Corps of Engineers, but most port development rests with the local authority and private industry. Many countries, such as Japan and Canada, have central governing bodies, but the United States has no one agency responsible for port planning on a national basis.

Some of this division was changed by the passage of the Water Resources Development Act of 1986 (P.L. 99-662), which significantly altered the relationship of federal, state, and local authorities around improvement in harbor and waterway maintenance (Pisani, 1989). So, where does that lead us in governing our coastal resources during the next 10 years and into the 21st-Century?

With all due respect to maritime and coastal history, the past models, if there were any, are obsolete. We have all learned that our coastal resources are one of the most endangered and fragile national treasures. Coastal degradation is not being reversed in most areas and the demands on the landside are overwhelming. Federal funding is becoming almost nonexistent and cities and states, particularly in the Northeast with its aging infrastructure, are finding the burden insurmountable. None of us has the simple solution but, as a case study, I would like to present some of the examples from Massachusetts that have worked, or at least people are working at making them work. But first, I would like to outline a few more concepts about ports.

What is a Port?

In the past, this query would be very simple to answer: a port was the transfer point for cargo and passenger traffic among vessels. But ports today are much more than that. They are one of the primary economic generators and resources in a region through which most of our country's and the world's international trade is executed. They are clearly part of the fabric of an urban area, whose development is interrelated to the management of the port area.

Ports are both public entities and competitive businesses, competing with each other for commerce and having to deliver a service at a market price with efficient and cost effective management. Ports as transfer points for international trade are the transportation links which are vital to that trade, which is estimated to be 25% of the U.S. Gross National Product. They are also essential to the national defense of the United States, as staging points for military deployments and reinforcement and for the handling of commercial cargo in support of our allies. Prior to the Persian Gulf crisis, US foreign trade was projected to exceed one billion tons in the 1990's (Ricklefs, 1989). The role of shipping in world trade and military needs has been brought into the spotlight with this recent international event.

Now that the economic definition of a port has been delineated, I would like to apply the concept of a port to basic bread and butter ideas. How many of us know how our car, our spirits, and probably our shoes and many of our clothes enter our lives? Chances are that if it was imported, it came through the Port of Boston, the Port of New York and New Jersey, the Port of Los Angeles, or the Port of Houston--in a container and loaded on a double stack train or onto a truck and then to its final destination. Do you plant bulbs in October? One of the largest ships on the North Atlantic, the Atlantic Class vessel which calls on the Port of Boston each Tuesday, was held in its European port six hours for 25 containers of Holland tulips bulbs to be loaded. If the bulbs did not make that sailing, both the Dutch economy and American gardeners would have been negatively affected. I know most visitors and certainly residents have strolled along Quincy Market in Boston or the Harborfront in Baltimore, but few have ventured across the other side of the expressway to watch a container ship come into the terminal.

Governance and Coordination

As with all complex organisms, ports do not and should not operate in a vacuum or as a seperate entity. We are all too aware of the demands placed on our port cities' infrastructure, both on the water side and the landside. The governance and stewardship of ports embody some of the most serious environmental issues that our nation and world face. Because ports represent a complex mixture of commercial, urban, marine, and cultural users and uses, they demand a stewardship that protects, revitalizes, and maintains their integrity and purpose. In the last several decades, ports have made substantial capital investments and used considerable resources toward improving the maritime properties and in addressing a wide gamut of environmental issues. This investment benefitted not just the port community but the port city as a whole.

Many, if not all the dilemmas that confront coastal planners also confront port planners: wetlands protection; coastal degradation; recreational use; coastal zone management; public access; disposal of dredged material; oil spill management; and maintenance of our nation's transportation corridors.

Proper disposal of dredged material is the foremost environmental dilemma facing US ports during the 1990's. Contaminated sediments, a relatively new environmental issue facing ports, occur in channel dredging projects and the development of the shore. Ports face critical challenges in maintaining the development necessary for their operation while sustaining the goal of no net loss of critical wetlands.

In Massachusetts alone, we have over 20 city, state, and federal jurisdictions overseeing the myriad web that governs our waterfront. And yet there are still gaps--such as responsibility for developing adequate rail access to the port to relieve the burden of transporting cargo on our city and state roads and highways. This issue is, not surprisingly, a major environmental issue for all city and waterfront development.

Most ports are located within dense urban areas which severely limit their ability to plan better rail and truck access and protect shrinking waterfront sites for maritime use. One of the most pressing challenges for ports is the competing use for valuable waterfront land. Once a hotel or condominium graces that site, the maritime industrial use is lost for the future.

On the landside, a port requires a range of backland services such as trucking, ship repair, and storage, which are integral components of a port's ability to function and operate productively. As ships become larger, there is a rising demand for landside space for containers, intermodal rail and truck facilities, and all the services that accompany large operations.

The changing role and importance of ports and their coordination with city, state, and federal agencies can be traced to the changing attitudes toward our waterfront legacy. In the 1970's, urban waterfronts were being rediscovered across the United States, as witnessed by the Quincy Marketplace development in Boston and the renaissance of the Baltimore waterfront. Industrial and abandoned maritime properties were being reclaimed for residential, commercial, and office uses that threatened to permanently displace cargo handling activities.

A nascent environmental movement sponsored legislation which helped to alter public perceptions of appropriate waterfront land uses. The federal commitment to coastal zone management placed the burden of justifying proposed waterfront land uses upon property owners.

Again, to use Massachusetts and the Port of Boston as a case history, the city and state have developed compatible zoning regulations which mandate preservation of certain maritime economic reserve zones for maritime industrial use. This example has been followed in several other port cities. The Massachusetts Port Authority invested over $240 million during the last decade in its waterfront properties. This investment was not generated from state, city, or federal dollars, but from user fees, rents, and independent bonding revenue. Each ton of cargo handled at the Port of Boston's seaport facilities created $985 in regional economic benefits. The direct and indirect ecomomic benefits of seaport facilities are $1.3 billion per year. When appropriate and feasible, properties in Designated Port Areas are purchased to support and provide working waterfront activities.

Beyond the broad mandate of managing and operating public terminals, ports share a variety of important but secondary goals:

*port advocate and planner;

*promoter of water-dependent uses, e.g., capital investment in facilites for fish processing and lobster industries; assistance with water transportation facilities, such as the Airport Water Shuttle operations in Boston;

*improver of port acess - good inland transportation infrastructure, which has a profound environmental impact on the area surrounding port facilities;

*redeveloper of obsolete properties; provider of public access to the waterfront - whenever feasible and appropiate, public open space and access to the waterfront.

The issues are not becoming easier or less costly to solve. We must all work toward a way to balance multiple demands and use of our coastal waters and land, to work at solving the issues together, to lessen the jurisdictional battles in doing so, and to respond and react to environmental, community, and economic needs of our port cities.

References

Hershman, M.J. (ed.) 1988. Urban Ports and Harbor Management Taylor & Francis. New York.

Pisani, J.M. 1989. Port Development in the United States. The IAPH Foundation. Tokyo.

Ricklefs, J. 1989. Many storms in a port. Oceanus. V. 32, N. 3. Fall, 1989.

Membrane Structures in Water for Fisheries Development and Environmental Protection

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Abstract

In Japan, one can see long linear, flexible floats in the vicinity of all underwater construction sites. Canvas sheets are installed vertically beneath these floats in order to prevent resuspended sediment particles from being advected away from the construction site. This paper presents typical examples of silt protector sheets which are installed at construction sites, reviews test data on their effectiveness, and discusses possible new applications of this technology.

Silt Protector Sheets

Silt protector sheets are canvas sheets made of synthetic fibers and coated with synthetic resins. These sheets have low permeabilities and are designed to trap or limit the dispersal of soil particles injected into the water column during underwater construction projects. The several types of silt protector sheets are described below.

(a) self-standing type

Typically, a silt protector sheet is suspended from floats at the water surface, with the bottom edge hung with chain to stretch the sheet vertically. In cases where large amounts of suspended material are anticipated, the bottom chain is replaced with by a large-diameter sand removal pipe (Fig. 1) The upper edge of the self-standing design need not be at the water surface. If circumstances so dictate, adjustments to floatation levels are used to regulate the height off the bottom of the top edge of the sheet.

(b) large depth type

This type of silt protector consists of two separate sheets, as shown in Figure 2. One sheet generally hangs vertically from the surface and the other is a self-standing unit of the type described above. At substantial depths, total acting forces on the sheet due to water flow become large enough to make a single sheet deployment problematic. In designing multiple sheet deployments in deep water situations, several factors are considered, including which of the sheets (surface or bottom) is placed in the upstream position, the optimal horizontal distance between the sheets, and the optimal height ratio of the two sheets. Based on experiments with aerial flow models, numerical simulations, and hydraulic model tests, maximum effectiveness is produced when the self-standing unit is in the upstream position, the height of each sheet is approximately one-half the water depth, and the horizontal distance between the sheets is more than twice the water depth (Kano et al., 1989).

Approximately 9.0 km of this style of silt protector was installed at a land reclamation project at the new Osaka International Airport. The curtain enclosed the reclamation area, protecting nearby fishing grounds from suspended sediments associated with the project.

(c) submerge and refloat type

At construction sites where vessels must pass through the area where the protector sheet is deployed, generally the case with reclamation and dredging projects, this type of silt protector is required (Fig. 3).

(d) sites with large water level fluctuations

A silt protector such as that shown in Figure 4 is used at sites characterized by large water level fluctuations. Such a design controls the amount of slack produced in the sheet during periods of low water.

(e) bucket type

This type of silt protector is attached directly to the dredge in reclamation or dredging projects (Fig. 5). It is used in combination with one of the above types of silt protectors, which is used to enclose a larger region around the dredging area, as shown in Figure 6.

Reclaiming a Pond in a River Using a Silt Protector

The Sumida River, which flows through the center of the Tokyo metropolis, is highly polluted by sewage and industrial wastewater. The biological community of the river is severely stressed. Recently, Arakawa Ward of the Tokyo metropolis initiated planning for a major development along the riverfront. One component of this development project will be the Arakawa Play Garden, which is to be constructed on the riverbank and will feature the creation of aquatic and riparian habitats to attract fishes and other organisms.

The Sumida is a tidal river with maximum flow velocities on the ebb of spring tides of nearly 4.0 m/s. This high energy environment, and the heavy use of the Sumida by commercial vessels, indicated to planners that it would be impossible to improve aquatic habitats of the entire river basin at one time. Ward planners decided to focus primarily on improving dissolved oxygen concentrations in an enclosed basin to be constructed along a stretch of the river in the downtown area. The fish species that planners expect to attract to the basin are gibel and carp. Aeration by bubbling at the center of the basin is planned, but the impacts of the rapidly flowing water outside the enclosing silt protector was unknown. Hydraulic model tests were conducted to determine the water maintaining capacity of the silt protector sheets and the effects of the sheets on the convection of water induced by the aeration process. A plain view of the enclosure and related facilities of the hydraulic model test is shown in Figure 7.

The results of the hydraulic model test showed that water exchange through the silt protector was quite small; movement of aerated water through the silt protector curtain was minimal. The enclosing silt protector confined and accelerated convection in the basin. Based on this demonstration of the effectiveness of silt protector sheets in improving water quality, the project will be completed in the coming financial year.

Other Possible Uses of Silt Protector Sheets

(a) submerged fish habitat structure

In most cases, artificial fishery habitat structures are installed on the bottom of a lake, river, or coastal waterbody, although surface-floating structures have also been developed for this purpose. Mid-water locations are often desirable for habitat structures designed for certain pelagic fish species. However, due to construction and maintenance difficulties, mid-water artificial habitats are not much used. Such structures, if fabricated from membrane material, would probably be relatively simple to install and have low maintenance requirements. A large bag constructed of silt protector sheets and filled with sufficient water to render it neutrally buoyant would be relatively easy to locate and tether in a mid-water location (Fig. 8).

(b) localized water quality improvement

This is a variation of the Sumida River project. Clean water from a well is continuously supplied to a degraded tidal basin enclosed with silt protector sheets. Degraded water inside the basin would gradually pass through the sheet and be displaced by the cleaner water (Fig. 9).

Problems Associated With Silt Protector Sheet Technology

Evidence indicates that the strength of silt protector sheets gradually decreases during prolonged submerged exposures. Additionally, the sheets are attractive to various biofouling organisms. Strength deterioration and biofouling are problems limiting the further application of this technology in aquatic systems. Submergence tests over a 3-year period indicate that the nature of the coating material used on the sheets plays an important role in the durability of the sheet and its susceptibility to marine fouling (Minami et al., 1990).

References

Kano, T., Y. Honjo, and H. Kawamoto. 1989. Hydraulic Model Studies on Effective Installation Methods of Silt Protector Sheets for Large Depth Working Sites. Proceedings of Coastal Zone '89 Conference, ASCE.

___, M. Satomura, S. Kobayashi, and H. Tamaru. 1990. Hydraulic Model Test for the Function of Facilities to Create Livable Environments for Fishes at a Polluted urban River. Proc. Int'l. Conference on Physical Modelling of Transport and Dispersion. IAHR and ASCE.

Minami, H., H. Toyoda, S. Segawa, and T. Kano. 1990. Investigation of Marine Fouling Characteristics and Mechanical Properties Changes with the Progress of Time to Submerged Membrane Materials for Marine Construction. Fish. Engineering, Vol. 26, No. 1. (in Japanese)

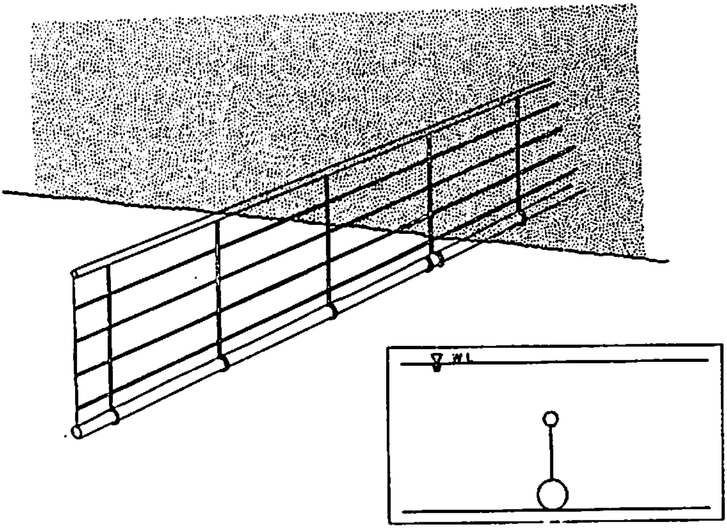

Fig. 1 Self Standing Type

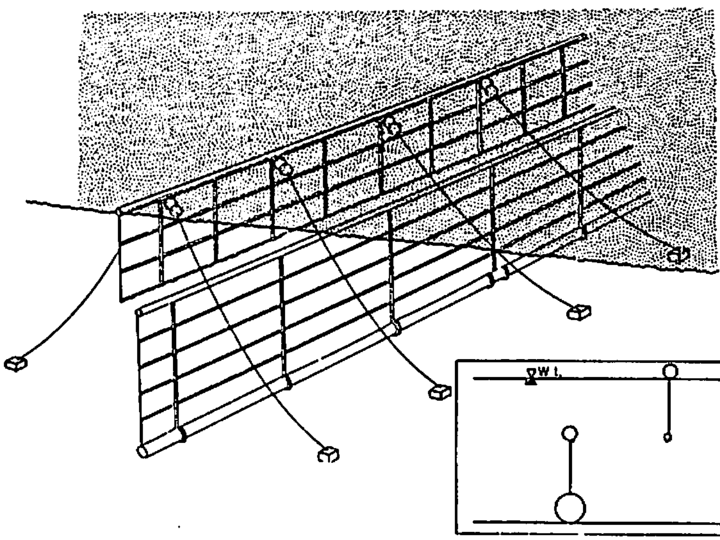

Fig. 2 Large Depth Type

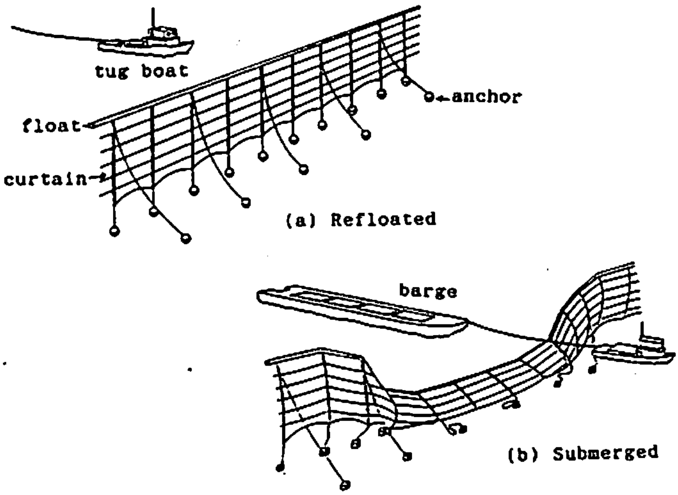

Fig. 3 Submerge and Refloat Type

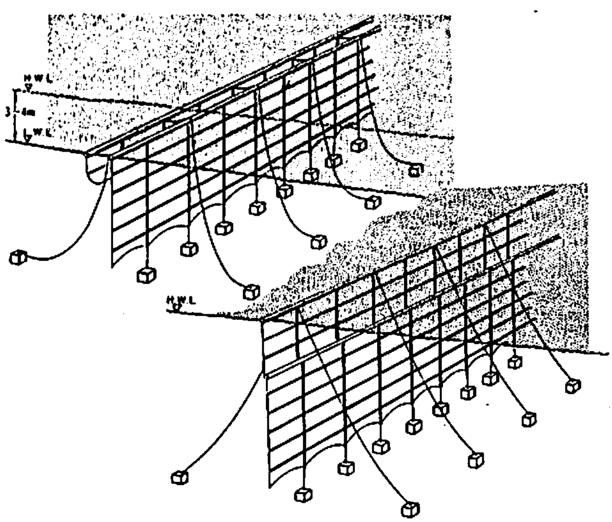

Fig. 4 For Large Fluctuating Site

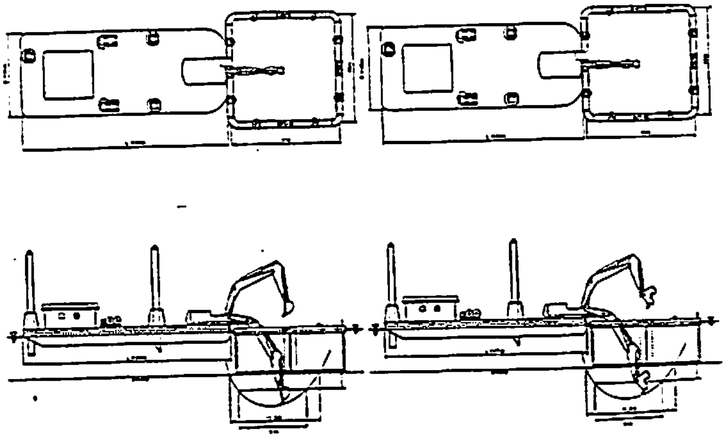

Fig. 5 Dredging Machine and Bucket Silt Protector

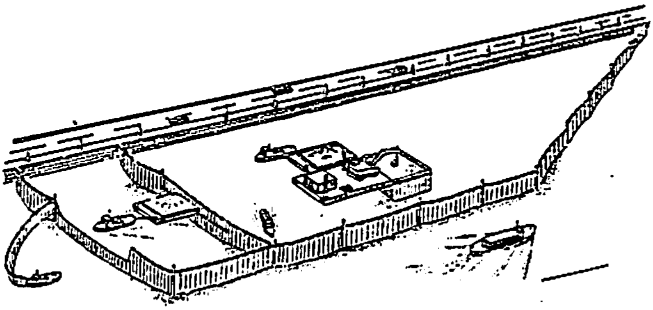

Fig. 6 Bird Eye View of Dredging Works

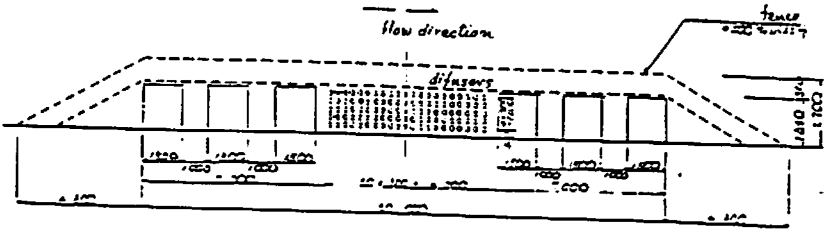

Fig. 7 Plain View of Enclosure and Facilities

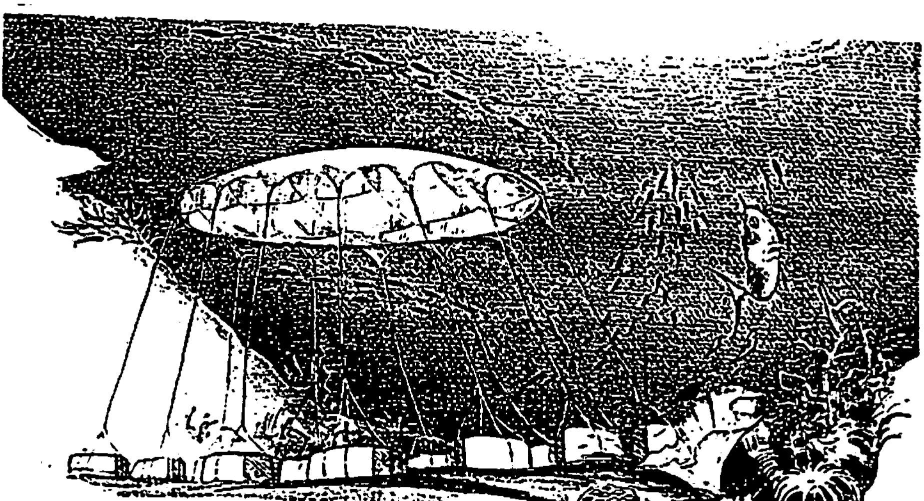

Fig. 8 Submerged Fish Habitat Structure

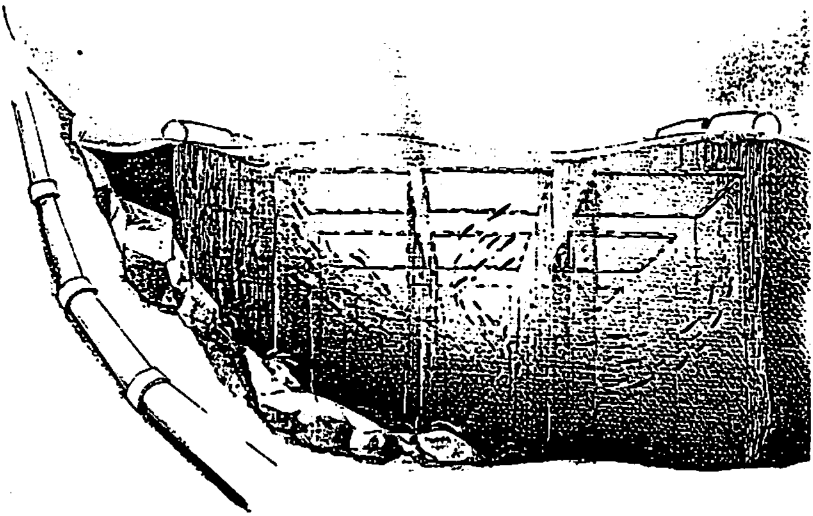

Fig. 9 Clean Water Basin Using Silt Protector

Offshore Oil and Gas Problems from International and Industry Perspectives

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There is an old Bedouin saying, "It is not every cloud that brings rain." With less than three months having elapsed since Iraq's invasion of Kuwait, it is difficult to draw any long-term conclusions just yet. Nevertheless, we already know that everything is changed.

On 02 August 1990 the world was reminded that oil is the closest thing we have to industrial oxygen (Figure l). Looking at some of the macro trends, we see that crude oil prices in the United States have been over $40/barrel this month (Figure 2). At the same time, U.S. crude oil production has fallen dramatically by 2 million barrels a day (mbd) since 1985, from over 9 mbd to about 7 mbd. The nation's dependence on foreign oil has increased 60% since 1985 and foreign oil now accounts for half of U.S. consumption.

The combined oil production of Iraq and Kuwait was approximately 4.8 mbd per day just before the embargo imposed by the United Nations Security Council. The gross shortfall in world supply caused by the embargo is about 4 mbd. While other OPEC members may have the potential to make up for a temporary shortage of up to 3.5 mbd, from a policy standpoint it seems unlikely that all countries will increase production to full capacity.

The Bush Administration's response to the supply shortfall can be seen in Table 1, which shows 607,500 barrels per day savings under the category of crude oil production increases and fuel switching, and another 530,000 barrels per day saved by means of conservation and efficiency measures. Note that the Department of Energy's schedule refers to all these items as savings goals. None of the savings is guaranteed and they all require time and a good deal of luck and volunteerism.

Going back to the decline in U.S. production, (Figure 4) what everyone seems to be missing is the fact that there is absolutely no evidence that this decline will cease. In fact, the current estimate is that we will lose another 600,000 barrels per day of production in 1990, which will be only partially offset by those savings on the Bush Administration's wish list likely to come about.

Successive government administrations, the Congress, and the media have missed the fact that, had the invasion of Kuwait never occurred, we would still have a ticking time bomb in our midst, namely, the rapid decline in domestic oil production initiated in 1986 with the shutting in or abandonment of marginal wells as the result of $15/barrel and lower oil prices. Put another way, during the past five years we have been creating the domestic equivalent of the Iraq/Kuwait embargo.

Figure 5 shows that the current rig count in the United States of around 1,000 rigs is not only well below the ten-year average of 2,500 rigs running, but also well below the fifty year average of 1,800 for the years 1940 - 1989. Simultaneous with the production drop of 1986, the rig count collapsed (Figure 6). Given the inevitable lag effect, the impact of that collapse was certain to arrive. It did, three years later in 1989, when domestic crude oil production fell dramatically by 600,000 barrels per day. This is why I think the government's production projection for the 1990's is excessively optimistic. I don't see how it is possible to keep production essentially flat for seven years when the number of rigs operating is below the fifty year average for all this time. If one accepts the theory that 1989 was 1986 arriving, time-delayed, it is not difficult to guess what the country has in store for 1990, 1991, and 1992 since the rig count for 1987, 1988, and 1989 is now history. We need to plan on similar production drops for the next several years. In fact, the most recent 1990 domestic production figures only reinforce this fact. According to the latest API figures, the U.S. oil production has finally slipped below 7 mbd and has lost an additional 400,000 barrels per day in the first six months of 1990. The United States will run out of oil if we are not drilling for it.

Government policy makers and the media have failed to separate the decline in U.S. oil production caused by the low rig count from the notion that there are no more oil reserves to be found in this country. I'm sure you've seen all the "no more oil" stories in the media in recent months The truth is that there is still a lot more oil to be found in the United States if we just put rigs to work looking for it.

For example, if we look at the history of U.S. reserves found in the past 125 years (Figure 7), we see that the average annual amount of oil and gas equivalent barrels found in the past 25 years far surpasses those found in the first 100 years, 2.23 billion barrels per year to 1.83 billion barrels per year Also, the exploratory success ratio of 26.1% for the past eight years is better than it was during the previous thirty years (Figure 8). Reserves added per exploratory rig has been essentially consistent (Figure 9) and average oil well productivity in 1989 was only slightly less than it was in the years between 1947 - 1989 (Figure 10). Finally, drilling economics in constant dollars, i.e. the cost to drill and complete a well in the United States, was less in 1989 than it was in 1977 (Figure 11).

Finding and developing oil and gas has always been a tough business, but there is nothing in all these figures to support the myth that the U.S. should be written off as a mature, high-cost producing area and that we should allow our domestic oil and gas business to die gracefully.

The United States can never again be self-sufficient in energy (Figure 12), but there is much we can do to stem the tide of rising imports if we have rigs turning to the right onshore and offshore. It is wishful thinking to assume that, once the crisis in the Gulf is over, we will return to the halcyon days of cheap foreign imports. For several years, oil analysts have been underestimating growing world demand and overestimating OPEC capacity. Also, the politics of OPEC members abusing their quotas is forever changed. My guess is that, however the situation with Iraq and Kuwait is resolved, we are unlikely to see prices below $24 - $25 per barrel.

From industry's perspective, it is difficult to comprehend how, as a matter of national policy, Congress and the Bush Administration have chosen to brush aside offshore petroleum resources as a source of additional domestic supply when about half of the nation's remaining proven reserves are located off our shores.

The paradox of President Bush's action on 26 June 1990, and the action of the House Appropriations Committee on 1 October 1990 extending leasing moratoriums even further, is apparent in the Energy Information Administration's recent report on U.S. crude oil reserves. While explaining that, in 1989, U.S. proved reserves declined by 1.2%, or 324 million barrels, the report said, "Crude oil discoveries have been relatively low, reflecting a similar trend in exploratory drilling following the crude oil price collapse of 1986." The EIA report noted that most of the new field discoveries in 1989 were in the Gulf of Mexico offshore, which accounted for 93 million barrels, or 83% of all new discoveries! Need there be clearer evidence of the growing importance of offshore oil and gas development? Yet, we have just placed most of our offshore frontier areas off-limits to leasing for the next decade. Some estimates indicate the potentially economically recoverable hydrocarbon reserves in the areas removed from leasing on our East and West coasts could be as much as 4 billion barrels of oil equivalent.

If we should expect import increases of the magnitude of 500,000 barrels per day or more for the next several years, then we should also expect import levels to be at the 60 percent level sooner rather than later. What does this mean for those of us involved in coastal issues?

In a nutshell, the problem is that our hydrocarbon delivery system is designed around the assumption that we have a reliable base of around 8 million barrels of daily domestic oil production, and a like amount of domestic gas production, coming from about 850,000 individual wells located in 29 different states. When we allowed domestic drilling to hit bottom, we forgot that we have to build a new plumbing system in order to substitute imported crude oil for domestic crude coming from a variety of U.S. locations. Matthew Simmons of Simmons & Company International in Houston says, "In a word, this is the coming domestic embargo, which triggers at the point that U.S.

production sinks an incremental 100,000 barrels per day more than we have the capacity to sustain this drop with imports." Mr. Simmons made a fascinating presentation to the U.S. Department of the Interior's Outer Continental Shelf Policy Committee at its meeting in Anchorage in May, 1990. If you have not read his analysis, you should.

I believe we are going to pay a heavy price for so cavalierly disregarding our OCS oil and gas potential. Later in the 1990's, the OCS regulatory issues we have all struggled with will seem minor compared to the issues in which state regulators and conservation organizations will be involved as the result of rising imports.

Think of the import process as a series of links in a chain beginning with tankers and product carriers. After tanker transportation comes the offloading link in the chain, which includes lightering berths, offshore terminals, and dockside unloading facilities. After this comes onshore storage tanks. Then, the right type of refinery capacity at water's edge, and finally, the pipeline systems needed to take crude from the few harbors presently capable of receiving imports to the 40% of our U.S. refineries that are not located on water.

As Matthew Simmons points out, while precise data on each of these links is hard to obtain, the data that are available indicate that all these links are near the limit of their capacity. More will have to be built. There will be more oil spills from the higher volume of tanker traffic. When the crisis arrives we could see both a major effort to add import facilities and a costly scramble for domestically produced crude oil. Congress and a large segment of the public will blame the petroleum industry for inducing shortages to increase prices. Industry will point the finger at the environmentalists for keeping us out of the Arctic National Wildlife Refuge (ANWR) and the OCS frontier areas. There will be plenty of blame for all of us to share, and if we have the kind of mayhem I think we could have in the 1990's, I am not sure any of our interests will be served by maintaining the status quo as far as OCS development is concerned.

As a result of recent Presidential and Congressional actions limiting access to offshore lands, threats of increased taxes and expensive political and regulatory failures such as Point Arquello in California and Mobil's Manteo project offshore North Carolina, the U.S. offshore petroleum industry is rapidly becoming more internationally-oriented.

To give you an example of how quickly the pace of foreign investment by U.S. oil companies is accelerating, Salomon Brothers found in its July, 1990 survey that budgeted increases in international exploration and production expenditures far exceed the projections made just last December. The 65 companies in Salomon's survey, including independents and majors, now plan a 24.7% rise in their 1990 expenditures compared with a 12.6% increase forecast by the same companies in December. Sixty percent of the total activity will be outside the United States. When I asked an oil company customer the other day if he expected this trend to continue next year, he replied, "You have just seen the tip of the iceberg."

As the difficulty of conducting exploration and production in the U.S. grows, foreign governments have made significant policy moves to attract U.S. exploration and production investment. Since the oil price collapse in 1986, more than 25 countries have made changes in royalties, taxes, and contract terms which recognize the high costs and risks involved in petroleum exploration and, in one way or another, reduce the government's take. Foreign governments, unlike our own government, realize that one of the realities in the world petroleum arena is that governments must compete with each other for the finite capital of the petroleum industry. The high utilization of drilling rigs and the tremendous level of activity now going on in the U.K. sector of the North Sea is proof of the British government's ability to fine tune and adjust taxes and incentives to keep the industry moving forward with exploration and production in the North Sea. While some in the U.S. Congress criticize the petroleum industry, the British Energy Minister speaks of our industry as a national asset and a good, responsible neighbor; and moreover, says openly that Britain intends to have London replace Houston as the world energy capital.

Many of our most technically advanced offshore drilling rigs, including those capable of drilling in a zero discharge mode, are leaving the U.S. for foreign waters where they are more welcome. It is not an exaggeration to say current U.S. government policy is driving exploration and production away from the United States. Our current energy policy, which can be summed up as a reliance on cheap imported oil, is now being tested by the crisis in the Middle East. To date, the response of Congress and the Administration ignores reality. Solutions like increasing the air pressure in the tires of our cars just will not do the job alone.

Virtually all opposition to offshore drilling in the U.S. grows out of environmental concerns. Yet offshore production throughout the world is rising to the point where it is now responsible for 25% of the world's oil, and there is no evidence that these operations are having any long-term, measurable negative impact on our oceans and seas. In fact, exploration, drilling, and producing operations create less pollution in our oceans than river runoff, atmospheric phenomena, municipal discharges, marine transportation, and even natural seeps. Isn't it time we rethink our blind opposition to drilling on the U.S. Outer Continental Shelf?

The combined decline in U.S. oil production in 1990 and 1991 alone will be well over one million barrels, with that trend almost certain to continue. What happens when our oil trade deficit exceeds $100 billion? Money used to buy foreign oil can be better used building a strong economy at home. Foreign credit used to finance much of our economic expansion in the 1980's will not be as available in the 1990's because there will be too much competition for this investment internationally. Investment alternatives in Eastern Europe and better markets in Asia will lure German and Japanese investment away from the United States. For this reason, rising interest rates could be the order of the day in the U.S. in the 1990's.

A number of energy mega-projects outside the U.S. will demand huge amounts of capital in the years ahead. For example, before the Kuwait invasion, OPEC President Subroto said in Houston that it would take $60 billion of investment to boost OPEC production in the 1990's to meet anticipated world demand. A large part of this demand will come from the rapidly growing Pacific Rim. We will need more tankers and LNG ships. Analysts say that $25-$30 billion will be invested in LNG projects and another $10-$15 billion in LNG ships. A recent worldwide survey of oil company operators indicates that a total of 718 new potential offshore oilfields outside the United States have been marked for development during the years 1990 to 1995.

There are tremendous economic forces at play which will have a great impact on U.S. competitiveness in the global economy of the nineties. Energy will play an important part in this competition, and so far we seem oblivious to this fact. At some point, sooner rather than later, it will become apparent that in the national interest, we can no longer put off frontier OCS development until after the turn of the century. When that happens, we will have no choice but to work together.

The environmental record of the offshore petroleum industry is a good one. I believe that, sharing our technical and engineering data with coastal regulators and conservationists, our industry can develop more public confidence about the safety of our operations. U.S. offshore technology is being used to develop offshore oilfields throughout the world, and it is really sophisticated and exciting when you get into it. Indeed, we should be proud of this technology as a preeminent American product. I am convinced that economic changes will soon change the politics of the offshore oil issue and that all of us will be required to respond to that change. When this occurs, I am confident that, working together in good faith, we can develop more energy resources on our continental shelf while at the same time taking all precautions to preserve our other coastal resources.

U.S. CRUDE OIL PRICES

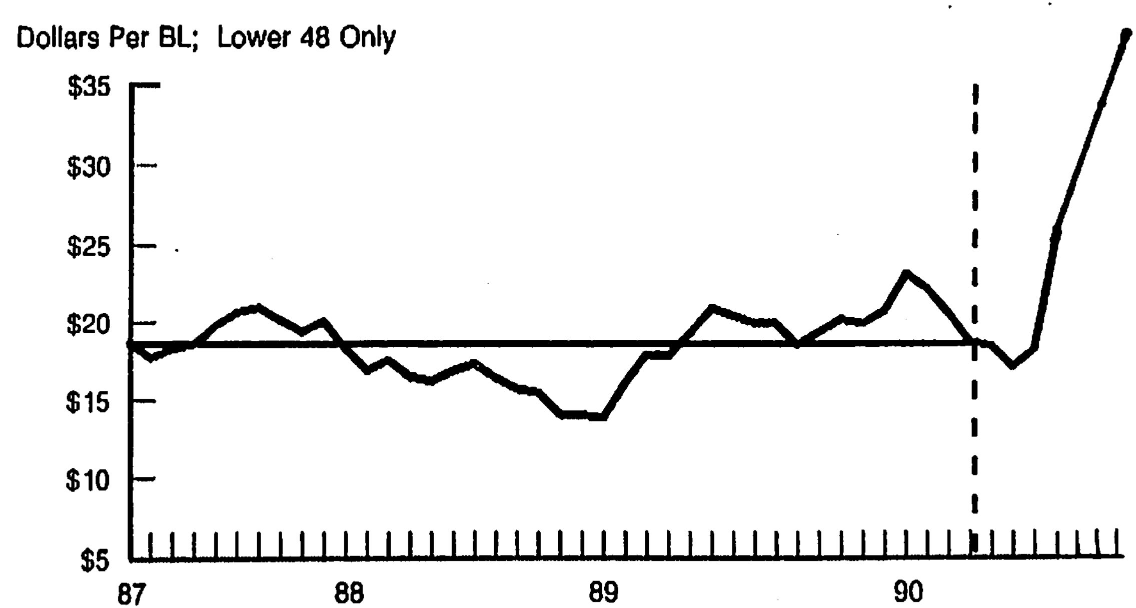


Figure 1

U.S. CRUDE OIL PRODUCTION

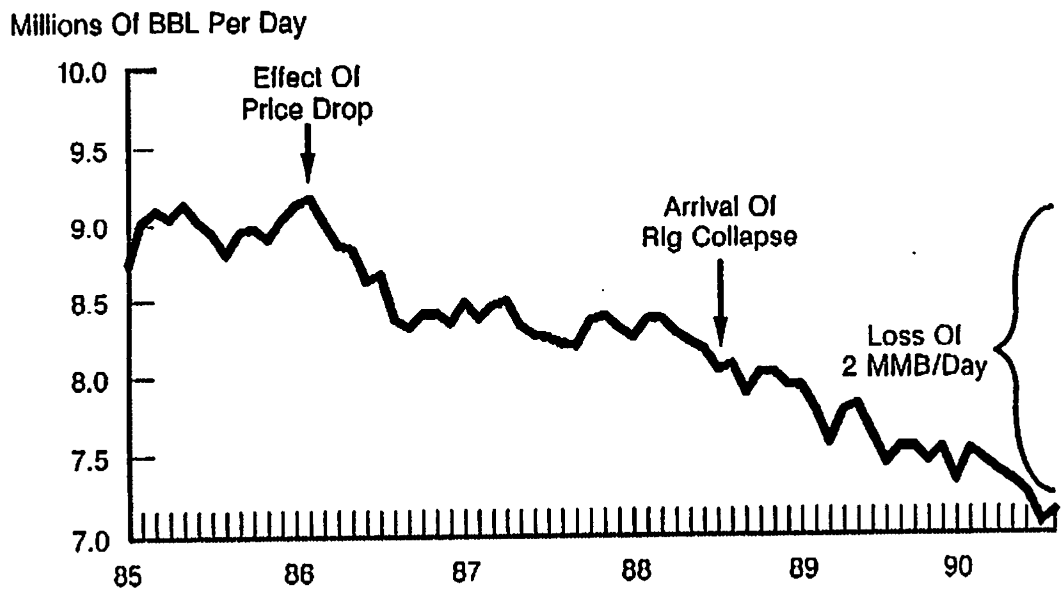


Figure 2

BUSH ADMINISTRATION OIL OFFSET INITIATIVES

(Savings in Barrels per Day)

CRUDE OIL PRODUCTION/FUEL SWITCHING

Measure	Savings Goal[1]
Increased Prudhoe Bay Production	100,000
New Alaska Production[2]	100,000
California Heavy Oil Production	100,000
Point Arguello Production	75,000
Increased State Allowance	30,000
Increased National Petroleum Reserve Production	5,000
Utility/Industry Fuel Switching	100,000
Natural Gas Pipeline Projects	55,000
Greater "Gasohol" Use	10,000
President's Oil and Gas Tax Incentives	32,500
TOTAL	607,500

Additional contemplated measures include dispatch of oil-fired generation, accelerated use of alternative fuels and waste-to-energy permitting.

EFFICIENCY MEASURES

Measure	Savings Goal[1]
Better Driving Techniques	120,000
Proper Tire Pressure	50,000
Car Pool/Van Pool	90,000
Utility/Industrial Conservation	75,000
Compliance with Speed Limit	50,000
Use of Lower Octane Gasoline	50,000
Oil Burner Tune-Up/Replacement	45,000
Use of More Efficient Car	40,000
Federal Energy Conservation	10,000
TOTAL	530,000

[1] By December 1991.
[2] Niakuk and Point McIntyre fields.

Figure 3

U.S. CRUDE OIL PRODUCTION

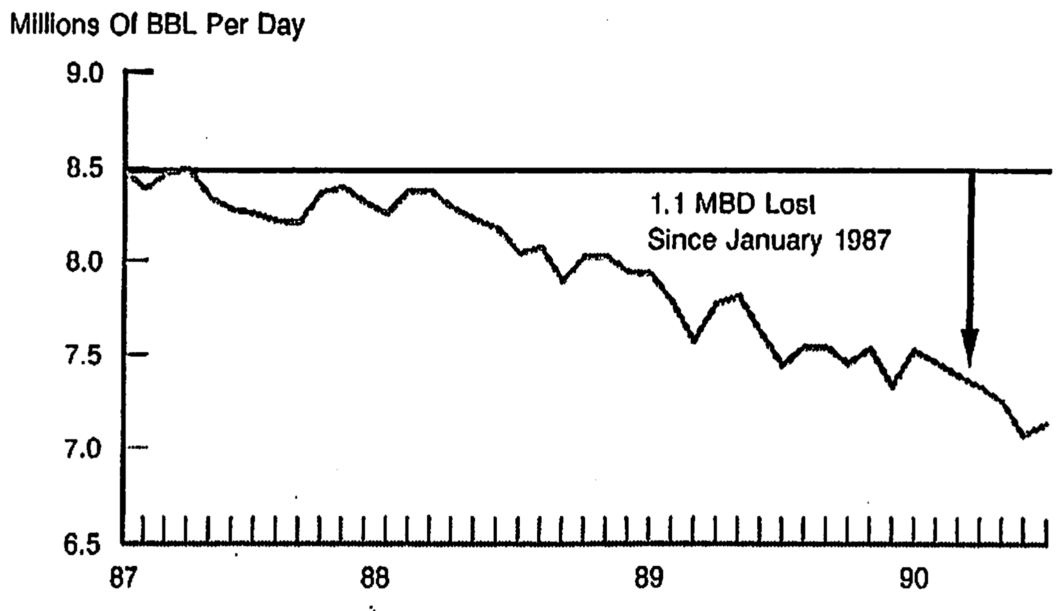


Figure 4

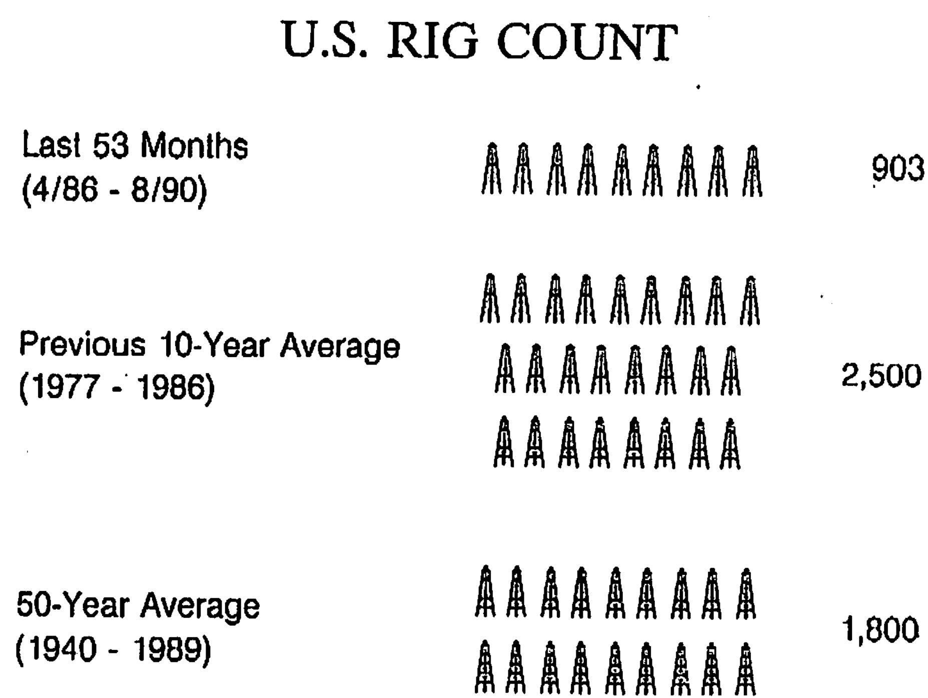
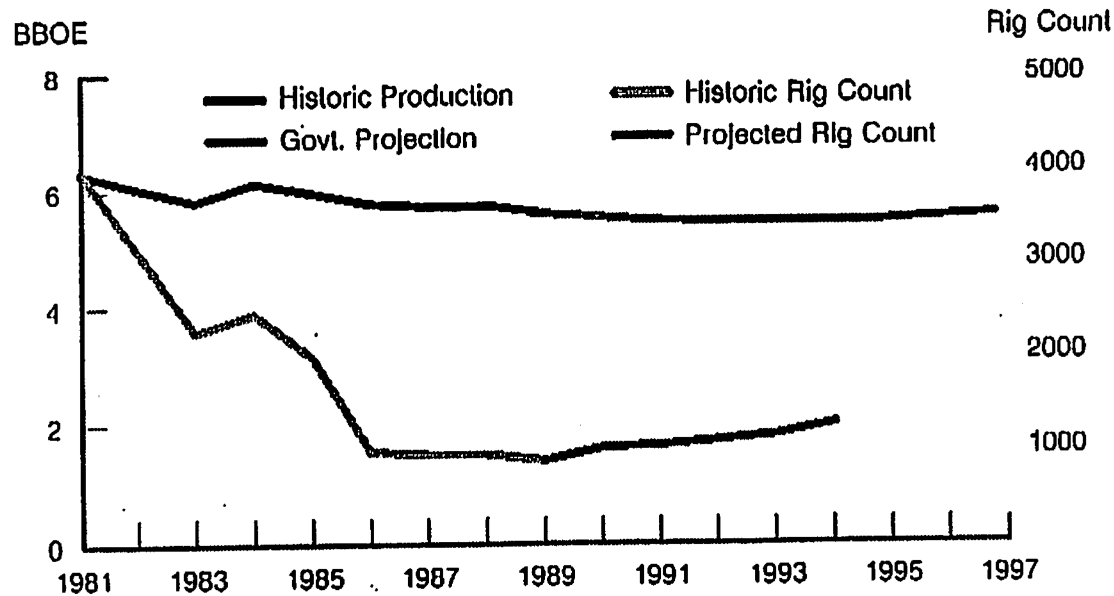

U.S. RIG COUNT
Last 53 Months
(4/86 - 8/90)
903
Previous 10-Year Average
(1977 - 1986)
2,500
50-Year Average
(1940 - 1989)
1,800

Figure 5

PRODUCTION VS. RIG COUNT

With Projections



Excludes Prudhoe Bay

Figure 6

U.S. RESERVES FOUND: 1863 - 1990

(Excluding Alaska)

	1863 - 1963 (100 Years)	*1963 - 1989 (26 Years)*
Wells Drilled	2 Million	1.2 Million
Reserves Added*	183 Billion	58 Billion
Billion Barrels/Yr.	1.83/Yr.	2.23/Yr.

* Oil And Gas Equivalent Barrels.

Figure 7

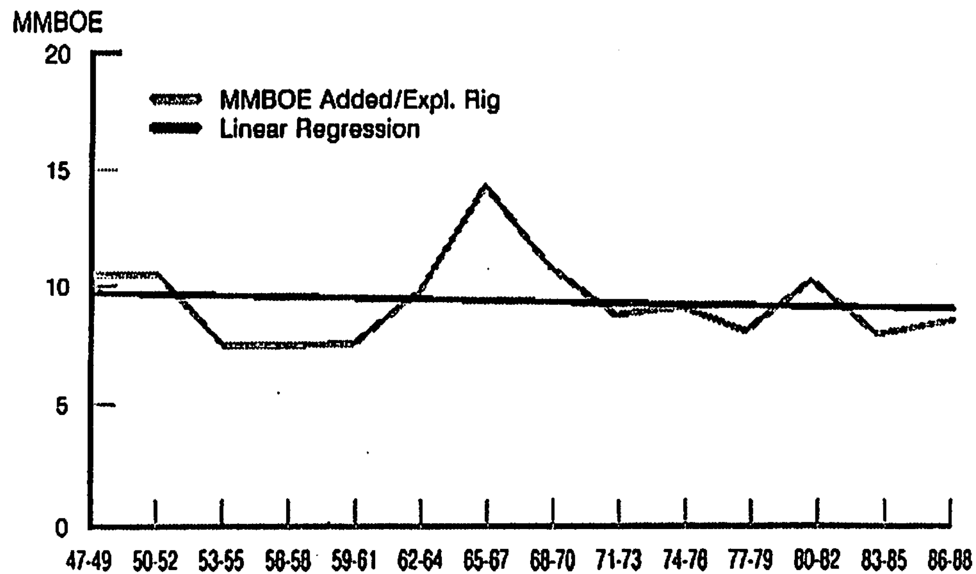
U.S. EXPLORATORY SUCCESS RATES

	1951 - 1960	*1961 - 1970*	*1971 - 1980*	*1981 - 1989*
New Field Wildcats	11.0%	10.3%	15.5%	15.3%
All Exploratory Wells	18.5%	17.0%	24.4%	26.1%

Figure 8

RESERVES ADDED PER EXPLORATORY RIG (a)

Three Year Increments, Three Year Lag



(a) Rig Count x Exp Wells x 1.75 *Excludes North Slope*

Figure 9

AVERAGE OIL WELL PRODUCTIVITY

(Non-Alaskan, Non-Stripper Wells)

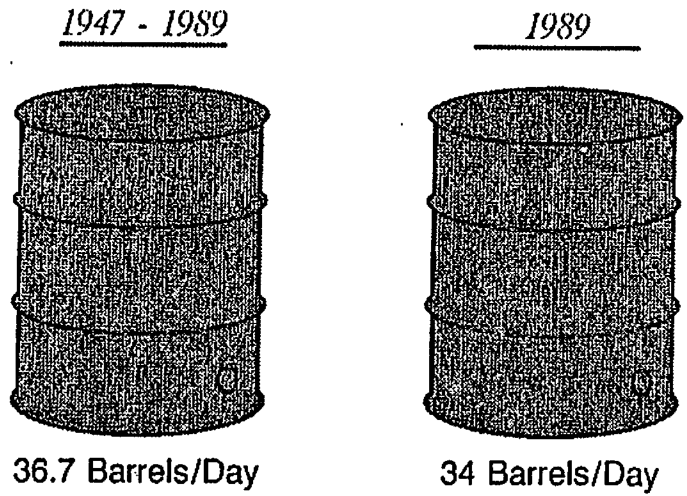


Figure 10

DRILLING ECONOMICS

(Cost To Drill Complete U.S. Well)

	Constant Dollars	
	1977	*1989*
Exploratory Well	$560,000	$406,000
Development Well	$339,000	$264,000

Figure 11

U.S. PETROLEUM IMPORTS AS A PERCENT OF DOMESTIC DEMAND

Figure 12

Nearshore Berm Site Selection and Construction: South Padre Island, Texas

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Abstract

The high cost of beach protection has led many coastal zone planners to investigate effective lower-cost alternatives for shoreline stabilization. One method currently being investigated by the U.S. Army Corps of Engineers is the use of dredged material to construct nearshore berms to protect the shoreline and augment the beach profile. Several projects have recently been completed and are currently under study. One nearshore berm has recently been constructed off the Gulf Coast of Texas near South Padre Island. The berm was constructed using sandy dredged material from the Brazos-Santiago Pass Channel and placed downdrift of the channel. An extensive site selection process was used to determine the most effective site to use. Site selection was critical to ensure cost-effective construction, as well as an effective berm. Currently, a monitoring program is being undertaken to evaluate the berm's effectiveness in augmenting the existing beach profile. The monitoring plan includes bathymetry, sediment sampling, and seabed drifter (a bottom trailing drogue) releases.

Background

Beach nourishment can be an effective method for augmenting, protecting, and repairing a beach. The placed material also provides storm and flood protection to the back beach area. To date, most beach nourishment projects involve placing suitable material from the dune area to the swash zone. The expense of this type of beach nourishment often limits the quantity of material which can be placed on the beach. In addition, as wave action redistributes the material throughout the active beach zone, severe local erosion can occur. Within the last ten years, the construction of several shallow-draft, split-hull hopper dredges has created the potential for economical and effective placement of sediment in the nearshore area. Placement in the nearshore area can be half the cost of onshore placement and can provide several of the same benefits. Two types of berms can be constructed in the nearshore region--a stable berm designed to attenuate wave energy, or a feeder berm placed to augment the beach profile. Which type of berm to construct can vary depending on factors such as wave characteristics, type of material, equipment availability, and overall berm intent.

Beach quality material placed within the littoral system can benefit the shoreline by providing additional material in the beach profile. The material has the potential for mitigating erosion problems by providing a sacrificial source of sediment, a sill to reduce the movement of material offshore, a source of sand for downdrift areas, and, during times of accretion, provide a sand source for the beach profile. Feeder berm erosion rates will depend on wave climate, sediment grain size, depth of placement, and mound dimensions. By calculating and monitoring the erosion rates, the berm can be nourished at appropriate intervals to provide a continuing source of sand. In the case of artificial beach nourishment, Bruun (1988) has described the importance of placing material offshore to nourish the beach profile. Since grain size normally decreases with distance offshore, placement of suitably-sized material at the proper depth will increase stability and reduce costs compared to similar material placed on the beach. Whatever the desired objectives, the proper equipment, location, and placement techniques must be selected.

Early attempts at beach nourishment through offshore placement were not successful (McLellan 1990a). However, with the advent of shallow-draft, split-hulled hopper dredges in the 1970's, the feasibility of using conventional dredging and placement practices for berm construction became a reality. Several projects have recently been completed by the U. S. Army Corps of Engineers demonstrating berm construction with conventional equipment. In addition, several projects have been completed outside the United States with a high degree of success (McLellan 1990b).

Although several projects have been constructed, additional site-specific guidance is required for site selection, construction, and monitoring. Site selection can be aided by examining long-term sediment transport trends. By collecting site-specific data about local inlets, bathymetry, structures, and anomalies that may effect sediment transport, an understanding of the area can be acquired. Care must be taken to insure that the placement site is far enough downdrift of an inlet so that sediment moving off the berm is not trapped by the jetties or returned into the channel. This must be accomplished while maintaining minimal travel distances for the operating dredge. To better define a berm construction location for Brazos-Santiago Pass, Texas (Figure 1), a field study was designed and conducted for the downdrift side of the jetties (McLellan and Burke, 1988). The field study utilized seabed drifters (SBDs), supplemented by additional instrumentation and procedures, to delineate nearshore flow patterns in December, 1987. Approximately 1 year later, a nearshore berm was constructed using material dredged from the Brazos-Santiago Pass Channel.

Berm Site Selection

Brazos-Santiago Pass (BSP) Inlet is located just north of the Texas-Mexico border on the southern tip of Padre Island, Texas (Figure 1). Early attempts to maintain a navigable channel at BSP were unsuccessful (Morton and Pieper, 1975) until the construction of the present jetties in 1935.

The entrance channel is maintained at a -38 ft depth and a 300 ft width. South Padre Island has a history of erosion with exception of the extreme southern tip of the island located next to the BSP jetties. Historical evidence developed by Morton and Pieper (1975) shows that the predominate littoral drift in this area is to the north but seasonal reversals occur during the winter months (October-February). Tides near south Padre Island are predominantly diurnal with a frequent superimposed semidiurnal component which produces two low waters of different elevation each day, resulting in a mixed cycle. Winds are predominately south-to-southeast throughout the year with the exception of December, when winds are predominately north-to-northwest.

The water depth at which sediment is an active part of the littoral system is dependent on wave height and period, and sediment composition. The complex littoral system extends from the back beach and dune to some distance offshore. The distance offshore is depth-dependent; determination of that depth will provide a boundary for the active portion of the beach profile where sediment may be introduced into the littoral system. Hallermeier (1981) utilized lab data to develop an equation to predict the depth at which significant amounts of sand are moved and can be considered part of the littoral system. The Hallermeier equation estimates the maximum depth at which changes in the beach profile occur for large storm events based on the wave period and the significant wave height which is exceeded 12 hrs a year. Using the significant wave height and period from the Wave Information System, a 20-year hindcast data base (McAneny 1985), the depth of closure for the south Padre Island area is estimated at 28 ft.

One thousand and seven hundred bright orange cap and stem Woodhead-type SBDs were released at 9 offshore stations for the BSP project (Woodhead and Lee, 1960). SBDs are inexpensive, disposable bottom current trailing drogues that can be used in all types of marine conditions and can reflect integrated bottom current paths and unobstructed sediment transport paths. All the SBDs carried an attached extremely durable, sequentially numbered, self-addressed polyvinyl chloride (PVC) return card which asked specific questions on return time, date, and location and had a map for easy recovery location identification. Six locations were identified to evaluate potential berm construction sites and two locations were identified to evaluate drift patterns of the historical and proposed dredged material disposal sites. The ninth station was placed in the surf zone to establish SBD drift patterns when the SBDs entered the surf zone. Economical haul distance for a dredging operation at BSP was determined to be 3 miles and loaded draft of the vessel was at least 20 ft (Medina, 1987, personal communication). Release sites for the berm were therefore limited to within three miles of the jetties in a depth of at least 20 ft. Stations to determine the berm construction site were located approximately 1, 2, and 3 miles from the jetties approximately 1/4 to 3/4 miles offshore on the 20 and 28 ft contours.

As of the writing of this report, 801 (47%) SBD cards of the 1700 released have been returned, with the six potential construction sites returning an average of 50% of those released. Seabed drifter returns ranged from approximately 18 miles north of the BSP jetties to 20 miles south of the jetties. In general, recovered drifter moved northward an average of 4 - 6 miles from their release locations. The closer to shore the drifters were released, the greater the percentage of recoveries and the shorter the distance traveled along shore. All drifters were recovered north of the jetties with the exception of 10 drifters collected in the bay or south of the jetties. These 10 drifters were from release sites located one mile from the jetties and are an indication of the current influence caused by the inlet/jetty.

SBD returns from the 6 longshore locations suggest that the berm needs to be constructed at least 1 mile north of the jetties. A berm constructed closer to the jetties may be equally successful but sediments moving off this berm stand a higher chance of returning to the channel or being trapped by the jetty. In addition, the historical wave data indicated that the berm should be within the 28 ft contour and that late winter/early spring was the best time for construction to take advantage of seasonal current reversals.

Berm Construction and Monitoring

As shown in Figure 1, the berm construction site was approximately 1 mile north of the jetties, located 1/4 to 3/4 miles offshore. Prior to construction, a pre- and post-construction monitoring plan was established for the BSP berm. The monitoring plan included bathymetric surveys, beach profiling, sediment samples, diver cores, releases of SBDs and collection of Littoral Environmental Observation (LEO) (Schneider 1981) to determine wave characteristics. Pre- and post- construction surveys are to determine the overall size and shape of the berm and measure berm changes with time. Beach profiles will document any changes which occur on the beachface itself and the sediment samples will provide information on the sediment migration in the area. Diver-collected cores can provide information on the depth of movement vertically into the sandy bottom. Additional releases of SBDs provide a continuing data base for nearbottom currents.

North American Trailing Company was awarded the contract to dredge 750,000 yd^3 of sand from the BSP entrance channel. The split-hulled hopper dredge MANHATTAN ISLAND performed the dredging beginning in December, 1988. The MANHATTAN ISLAND has a 19 ft loaded draft and a 3600 yd^3 hopper. Approximately 1/2 the total dredged quantity was to be placed in the berm site, with the remainder being placed in the designated disposal site directly north of the channel. To limit exposing the dredge broadside to waves during high energy events, the actual placement times and volume were left to the discretion of the dredge captain. Due to a relatively stormy season, only 173 trips to the site were made, resulting in the placement of 220,000 yd^3 of material.

To ensure beach quality material was placed into the berm site, periodic samples were collected from the hopper dredge. Mean grain size of beach samples collected ranged from 2.40-2.62 phi, a fine sand typical of Texas beaches (Folk, 1980). Material from the hopper ranged in size from 3.08-3.15 phi, indicating fine to very fine sand. In addition, to determine the effect of the mound on offshore resources, samples were collected before and after placement in the berm construction area. Prior to berm construction, offshore phi sizes were 3.13-3.89, very fine sand. After placement of the dredged material, grain size increased to 2.6 phi in the vicinity of the berm. This shift to a coarser grain size was not evident in other samples collected in the vicinity of the berm offshore, but outside of it's influence. The higher quality beach material in the vicinity of the berm is most likely due to winnowing of the finer-grained fraction of the sediments during the berm placement operation.

Although analyses are continuing on the collected data, some preliminary results are available. In addition to the pre-construction survey in December, 1988 and post-construction survey in January, 1989, surveys were conducted in March and June, 1989. Additional surveys have been done and are being analyzed. Comparison of the pre- and post-construction surveys indicate the berm rises to +4 ft above the natural bottom and is approximately 3500 ft long. The berm is a shore-parallel feature constructed on the 26 ft pre-construction depth contour and contains approximately 190,000 yds^3 of sand, slightly below the hopper estimates of 220,000 yds^3 but within the accuracy of the bathymetric surveys. Figure 2 shows that, subsequent to placement, during the winter months (January-March, 1989), the berm moved approximately 300 ft shoreward. Historically, this is the most energetic time for the area and the maximum movement can be expected. From March to June, with lesser energy in the environment, the berm moved little. Preliminary indications are that the berm is moving as a bar directly towards shore, not in the longshore direction. There has been some erosion of the peak elevations, but there is still a well-defined feature evident. The berm is expected to continue migrating towards shore as a bar, until it encounters the naturally forming bar, between the 14 to 18 ft contours. It will then become assimilated into the littoral system and, from a monitoring standpoint, become indistinguishable from the natural system. Additional monitoring and analyses will determine the final result.

Summary

The U. S. Army Corps of Engineers Galveston District and the Waterways Experiment Station's Coastal Engineering Research Center cooperated on a project in the Gulf of Mexico near the Brazos-Santiago Pass inlet to delineate nearshore flow patterns and evaluate possible sites for construction of a nearshore berm using dredged material. The project incorporated the release of bottom trailing drogues called seabed drifters, collecting sediment samples, and reviewing historical wind and wave data. A site approximately 1 mile north of the jetties was selected for berm construction. Approximately 220,000 yd^3 of sandy dredged material was placed as a nearshore berm. An extensive monitoring plan evaluated the berm's effectiveness. The berm's maximum elevation was +4 ft above existing bottom elevations and the berm was 3500 ft. long. Sediment samples from the dredge and the berm site indicated that the finer fraction of the dredged sediment was winnowed out during the placement operation, leaving a higher beach quality material. The berm has been moving as a bar shoreward during the first five months of its existence and is expected to continue its shoreward migration until it is assimilated into the natural occurring bar system.

Acknowledgements

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References

Bruun, P. 1988. Profile nourishment: its background and economic advantages. Journal of Coastal Research, 4(2):219-228.

Folk, R. L. 1980. Petrology of Sedimentary Rocks. Hemphill Publishing Co. Austin, TX.

Hallermeier, R.J. 1981. Seaward Limit of Significant Sand Transport by Waves: An Annual Zonation for Seasonal Profiles. Coastal Engineering Technical Aid No. 81-2, U.S. Army Corps of Engineers, Coastal Engineering Research Center, Vicksburg, MS.

McAneny, D.S. 1986. Sea-State Engineering Analysis System (SEAS), Supplement I. WIS Report 10, US Army Corps of Engineers, Waterways Experiment Station. Vicksburg, MS.

McLellan, T. N. 1990a. Nearshore mound construction using dredged material. Journal of Coastal Research, Spec. Issue 7:99-107.

______. 1990b. International Applications of Nearshore Berms. Beneficial Uses of Dredged Material in the Western United States, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

_____ and C.E. Burke. 1988. Site Selection for Nearshore Berm Construction, South Padre Island, Texas. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Medina, R. US Army Engineer District, Galveston. Galveston, TX.

Morton, R.A and M.J. Pieper. 1975. Shoreline Changes on Brazos Island and South Padre Island (Mansfield Channel to the Rio Grande); An Analysis of Historical Changes of the Texas Gulf Shoreline. Bureau of Economic Geology, The University of Texas at Austin, Austin, TX.

Schneider, C. 1981. The Littoral Environment Observation (LEO) Data Collection Program. Coastal Engineering Technical Aid No. 81-5, U.S. Army Corps of Engineers, Coastal Engineering Research Center, Vicksburg, MS.

Woodhead, P.M.J. and A.J. Lee. 1960. A new instrument for measuring residual currents near the sea-bed. International Council for the Exploration of the Sea, vol. 12.

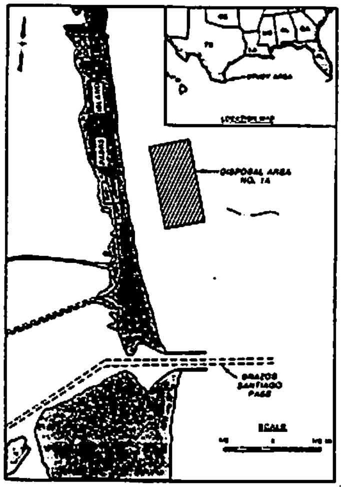

Figure 1. Nearshore berm construction site, Brazos-Santiago Pass, TX

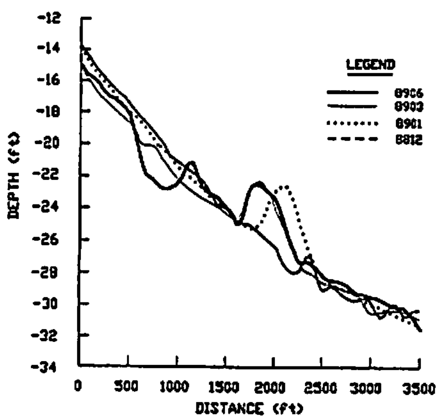

Figure 2. Cross section Brazos-Santiago Pass nearshore berm.

Distribution Analysis of Heavy Minerals on the Inner Continental Shelf of Virginia

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Abstract

Based on analysis of the 3-4 phi size (very fine sand) fraction of 129 surficial heavy mineral samples, three different local source areas of heavy minerals were identified using Q-mode factor analysis. This area has a high potential for heavy mineral resources and is located within 15 km off shore of the Atlantic side of the southern Delmarva Peninsula. The heavy mineral analyses were concerned only with the movable, non-cohesive, upper layer of benthic sediment (0-20 cm). Q-mode factor analysis was performed on the heavy mineral data matrix, which consisted of 129 samples (observations) and 7 minerals (variables). A 3-factor solution accounted for 98.0% of the variance in the entire set of data and provided a geologically suitable model. The first factor (consisting mainly of amphibole, pyroxene, and epidote) indicated Chesapeake Bay as a possible source for amphibole, and pyroxene; concentrations of these minerals decreased from inside the bay mouth to off shore. The second factor (consisting mainly of zircon, garnet, and amphibole) showed that the southern part of the bay mouth and approximately 4 km southeast off Wachapreaque Inlet are potential sources for zircon and garnet. The third factor (consisting of mainly garnet, amphibole, and zircon) indicated a bayward influx of sediments from the adjacent shelf, and also the eastern shore of Delmarva Peninsula as a source for garnet, amphibole and zircon. This factor may be an indicator of the southerly long-shore drift of the sediments by current and wave action. Although 2-, 4- and 5- factor solutions were also applied to explain the regional variability and local source areas of heavy minerals, a 3-factor solution was selected because better mathematical results were obtained from this solution to explain geologically meaningful distribution patterns.

Introduction

The heavy mineral associations in fluvial sedimentary sequences have been studied as a guide to source rock lithologies, dispersal patterns, erosional weathering, and tectonic history of their source area. Potentially economic concentrations of placer heavy minerals have been reported in the inner continental shelf deposits of the southern Delmarva Peninsula (Figure l) by Goodwin and Thomas (1973), Grosz and Escowitz (1983), and Berquist and Hobbs (1988). The objectives of this study are: (l) to determine the regional variations of heavy minerals in post-Wisconsinan sands of the inner shelf of the southern Delmarva Peninsula; (2) to establish the locations and influences of multiple local sources (if any) of heavy minerals; and (3) to review sediment transport pathways by examining distribution patterns of heavy minerals along the area of interest.

Physical Setting

The study area is located along the Middle Atlantic Bight in the vicinity of the Eastern Shore of Virginia, between latitude 37'00"N and 37'49" N, longitude 75'30" W and 76'10" W. It is about 50 km long and extends up to 15 km offshore from the Delmarva Peninsula. Along the Atlantic coast of the southern Delmarva Peninsula, tides are semi-diurnal and the mean tide range is about 1.0 m (Harrison, 1972). Surficial sediments consist basically of (1) greycolored, rounded, well-sorted fine sand and (2) poorly-sorted, rich in shell, medium-to-course sand (Nichols, 1972). The coastal plain strata dip gently eastward and unconformably overlay Precambrian to Triassic Age crystalline rocks (Shideler et al., 1984). The circulation of shelf water off Virginia's coast causes a significant bottom drift of shelf sediments. Although there are areal and seasonal variations, this drift tends to move southwesterly and causes large amounts of surficial sediments to move (Harrison et al., 1967). The geology of the mainland adjacent to the study area has been described by Mixon (1985). He found the unconsolidated, Quaternary sand, gravel, silt, clay, and peat deposits (2-60 m thick) unconformably overlay approximately 100 m-thick, more consolidated, upper Tertiary glauconitic sand and clay-silt deposits in the surface and subsurface sediments of the southern Delmarva Peninsula.

Methodology and Data Analysis

Laboratory Techniques

In this study, the heavy mineral analyses are concerned only with the mobile, non-cohesive, upper layer of benthic sediment (about 0-20 cm). One hundred twenty nine samples (13 core and 116 grab) were selected for the particular area of interest (Figure 2). Only the top portion (0-20 cm) of the core samples was analyzed. Recently, a detailed report has been published by Berquist and Hobbs (1988), explaining the spiral, heavy liquid and magnetic separation, concentration, and sample preparation of the heavy mineral samples used in this study. As an average, 0.75 g of each concentrated heavy mineral sample was sieved to obtain the 3-4 phi (0.125-0.063 mm) size fraction. The 3-4 phi (very fine sand) size fraction was chosen to eliminate variations in concentrations due to selective sorting of minerals. Small amounts of recovered heavy mineral samples (about 0.2 g) were mounted on glass slides by using Caedax medium as a glue (R.I.= 1.56). The slides were point-counted under a petrographic microscope to estimate the abundances of 17 transparent minerals as well as opaques. More than 200 transparent grains (average 210) were identified along the random line traverses on each slide. The abundances of each mineral in each sample were calculated as the grain percentage. Seven minerals were chosen to apply Q-mode factor analysis among the 17 transparent minerals by Principal Component Analysis (Berquist, 1986; Davis, 1986): zircon; sphene; amphibole; epidote; staurolite; pyroxene; and garnet. Finally, based on the abundances of 7 transparent heavy minerals and 129 samples, the raw-data matrix was ready to apply Q-mode factor analysis.

Q-mode Factor Analysis

In this study, an advanced mathematical procedure, Q-mode factor analysis, was performed to find the most compositionally-extreme samples (end-members) in the data set, which may represent potential source areas of heavy minerals. As heavy minerals arrive into a basin from various sources, they are mixed into new proportions. If this is an ancient system and we are relying on core samples, and our objective is to find the sources of these heavy minerals, we would not know how many sources (end-members) there are. Q-mode factor analysis has the potential of finding these end-members (Berquist, 1986). The results of Q-mode factor analysis indicate how much of each end-member (factor) is present in each sample. Once a suitable number of factors has been determined, composition gradients for each end-member can be established by contouring the percentage of the factor in each sample (Hobbs et al., 1986). The resulting distribution patterns suggest sediment transport directions. In this research, 3 advanced computer programs were used to analyze multi-variate compositional data: (1) CABFAC was developed by Klovan and Imbrie (1971); (2) QMODEL was written by Klovan and Miesch (1976) to extend the capability of the CABFAC program; and (3) EXQMODEL (Extended QMODEL) was revised from the QMODEL program by Full et al., (1981). The Extended Q-model program defines the compositionally-most extreme samples, which are considered end-members. In QMODEL and EXQMODEL, the oblique solution was selected (yielding real samples as the extreme end-members) by selecting the Option-3.

Results and Discussion

The 3-factor solution accounted for 98.0% of the total compositional variation of samples, showed high communalities (average communality was 0.97) and high diagonal values on the extreme normalized sample loading matrix, gave high coefficients of determination, and provided the most geologically suitable model, because there was no redundancy in either composition or location of the end-member samples as was seen on the 4- and 5-factor solutions (Figure 3). The 2-factor solution was rejected because only 96.3% of the compositional information was explained and sample projections (factor loadings) were interdependent (when loadings on one factor increased, loadings on the other factor decreased). Factor 1 is composed mainly of amphibole, then pyroxene and epidote (Figure 4). As it shows easterly (offshore) decreasing concentrations of heavy minerals southwest of

Fisherman Island, this could be an indication for the off shore transport of bay originated amphibole, pyroxene, and epidote. High concentrations of amphibole and pyroxene northeast of Smith Island are most probably related with the troughs of the sand shoals, as Goodwin and Thomas (1973) and Rowland (1988) mentioned. Factor 2 is composed of mainly zircon, then garnet and amphibole (Figure 5). The concentrations of these minerals decrease seaward. This indicates that erosion of the Eastern Shore and its tributaries,and of the channel-levee systems between barrier islands, (especially by the winter storms) may be local sources for zircon and garnet as can be seen off Parramore Island (Rice and Leatherman, 1983). Factor 3 is rich in garnet, and also includes amphibole and zircon (Figure 6). This end-member is located about 3 km southeast of Fisherman's Island. It shows high concentrations of garnet and amphibole around the bay mouth area that decrease westerly (bayward). This might reflect a bayward influx of adjacent littoral and shelf sediments by coastal erosion as Berquist (1986) suggested. Factor 3 indicates a high concentration area about 5 km north east of Quinby Inlet. These more mature minerals like zircon and garnet might be derived from Delaware Bay estuary, the northeastern part of Delmarva peninsula, and/or sand-shoal deposits around Quinby Inlet. The composition gradients of Factor 3 are spotty, but show a possible tendency to decrease in a southerly direction. Consequently, southward transport of inner shelf sediments along the eastern shore of the Delmarva Peninsula may be suggested. The patterns are slightly different around the bay mouth. Higher concentrations of garnet and amphibole off Fisherman's Island decrease bayward. Therefore, isopleths of the 3-factor solution show a tendency of sediment movement into the bay around Fisherman's Island.

Summary and Conclusions

The mathematical results and geological interpretations of the factor maps of 129 surficial samples of heavy minerals taken from the inner continental shelf off the southern Delmarva Peninsula indicated three different heavy mineral associations. Factor 1 suggested off shore movement of amphibole, pyroxene, and epidote mineral associations originating in Chesapeake Bay. Factor 2 provided a relatively homogeneous distribution pattern, but suggested Chesapeake Bay and an area approximately 4 km southeast of Wachapreaque inlet as potential sources for zircon, garnet, and amphibole. Factor 3 showed a landward sediment transport from the shelf adjacent to the bay mouth and from approximately 5 km southeast of Hog Island.

In conclusion, heavy minerals on the inner continental shelf of the southern Delmarva Peninsula exhibit regional variations under the effects of modern hydrodynamic processes and circulation patterns of continental shelf waters. Their concentration isopleths tend to parallel the present coastline. These regional variation patterns are produced by sediment dispersal from (1) the northern Delmarva Peninsula due to southerly longshore transport of sediments, (2) barrier islands of the Delmarva Peninsula, especially from sandy beaches and inlets along the coastline by the effects of severe winter storms, (3) relict, reworked, possibly Pleistocene age more mature inner continental shelf sediments, associated with linear offshore sand shoals, and (4) Chesapeake Bay sediments deposited during the post-Wisconsinan time interval. Results of this study may have the potential to help answer many questions relevant to future explorations of economic placer deposits, the preservation of beaches and wetlands, sediment budget investigations, and an understanding of estuarine and near-shore sedimentary processes along the inner continental shelf of Virginia.

References

Berquist, C.R., Jr. 1986. Stratigraphy and Heavy Mineral Analysis in the lower Chesapeake Bay, Virginia. Unpublished doctoral dissertation. School of Marine Science, The College of William and Mary, Williamsburg, Virginia.

______, and C.H. Hobbs, III. 1988. Reconnaissance of Economic Heavy Minerals of the Virginia Inner Continental Shelf. Virginia Division of Mineral Resources open-file report, 88-1.

Davis, J.C. 1986. Statistics and Data Analysis in Geology. John Wiley & sons, New York. 646 p.

Full, W.E., R. Ehrlich, and J.E. Klovan. 1981. Extended Q-model. Journal of Internat. Assoc. Mathematical Geology, 13(4): 331-344.

Goodwin, B.K. and J.B. Thomas. 1973. Inner Shelf Sediments off Chesapeake Bay: Heavy Minerals. Special Scientific Report, 68, Virginia Institute of Marine Science, Gloucester Point, VA.

Grosz, A.E. and E.C. Escowitz. 1983. Economic heavy minerals of the U.S. Atlantic continental shelf. Pages 231-242. In: W.F. Tanner (ed.), Proceedings of the Sixth Symposium on Coastal Sedimentology. Florida State University, Tallahassee, Florida.

Harrison, S.C. 1972. The Sediments and Sedimentary Processes of the Holocene Tidal Flat Complex, Delmarva Peninsula, Virginia. Louisiana state University, Coastal Studies Institute, Technical Report 112, Baton Rouge, Louisiana.

Harrison, W., J.J. Norcross, N.A. Pore, and E.M. Stanley. 1967. Circulation of shelf waters off the Chesapeake Bight. Environ. Sci. Serv. Adm. Prof. Paper, 3, U.S. Dep. of Comm., Washington, D.C.

Hobbs, C.H., III, S.M. Colman, and C.R. Berquist, Jr. 1986. Sandy estuarine fill transported into the mouth of Chesapeake Bay. Pages 180-198. In: W.F. Tanner (ed.), Suite Statistics and Sediment History. Proc. of the 7th symp. on Coastal Sedimentology, Florida State University, Tallahassee, Florida.

Joreskog, K.G., J.E. Klovan, R.A. Reyment. 1976. Geological Factor Analysis. Elsevier Scientific Publishing Comp., New York. 178 p.

Klovan, J.E., and J. Imbrie. 1971. An algorithm and Fortran-IV program for large scale Q-mode factor analysis and calculation of factor scores. Journal of the Internat. Assoc. Mathematical Geology, (3) 1: 61-77.

______, and A.T. Miesch. 1976. Extended CABFAC and QMODEL computer programs for Q-mode factor analysis of compositional data. Computers & Geosciences, 1(3):161-178.

Mixon, R. B. 1985. Stratigraphic and geomorphic framework of uppermost Cenozoic deposits in the southern Delmarva peninsula. U.S.G.S. Professional Paper, 1067-G, 604 South Pickett Street, Alexandria, Virginia. 53 p.

Nichols, M.M. 1972. Inner Shelf Sediments off Chesapeake Bay: I: General Lithology and Composition. Special Scientific Report No. 64, Virginia Institute of Marine Science, Gloucester Point, Virginia. 20 p.

Rice, T.E. and S.P. Leatherman. 1983. Barrier island dynamics: the eastern shore of Virginia. Southeastern Geology, 24:125-137.

Rowland, T.J. 1988. Availability of mineral deposits offshore Virginia. Minerals Management Service, Office of Strategic & International Minerals, Vienna, Virginia. 12 p.

Shideler, G.L., J.C. Ludwick, G.F. Oertel, and K. Finkelstein, 1984. Quaternary stratigraphic evolution of the southern Delmarva peninsula coastal zone, Cape Charles, Virginia. Geological Society of America Bulletin, 95:489-502.

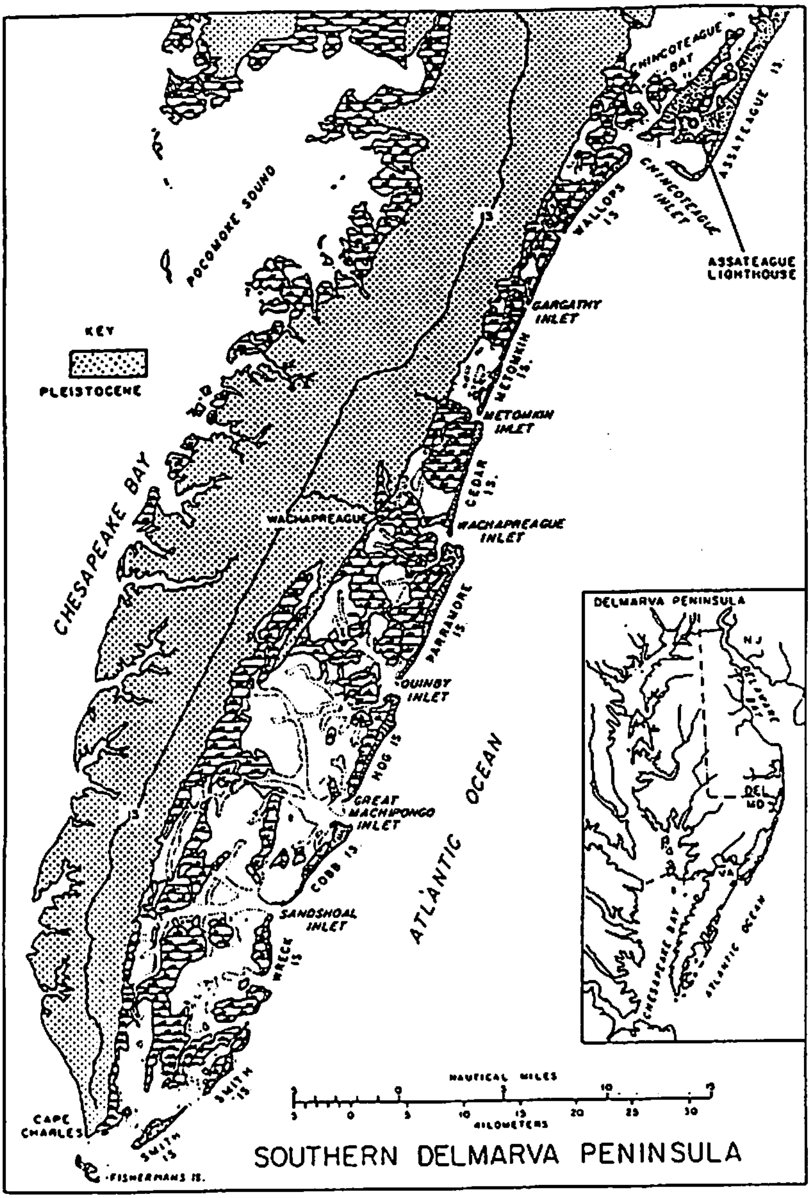


Figure 1 Index map of the study area on the Atlantic coast of southern Delmarva Peninsula. Inset map shows Delmarva Peninsula between Delaware and Chesapeake Bay estuaries (from Harrison, 1972).

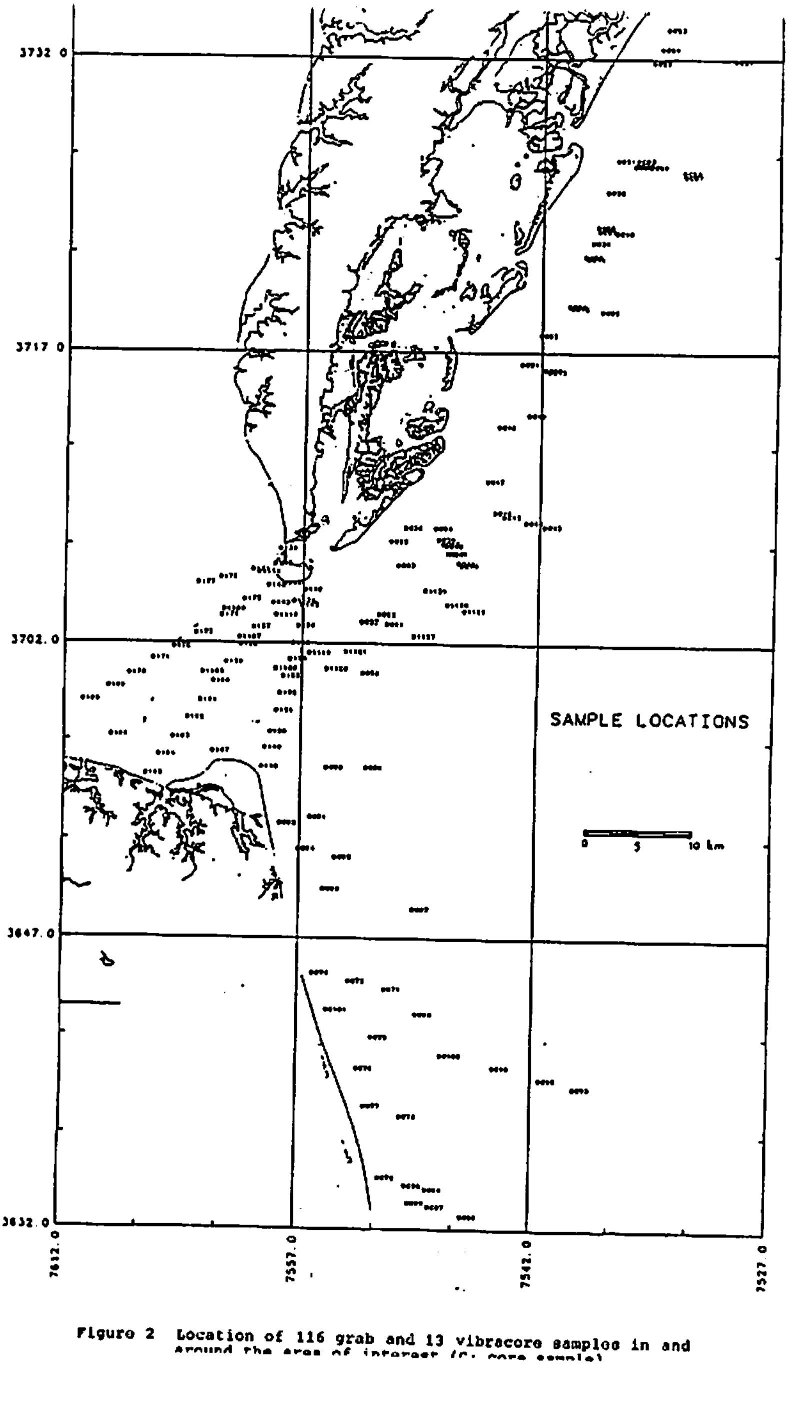


Figure 2 Location of 116 grab and 13 vibracore samples in and around the area of interest (C: core sample)

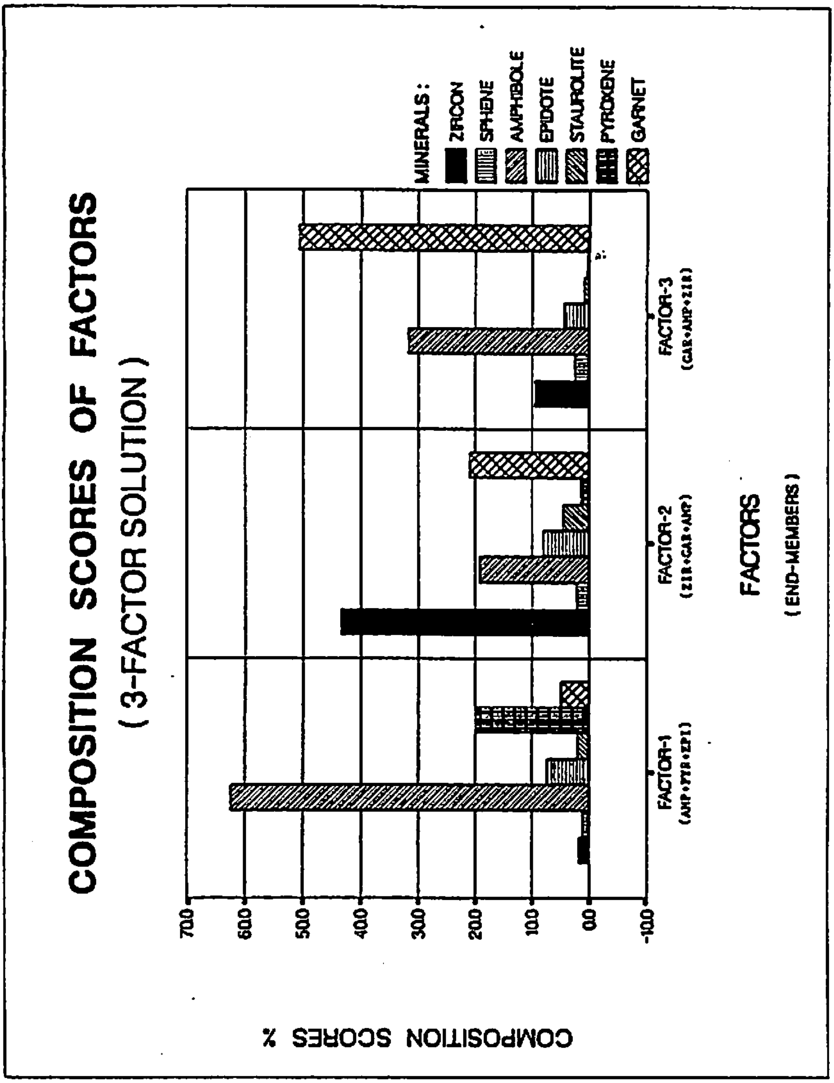


Figure 3 Compositions of the factors obtained from Q-mode factor analysis of 129 surficial off-shore heavy mineral samples.

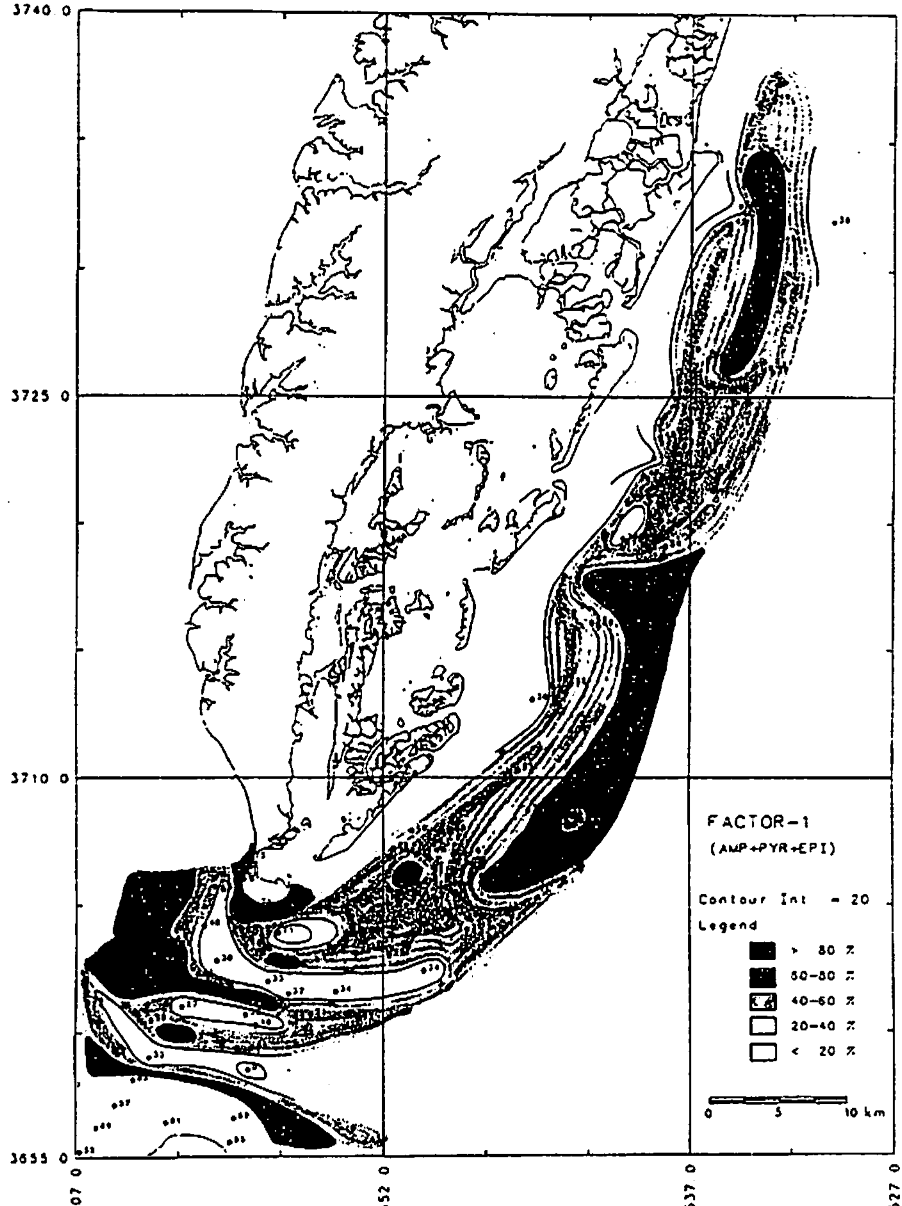


Figure 4 Contour map of sample composition loadings on Factor 1. Factor 1 is sample 166 and located at the southwestern part of the interest area (not shown in this figure).

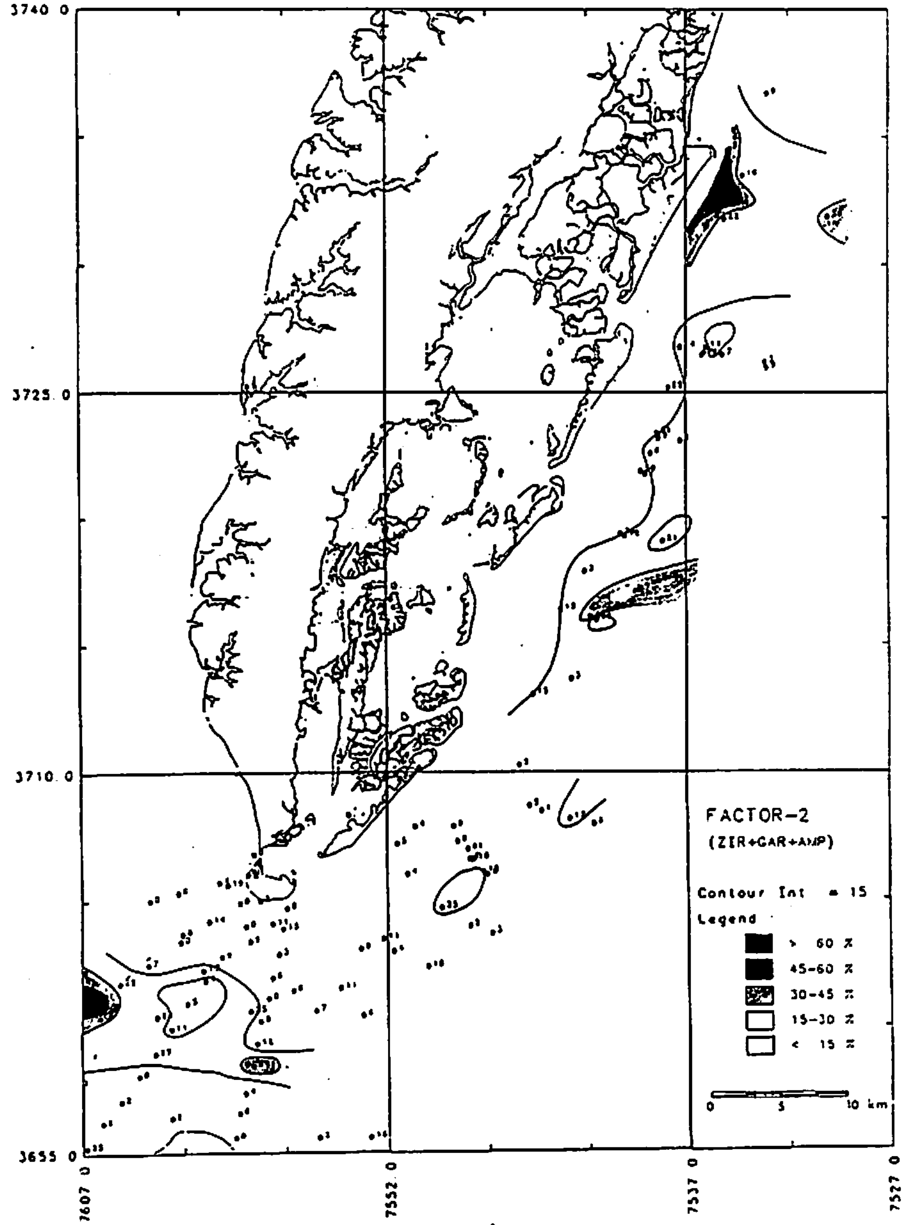


Figure 5 Contour map of sample composition loadings on Factor 2. Factor 2 is sample G84 and located at the southernmost part of the interest area (not shown in this figure).

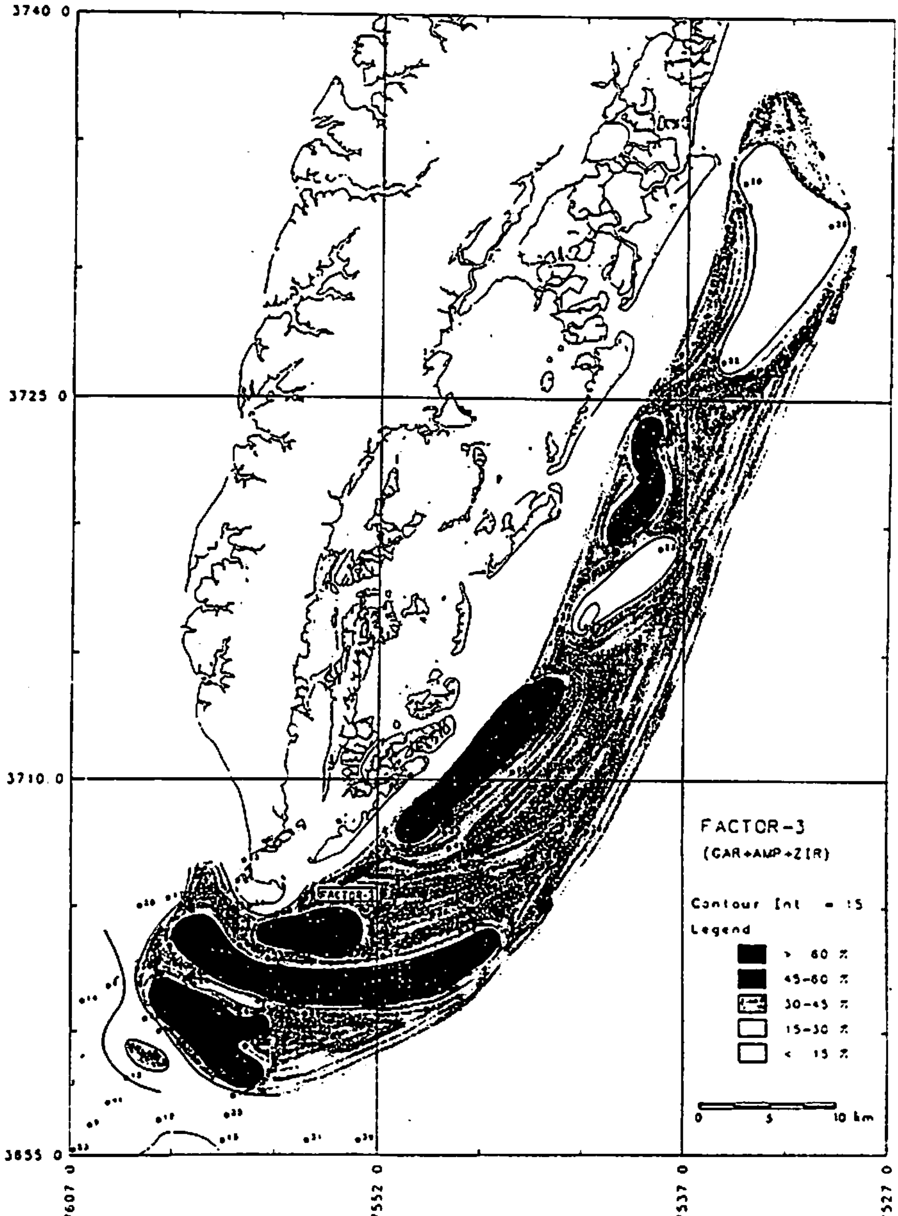


Figure 6 Contour map of sample composition loadings on Factor 3. Factor 3 is sample 145 and located at near Fisherman's Island.

VI. COASTAL HAZARDS AND THEIR MANAGEMENT

Evaluating the Impact of a Hurricane on a Local Community

J. Fletcher Hickerson
National Coordinating Council on Emergency Management

Introduction

It is a real pleasure for me to be with you today as a representative of the National Coordinating Council on Emergency Management. I bring you greetings from Ms. Casey Marley, our President, and from the more than 1200 members of the Council. The Council is composed of persons on the local level charged with the responsibility of planning and preparing for, responding to, recovering from, and mitigating the effects of various threats from natural, technological, and man-made hazards. We are the technical advisors to the chief administrator of our respective jurisdictions. The Council has been quite effective in representing the local viewpoint on disasters in testimony before Congressional committees and with the Federal Emergency Management Agency (FEMA).

One of the Council's duties is to evaluate the threat from various hazards and advise the public on what steps should be taken to avoid loss of life and decrease the damage from the strike. In my presentation today, I will be describing the steps we in Baytown, Texas take in evaluating the threat of a hurricane and what we do with information.

Where Is Baytown?

For a person to understand the importance of hurricane forecasts in the City of Baytown, it is necessary to know something about the city's location in relation to the surrounding area. Baytown, a city of 65,000 people, is located about 25 miles east of Houston and 45 northwest of Galveston. It is situated on the north side of the Houston Ship Channel with a series of inland bays adjoining the city limits. A few miles southeast of the city, the ship channel enters Galveston Bay, which in turn empties into the Gulf of Mexico. Baytown is highly industrialized, with Exxon U.S.A, Exxon Chemical Americas, Chevron Chemical Company, and Mobay Corporation having major plants in or near the city. Elevation of the land in the city is 0-35' N.G.V.D. (National Geodetic Vertical Datum).

Galveston Bay is surrounded by land that is substantially higher than the surface of the water. When storms make landfall along the coast to the southwest of Baytown, the counter-clockwise rotation of the storm brings southeast winds directly up the bay. With the wind force from behind and high ground on the sides, the water in the bay is pushed upward. Because of its location near the upper end of Galveston Bay, Baytown is subject to storm surges from hurricanes that can be 50% higher than those experienced at

Galveston.

Subsidence

Until 1978, all of the land in Baytown and the surrounding area had been sinking steadily due to the withdrawal of groundwater. The entire Houston area formerly used two water-bearing aquifers as the main source of water for cities, industries, and agriculture. All users were, in effect, taking water from one big well. As the water was withdrawn, the water table sank, leaving voids in the clay soil. The clay is compacted under the weight of the land, causing the land to sink. From 1915-1978, the western part of Baytown sank more than 9 feet. Most of the subsidence occurred between 1940 and 1976. The city now relies solely on surface water resources, so that further sinking is negligible.

Methods Used to Evaluate Hurricane Effects

National Weather Service (NWS) marine forecasts are used to obtain authoritative information on the forecasted position of the storm. When a hurricane is under surveillance, the National Hurricane Center issues a prognosis on the storm's position and strength every six hours in the marine forecasts. At Baytown, we obtain this information through a weather service by means of a modem on our computer. The bulletin gives the present position of the storm, its direction of forward motion in degrees, its forward speed in knots, the diameter of the eye in nautical miles, maximum sustained winds and gusts in knots, radius of 64-knot (75 mph) winds by quadrants, radius of 50-knot (57.5 mph) winds by quadrants, and radius of 34-knot (39 mph) winds by quadrants.

The position, maximum winds, gusts, and radius of 50- and 34-knot winds are forecasted for the storm for 8, 20, and 32 hours after the time of the bulletin. As guidance only, the position, maximum winds, gusts, and radius of 50-knot winds are forecasted for 44 and 68 hours after the bulletin.

The Hazard Management Group Graphics Display System is used to help interpret the error associated with the NWS marine forecasts. By this system, the information is put into the computer and the predicted positions are drawn on a map shown on the computer monitor with ellipses surrounding the positions indicating the error associated with the forecast. A choice is available as to the degree of confidence to be placed in the forecast, from 50 to 90 % in increments of 10 %. We routinely use the 70% confidence limits.

The program is also capable of showing the area of winds with ellipses according to the confidence level desired. We can use the program to calculate the distance between the position of the storm and landfall. We have found that the printouts from this program are very valuable in briefing local leaders on the status of the storm.

SLOSH ("Sea, Lake, and Overland Surge from Hurricanes,") is a computer model capable of predicting the storm surge at various locations developed by Dr. Chester Jalesnianski of the National Weather Service. Dr. Carlton Ruch of Texas A&M University made a study of the entire Texas coast using the SLOSH model. Our panel chairman, Dr. Phillip Berke, also had a major role in the study. In 1981 they published the report, "Hurricane Relocation Planning," for the 5-county area surrounding Houston and Galveston. The report shows the effects of 80 different hurricanes of varying intensity and conditions for 52 specific locations, four of which are adjacent to Baytown.

For each hurricane, information is given on the time of arrival of 52 mph winds, which can overturn a high profile vehicle, relative to estimated time of landfall by the storm. The same information is given for the time of arrival for 65.5 mph winds, which can overturn a car. Time for low and high tide flooding from the storm surge is also predicted, along with the height of the maximum high tide surge. Of special help to us is the table showing the height of the storm surge by hourly increments before and after landfall. The study is being updated this year to include more than 900 storms.

We have developed a form to assist us in tabulating the storm information as each marine forecast is received. We calculate the predicted time of landfall based on the time for the storm to travel the distance from the position at the time of the bulletin, assuming its forward speeds remains unchanged and it goes in a straight path to landfall. If the hurricane's path is not directly towards us, we assume that it continues for 24 hours and then turns towards us. We find that for Baytown, the 52 mph winds, which can overturn a high profile vehicle, are the first effect of the storm that would limit travel.

Texas A&M Univesity has developed a computer program called ESTED, Estimating the Safe Time for Evacuation Decision. This program uses the position of the storm and its forward speed to calculate the time for decision for each evacuation zone to allow for evacuation time before the arrival of travel-limiting winds. We use ESTED to check on our calculations, but use our own information, since the time for preparation varies for different people.

Each month we prepare a prediction of the time and height of the normal tides for our area, based on the tide tables at Galveston. In calculating the time profile of the storm surge, we use the information from SLOSH and correct it for our own normal tide predictions. To arrive at a final height, we assume that hurricane rain will raise the level in the bays by one foot.

Use of Hurricane Information

Decisions on actions to be taken in anticipation of a storm are based on the information that has been generated. Our plans call for the evacuation of persons in the flood zone and for those in mobile homes for storms with winds of < 130 mph (Category 3 or less). For storms with winds > 130 mph (Categories 4 and 5), we recommend evacuation of the entire city to locations further inland. For a number of years, we have distributed brochures giving elevation information and instructions on what actions to take. With the aforementioned information, we can make a decision on the specific areas that should be evacuated and when the evacuation should be done. Before we make public any decision, we review our plans with the local office of the National Weather Service.

Information and instruction must be given to the public. In our Emergency Operating Center is a 2-way radio which is part of the Public Information Emergency System (PIES). Through it we can activate the Emergency Broadcasting System and give information and instructions to the public. The PIES frequency is monitored by nearly all radio and television stations in the Houston-Galveston area, with station KTRH as the control station. We have found that there is a great deal of interest in the information and have made it a practice to have daily briefing meetings with community leaders including industry, business, schools, and the local press.

How Do the Predicted Conditions Compare With Actual Conditions?

When Hurricane Alicia struck Baytown on 18 August 1983, we had an opportunity to compare the predicted hurricane conditions with what actually happened. What began as a minimal tropical storm ended up with sustained winds of 115 mph, a Category 3 storm. On Tuesday, 16 August, Alicia had winds of 80 mph and the the National Hurricane Center issued a hurricane warning which included our area. Using the SLOSH information, we made the decision to recommend evacuation of areas under +8 feet MSL. Warnings were issued to those in the low areas with the recommendation that evacuation be completed by noon on Wednesday.

By noon on Wednesday, 17 August, the storm was located 85 miles south-southeast of Galveston, with sustained winds of 100 mph. With a forward speed of 5 mph, the storm was predicted to make landfall by 5 am on Thursday. Calculations from the noon bulletin showed that 52 mph gusts should start around midnight and 62.5 mph gusts should start around 3:30 am. The predicted storm tide using the procedure outlined above is shown in Figure 1. Adjustments were made to the time of the maximum tide, since the NWS said that the maximum could be expected at high tide.

At 1:30 am on Thursday, 18 August, wind gauges at the Exxon Refinery registered 62 mph. The storm tide reached about 11 feet at 7:30 am. Waves in the bays were 8 to 9 feet high. Most people heeded the warnings and sought shelter. About 100 persons were rescued from the water by police and public works persons.

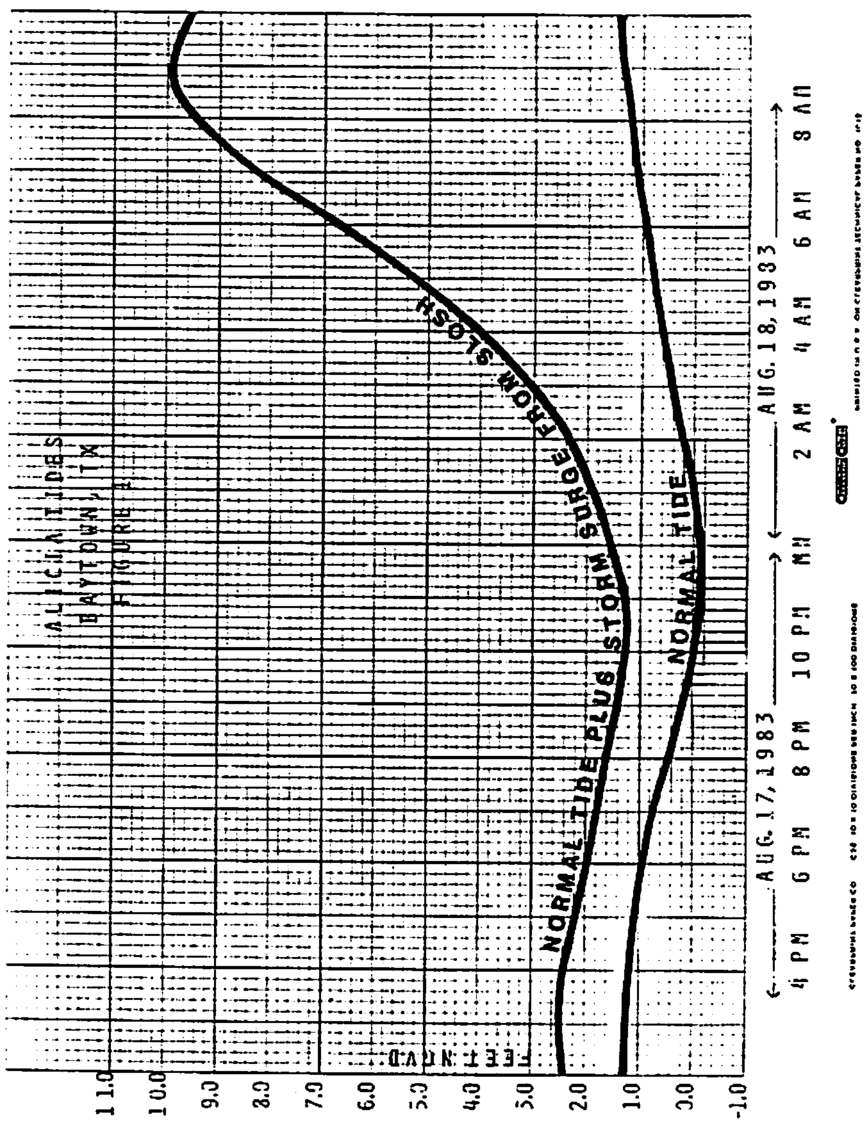
Figure 2 shows a comparison of the actual storm tide with that predicted from the Tuesday noon bulletin. The model underestimated the early phases of the storm. The actual maximum storm surge was about 11 feet compared with the 10 feet predicted. This was due to Alicia increasing in strength to sustained winds of 115 mph. The maximum was also about one hour earlier than predicted. The agreement between the actual and the predicted conditions depends in large part on how well the information agrees with the storm listed in the table. Alicia had almost the exact path and angle of strike and was moving at the exact speed. This does not always happen. In general, the prediction is more severe than actual conditions.

Conclusions

The marine forecasts together with the SLOSH predictions are very satisfactory tools for the local decision-maker to use in predicting and evaluating the effects of a hurricane a particular locale. The HMG Graphics Display System is of considerable help in giving confidence in the forecasts and in helping to show what can be expected as to the probability of a strike.

References

Ruch, C. 1981. Hurricane Relocation Planning for Brazoria, Galveston, Harris, Fort Bend and Chambers Counties. Study for Center of Strategic Technology, Texas Engineering Experimental Station, Texas A&M University System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-1.0
NORMAL TIDE PLUS STORM SURGE FROM SLOSH
NORMAL TIDE
AUG. 17, 1983
AUG. 18, 1983
4 PM
6 PM
8 PM
10 PM
MN
2 AM
4 AM
6 AM
8 AM

Fig. 1

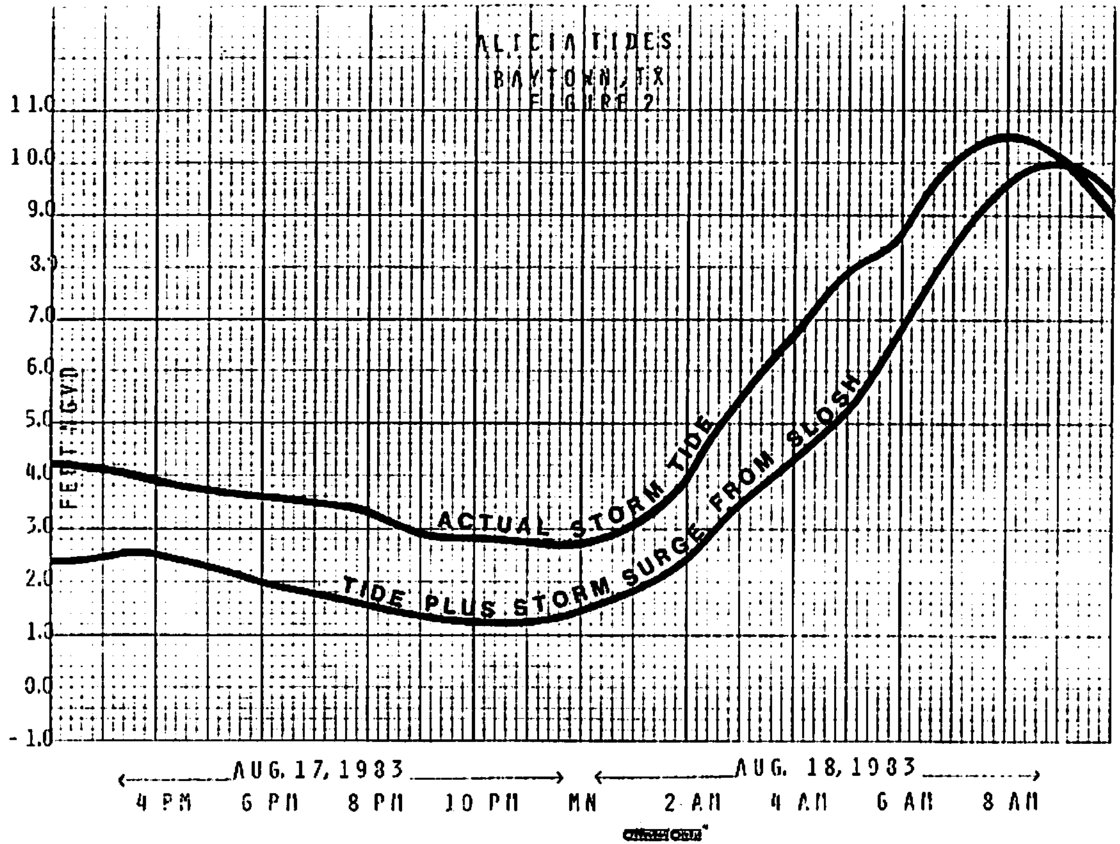
ALICIA TIDES
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FIGURE 2
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ACTUAL STORM TIDE
TIDE PLUS STORM SURGE FROM SLOSH
AUG. 17, 1983
AUG. 18, 1983
4 PM
6 PM
8 PM
10 PM
MN
2 AM
4 AM
6 AM
8 AM

Fig. 2

On the Use of NOAA's Storm Surge Model, SLOSH, in Managing Coastal Hazards: the Experience in Puerto Rico

Aurelio Mercado
University of Puerto Rico

Introduction

A numerical-dynamic, tropical storm surge model, SLOSH (Sea, Land, and Overland Surges from Hurricanes), was developed for real-time forecasting of hurricane storm surges on continental shelves, across inland water bodies, along coastlines, and for inland routeing of water - either from the sea or from inland water bodies. The model is two-dimensional, covering water bodies and inundated terrain. In the present version available at the University of Puerto Rico, a curvilinear, polar coordinate grid scheme is used (Figure 1). The grid cells are approximately 2 miles by 2 miles in size.

The model, developed by Dr. C. Jelenianski of the National Oceanic and Atmospheric Administration (NOAA), was brought to Puerto Rico as a result of a Flood Insurance Study (FIS) funded by the Federal Emergency Management Agency (FEMA). It should be emphasized that with the SLOSH model there is no calibration, or tuning, of empirical coefficients in order to fit observed data to simulations. Experience with the SLOSH model has shown that whenever observations strongly disagree with the results of the model, there is a strong likelihood that the cause is incorrectly specified hydraulics of the site (i.e., widths of channels or bay entrances, erroneous barrier heights, depths, etc.), or incorrectly specified storm parameters. This is an important fact since measurements of stillwater elevation during a hurricane were non-existent in Puerto Rico prior to Hurricane Hugo, and the situation in the rest of the Caribbean is similar.

Application of the SLOSH Model to Puerto Rico and the U.S. Virgin Islands

The flood insurance study

The FIS referenced above covered Puerto Rico and the U.S. Virgin Islands. Figure 2 shows a three-dimensional plot of the bathymetry supplied to the model in this study. Note the extremely narrow, deep shelf around Puerto Rico which protects the islands from the very high surges observed along the eastern seaboard of the U.S. during intense hurricanes. Figures 3a and b show an outline of the grid cells with the islands of Puerto Rico and the U.S. Virgin Islands, respectively. Also shown is the islands' outline as seen by the model. This FIS will result in a revision of all of the Flood Insurance Rate maps, which are also used by the state Planning Board for regulatory purposes. Maps showing the inland penetration of the 100- and 500-year stillwater elevation have been prepared, and we are presently in the process of delineating the width of the high-hazard (V) zone.

The hurricane evacuation studies

The model has also been used in preparing hurricane evacuation studies for six coastal cities in Puerto Rico, including the San Juan metropolitan area. In this type of study, flood maps are prepared showing the inland penetration of the storm surge according to the Saffir-Simpson hurricane strength category. Figure 4 shows the so-called "decision arcs" prepared for the San Juan study. These tell the local authorities when evacuation of certain areas should be started and when they should be finished. Figure 5 shows a section of a map prepared for the purpose of showing the authorities which shelters can be used, their capacity, the expected stillwater elevations, wind wave heights and runup, and information about the capacity of evacuation roads.

Hurricane Hugo: Observation versus Simulations

Hurricane Hugo provided the first opportunity to compare observations with simulations of the SLOSH model in Puerto Rico. Figure 6 shows the track of Hugo in the eastern Caribbean, with superimposed circles showing the radii of maximum winds. Figure 7 shows the so-called "maximum envelope of highest waters" for the simulation of Hugo. It shows the maximum stillwater elevation attained at each grid cell irrespective of the time when it occurred. Figures 8 and 9 show a comparison of the observed stillwater elevation time history inside San Juan Bay (obtained by a NOAA tide gauge) with the results from SLOSH for two contiguous grid cells inside the bay (the tide gauge happens to be located exactly at the boundary between these grid cells). Figure 10 shows observed stillwater elevation time history inside Charlotte Amalie Harbor (St. Thomas) versus the results from SLOSH for that location.

The results from the simulations, especially during the rise and maximum of the surge, fall within the ± 20% margin of error found for SLOSH along the eastern seaboard of the United States. Considering that no fine tuning has been done at all, the performance of the present SLOSH version available at Puerto Rico is very satisfactory. The rapid drop in surge height in the simulations compared with the observations can be easily explained as due to the use of "ocean" winds for winds going from land to sea. That is, as far as the wind model is concerned, there is no change in surface roughness due to the presence of the island. Consequently, the seaward-directed SLOSH winds are stronger than the observed ones and they help flush the bay much more rapidly than actually occurs.

Plans for the Near Future

Figure 11 shows the new SLOSH grid scheme developed at NOAA, specially adapted to the geometry of Puerto Rico. This will allow cells of smaller dimension near the coastline, producing much better resolution of small bays and coastal indentations. Further evacuation studies are planned with this new version of SLOSH. We are also working on describing the extreme wind-wave climatology due to hurricanes around Puerto Rico and the Virgin Islands.

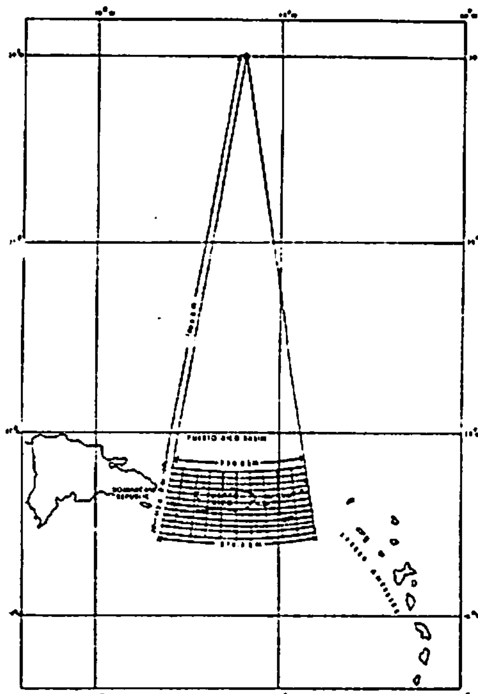


Fig. 1. Puerto Rico SLOSH basin

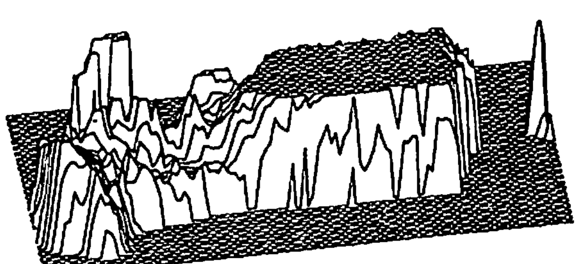


Fig. 2. Three-dimensional view of the bathymetry data supplied to the P.R. SLOSH basin

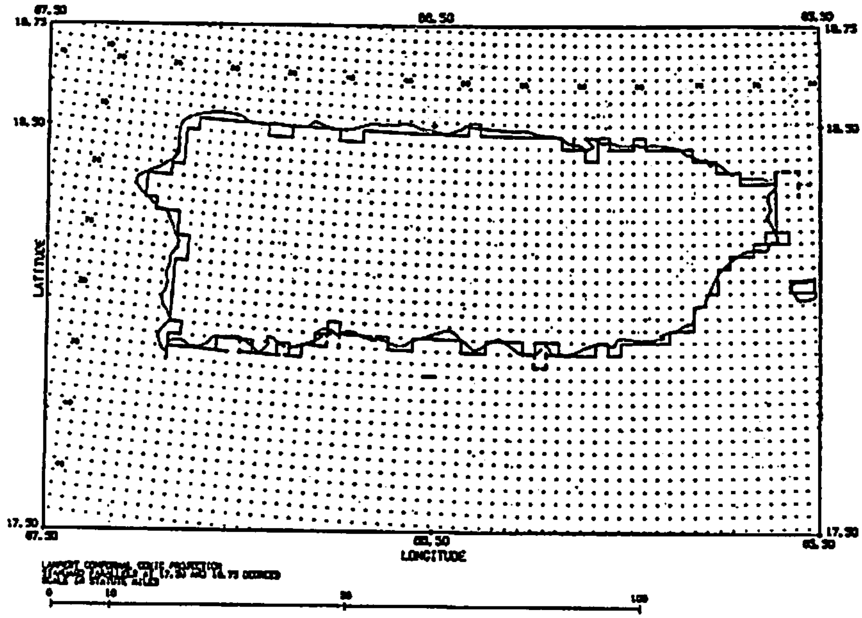
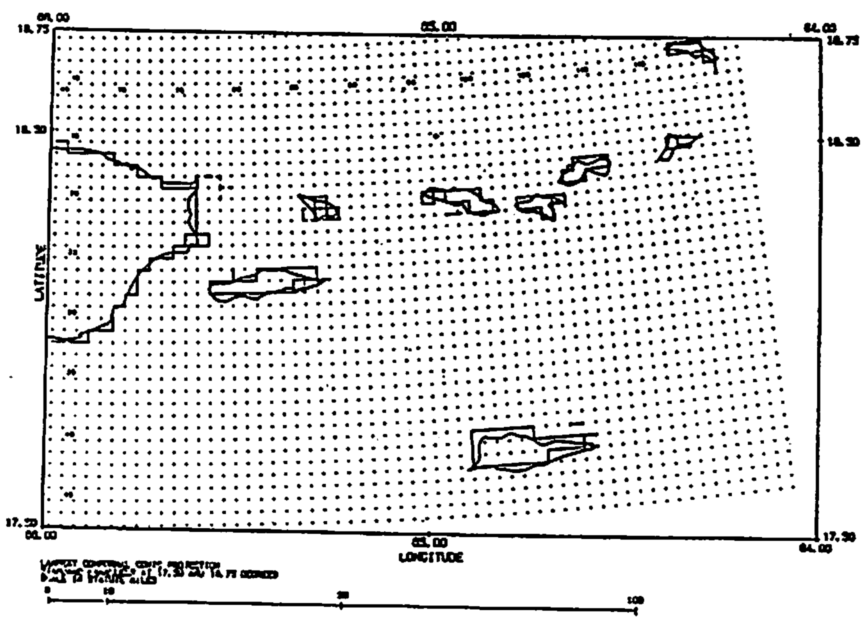


Fig. 3. Actual coastline (smooth) vs. coastline as seen by SLOSH.
a (top) Puerto Rico; b (bottom) U.S. Virgin Islands.



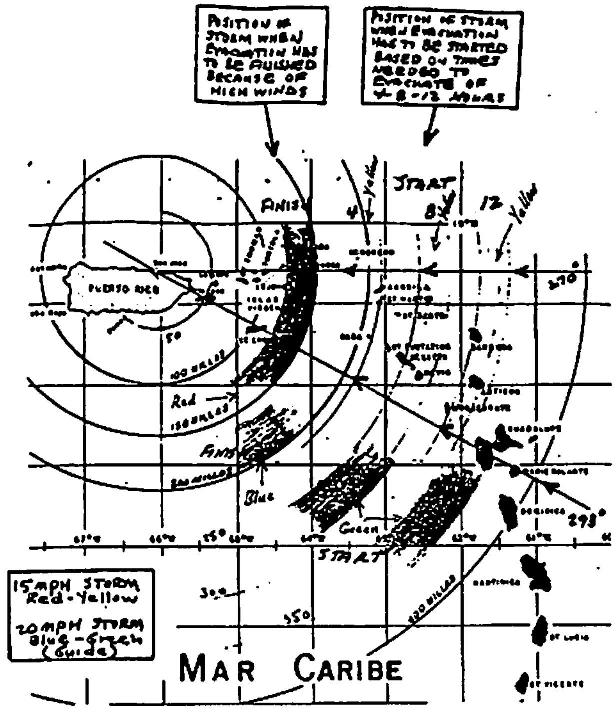


Fig. 4. Decision arcs prepared for the San Juan, P.R., metropolitan area hurricane evacuation study

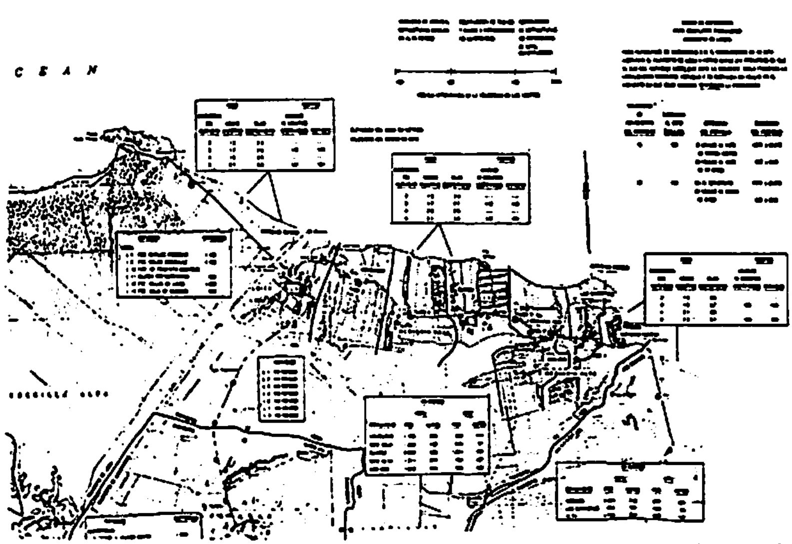


Fig. 5. Map prepared for the San Juan, P.R., hurricane evacuation study

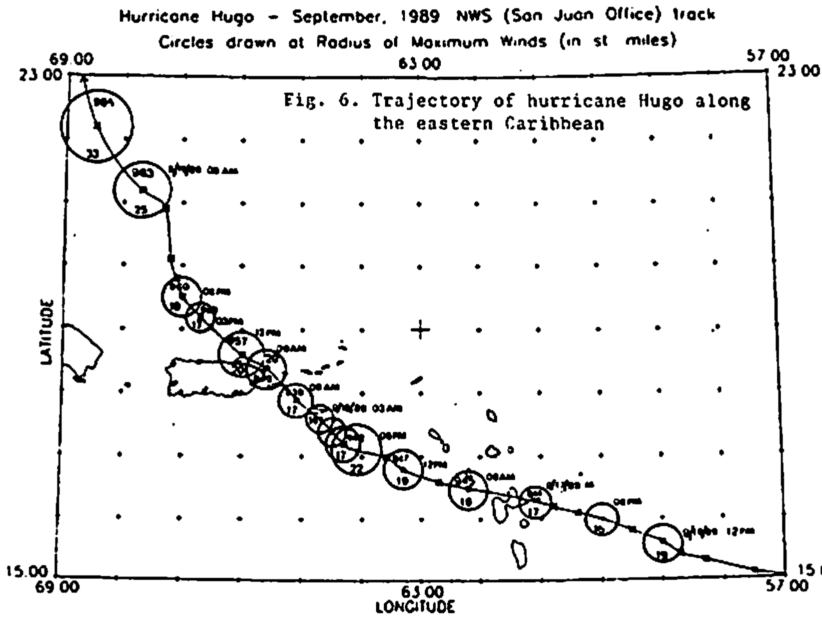
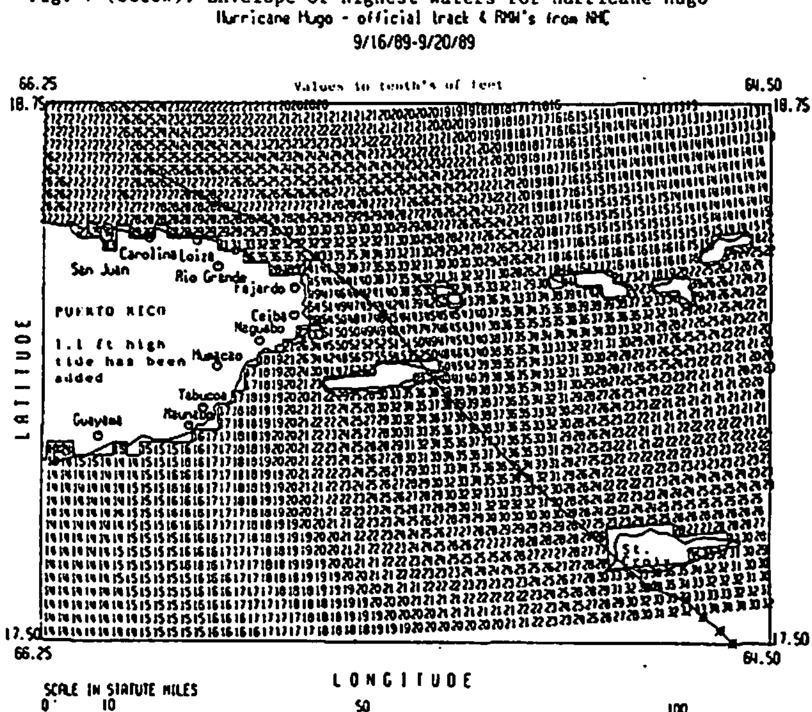


Fig. 6. Trajectory of hurricane Hugo along the eastern Caribbean

Fig. 7 (below). Envelope of highest waters for hurricane Hugo



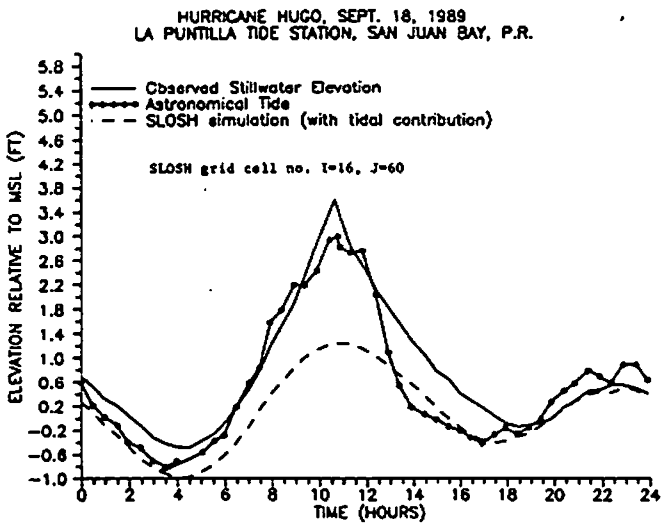


Fig. 8. Observed vs. results from SLOSH simulation

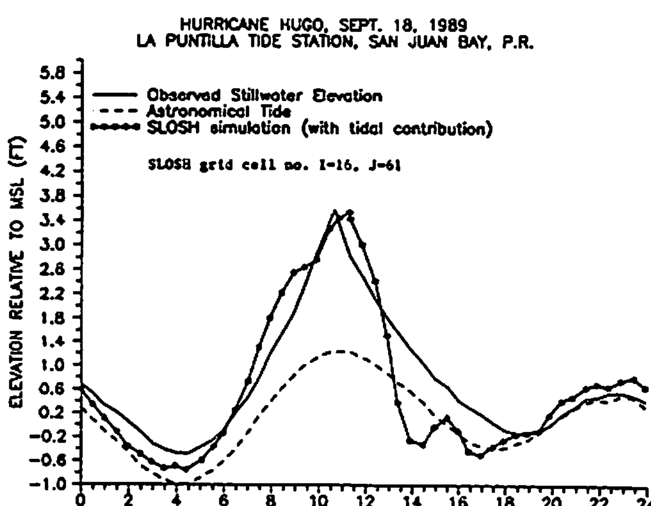


Fig. 9. Observed vs. results from SLOSH simulation

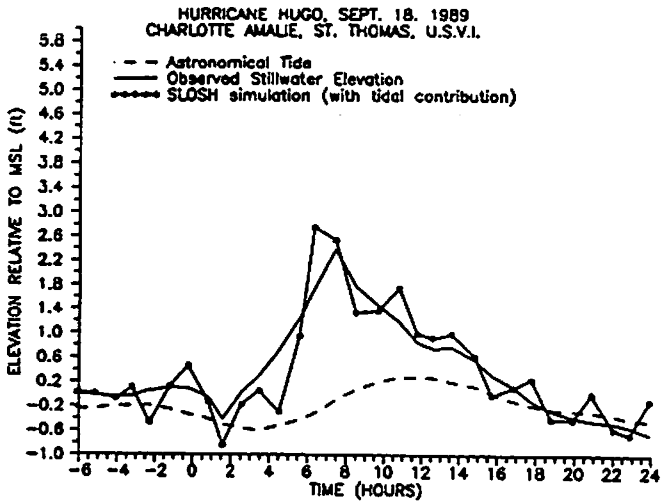


Fig. 10. Observed vs. results from SLOSH simulation

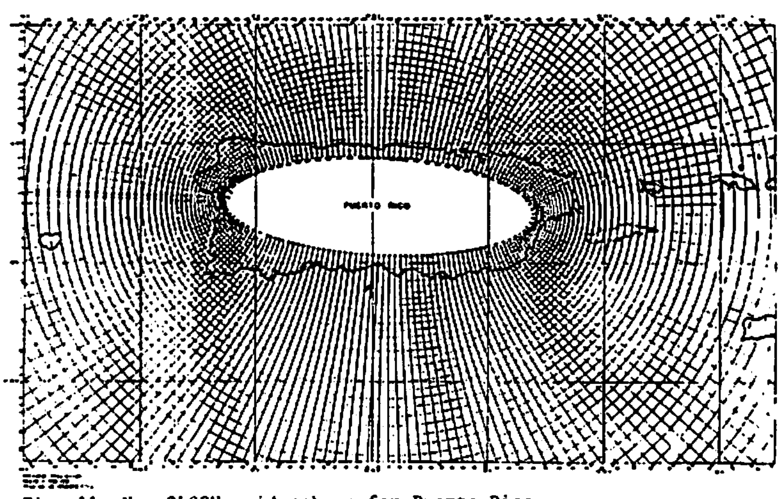


Fig. 11. New SLOSH grid scheme for Puerto Rico

Pre-Storm Beach Profile Survey Under Hurricane Threat

Shang-Yih Wang
Florida State University

Abstract

To protect coastal properties and control beach erosion during severe storm conditions, several beach erosion prediction methods have been developed during the last twenty years. Post-storm beach profiles were surveyed to provide a data base for beach erosion studies. Because of uncertain and hazardous conditions under hurricane threat, there is very little surveying that can be done on the beach immediately before a hurricane strikes. This lack of pre-storm beach profile data has limited the development of beach erosion prediction models.

This paper presents an empirical hurricane forecasting model primarily to identify a potential hurricane landfall area 3-5 days in advance. With the help of this information, coastal engineers may be given enough time to survey some pre-storm profiles before the coast becomes too vulnerable and potentially dangerous with the approach of the storm.

Introduction

A beach constantly adjusts its profile to cope with any weather condition. During storms, the beach is severely eroded due to large quantities of beach sediments that are carried offshore to dissipate incoming wave energy. In Hurricane Eloise, for example, all beach erosion occurred in less than 4 hours. An average of 7.4 yd^3 was removed (per foot of oceanfront) over a distance of 48 miles along the South Carolina ocean coast (Chiu, 1977). Recently, the coast of South Carolina showed this natural lesson again during Hurricane Hugo in late September, 1989. In a post-storm survey, Stauble et al. (1990) found that severe erosion of the beach and dune system was sustained from the storm along the affected coast. Many coastal erosion protection structures were either damaged or destroyed by the combined wave and surge action.

Predicting beach erosion during a storm, then, becomes one of the most important and difficult subjects facing coastal engineers. Recent research by Hughes and Chiu (1981), Kriebel and Dean (1985), and Vellinga (1986) has provided rational and practical methods to estimate storm beach erosion. But, these researchers claim that more before and after storm profile data are essential to refine the theory and to improve the accuracy of their models. Recognizing this fact, Birkemeier et al. (1988) for example, started to document available storm erosion data collected by the US Army Corps of Engineers between 1962 and 1978. They measured beach changes caused by

13 storm events on 7 coastal beaches of the northeast United States. The Coastal Society needs to continue similar efforts to collect more beach erosion data, especially during the hurricanes.

Major hurricane forecasting problems arise because the movement patterns of storms in higher latitudes are not always steady and easily predicted. A hurricane often can turn out to be an individualist and must be treated as such. At present, hurricane movement is monitored by aircraft, weather satellites, and radar. Modern prediction models using this monitoring information can minimize errors in a 24-hour forecast. owever, the errors of prediction increase dramatically with the length of forecast. Forecasters, therefore, avoid giving the public 72 or more hours notice with much confidence. For coastal engineers, a good understanding and monitoring of hurricane tracks in each affected area is a key for conducting successful pre-storm profile surveys. This study covers hurricanes of the North Atlantic Ocean.

Hurricanes of the North Atlantic Ocean

There have been 934 tropical cyclones of various intensities recorded over the North Atlantic area from 1871 to 1986 (NOAA, 1987). Tropical cyclones are defined as nonfrontal, low pressure, large-scale systems that develop over tropical or subtropical waters and have definite organized circulation (NOAA, 1977). The terms tropical depression, tropical storm, or hurricane are further classified depending upon whether the sustained surface winds near the center of the system are, respectively, less than 39 mph, 39 to less than 74 mph, or at least 74 mph. Since 1889, stages of development for cyclones are preserved on the North Atlantic Hurricane Tracking Chart. It is still not clear if all 934 cyclones moved following some patterns or rules. Without definite guidelines, one would stay on the sideline rather than try to predict the cyclone movement from those massive and complex tracks. Therefore, it is necessary to simplify the proposed model by excluding tropical storms and depressions whose forces are less destructive and whose movement more irregular. Hurricanes that originate near the equatorial area and reach hurricane intensity at early stage are then selected and analyzed. A total of 156 such hurricanes from 1889 to 1986 were used as the sample for this study.

Hurricane motion and its application

Since the nineteenth century, it has been well known that many hurricanes tend to follow an approximately parabolic path around the subtropical anticyclones over the oceans (Fig. 1). Winds from these large systems in which tropical cyclones are embedded were thought to "steer" the cyclones. According to this idea, the hurricanes move first westward at low latitudes in the prevailing easterlies. Near the western margin of an ocean their path is turned northward in the Northern Hemisphere. As they leave the easterlies and come under the influence of the westerly winds of high latitudes, they recurve toward the northeast. They may even go into the polar regions unless they strike land. This scheme is grossly simplistic, but probably correct for most hurricanes.

Analyzing these 156 hurricanes tracks from 1889 to 1986 shows that most hurricanes follow certain paths from their origins to landfalls or destinations. Six distinct groups are characterized by hurricane origins, paths, and geographic control points of the North Atlantic Ocean:

Group 1 moves from east of the Lesser Antilles to north of the Bahamas in a quasi-parabolic path toward the northeast region of the North Atlantic Ocean (Fig. 2). This group contains 75 hurricanes or 48% of the sample population. Thus, almost half the hurricanes will follow the simple parabolic path as described above. They start to move at an angle of 120 - 150° from the north, and recurve at about 25 - 30° North. This group is not a threat to Florida and the Gulf of Mexico area. It may, however, hit any part of the southeast and northeast coast depending on recurved angle and location. No pre-storm survey is recommended for this group of hurricanes.

Group 2 moves from east of the Lesser Antilles northwestward to Florida through the region between the Bahamas and Cuba (Fig. 3). This group accounts for 24 hurricanes or 15% of the total population. Except for a few cases, this group generally moves at about 120° or less from the north, keeping a fairly straightforward path through the islands until reaching the Florida area. If such a hurricane is monitored before it enters the Bahamas, there are about 3 days to make surveys in the southeast Florida area before it makes landfall. After these storms land in Florida, their paths become scattered into the Panhandle and it becomes hard to suggest an area of landfall anymore.

Group 3 moves from the south Caribbean northward through Cuba east of Havana and out into the North Atlantic Ocean (Fig. 4). There are only 9 hurricanes in this group. The chance to make a survey for this kind of hurricane is rare and not worthwhile.

Group 4 moves from the southeastern Caribbean northwestward to the Gulf of Mexico through control points between the Yucatan Channel and Havana (Fig. 5). Hurricanes of this group generally move along a smooth path at an angle of about 130° from the north without major disturbance. After they pass control points and enter the warm Gulf of Mexico, they have plenty of time to strengthen before making a landfall. Although there are only 12 hurricanes in this group, any hurricane of this type is very likely to develop into a major one such as Hurricane Camille of 1969. Once this kind of hurricane has developed in the southeastern Caribbean and moves toward control points, the survey team should start to move to west Florida areas.

Following the predictions of the National Hurricane Center after the hurricane passes control points, the survey team may have 2 to 3 days to survey before the hurricane lands. The major target area for this group is from west Florida to Louisiana.

Group 5 moves from south of Cuba northward to Florida through control points between the Yucatan Channel and Havana (Fig. 6). This group passes the same control points as Group 4, except it approaches control points at an angle of about 180° from the north. It is obvious that the target of all 15 hurricanes of this group is at Florida. Half of them passed south Florida, while the other half landed at the west coast. The major problem for the survey team under this group is lack of time. Although the path becomes more clear after it passes control points, it will be, usually, only 1 to 2 days before it hits Florida. When this type of hurricane develops and moves northward from south of Cuba, the survey team may start to prepare at southwest Florida, such as Collier County. If the hurricane turns northeast after it passes control points, the survey team may head east to the Miami area and reach that area in 2 hours.

Group 6 moves from the Lesser Antilles and the southern Caribbean westward to Texas and Mexico through control points between the Yucatan Channel and Yucatan (Fig. 7). This group includes 21 hurricanes, only 2 of which touched the most western part of Florida. It is, yet, a big threat to the Texas and Mexico coasts. These hurricanes start and travel in the same region as those in Group 4, except they move at a flat angle of about 110° from the north toward the western part of the Yucatan Channel. After passing control points, they have a good chance to keep similar paths toward Texas and Mexico. To survey pre-storm profiles on the Texas coast, engineers may watch those hurricanes move accordingly and pass through the western half of the Yucatan Channel only. There are about 3 days before the hurricane reaches Texas coast after it passes these control points.

Conclusion

Prediction of hurricane tracks is still a state-of-the-art task. It is unlikely that a perfect forecast will be available in the near future. Therefore, when meteorologists must decide where to post warnings, they face a scientific problem. Their only resort is to fall back on heuristic kinematic reasoning to assure that warning advice does not fail disastrously. Coastal engineers may need to make the same decision one day, if pre-storm profile surveys becomes a recognized routine to perform. It is important, though, to realize that pre-storm profile survey is a long-term investment. A good data base may take 10 or more years to collect, including some disappointing cases and wrong predictions. Despite the anomalous cases, a good total success rate is expected on this investment and should be encouraged by The Coastal Society.

References

Birkemeier, W. A., Savage, R. J. and Leffler, M. W., "A Collection of Storm Erosion Field Data," CERC-88-9, USAEWES, Coastal Engineering Research Center, Vicksburg, Mississippi, July 1988.

Chiu, T. Y., "Beach and Dune Response to Hurricane Eloise of September 1975," Coastal Sediments '77, pp. 116-134, ASCE, South Carolina, November 1977.

Dunn, G. E. and Miller, B. I., "Atlantic Hurricanes," Louisiana State University Press, pp. 30, Baton Rouge, Louisiana, 1960.

Hughes, S. A. and Chiu, T. Y., " Beach and Dune Erosion During Severe Storms," Coastal and Oceanographic Engineering Department, UFL/COEL-TR/043, University of Florida, Gainesville, Florida, 1981.

Kriebel, D. L. and Dean, R. G., "Numerical Simulation of Time-Dependent Beach and Dune Erosion," Coastal Engineering, Vol. 9, pp. 221-245, 1985.

NOAA, U.S. Department of Commerce, Federal Coordinator for Meteorological Services and Supporting Research, National Hurricane Operations Plan, FCM 77-2, pp. 104, Washington, D.C., May 1977.

NOAA, U.S. Department of Commerce, "Tropical Cyclones of the North Atlantic Ocean, 1871-1986," Asheville, North Carolina, September 1987.

Stauble, D. K., Seabergh, W. C. and Hales, L. Z., "The Initial Impact of Hurricane Hugo on the Beaches, Dunes and Inlets of South Carolina," Proceedings of the third Annual National Beach Preservation Technology Conference, pp. 362- 377, St. Petersburg, Florida, February 1990.

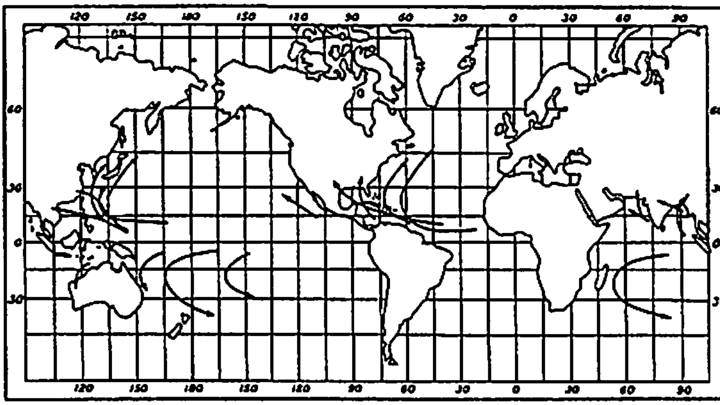


Fig. 1 Areas where tropical cyclones form, showing principal directions of paths (Dunn and Miller, 1960).

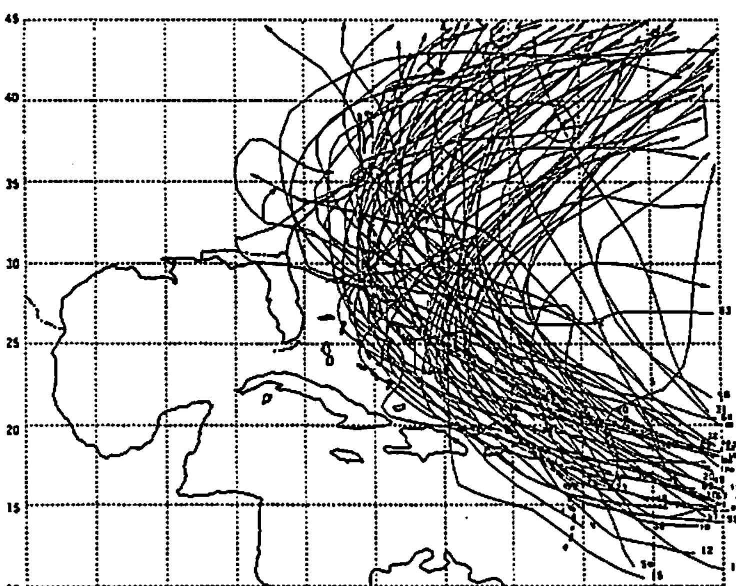


Fig. 2 Hurricane tracks of Group 1.

Group 2 Moving from the east of the Lesser Antilles northwestward to Florida through the region between the Bahamas and Cuba (Fig. 3). It counts 24

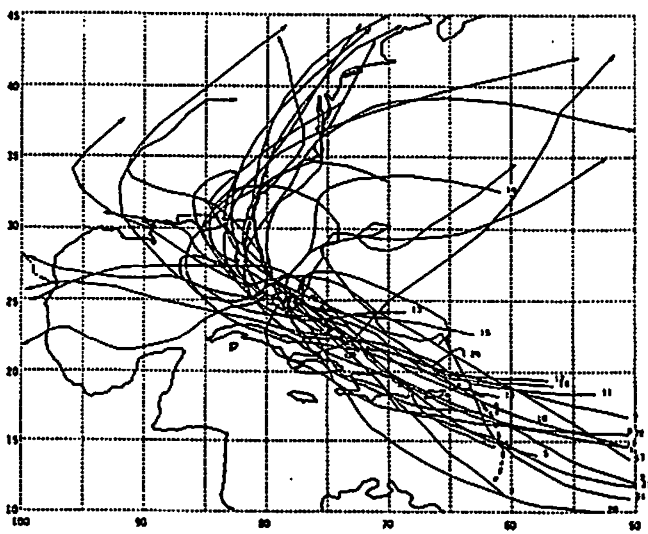


Fig. 3 Hurricane tracks of Group 2.

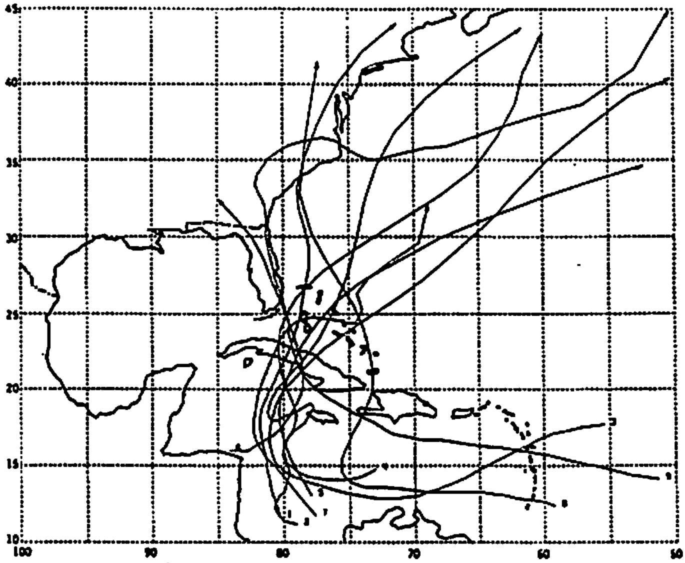


Fig. 4 Hurricane tracks of Group 3.

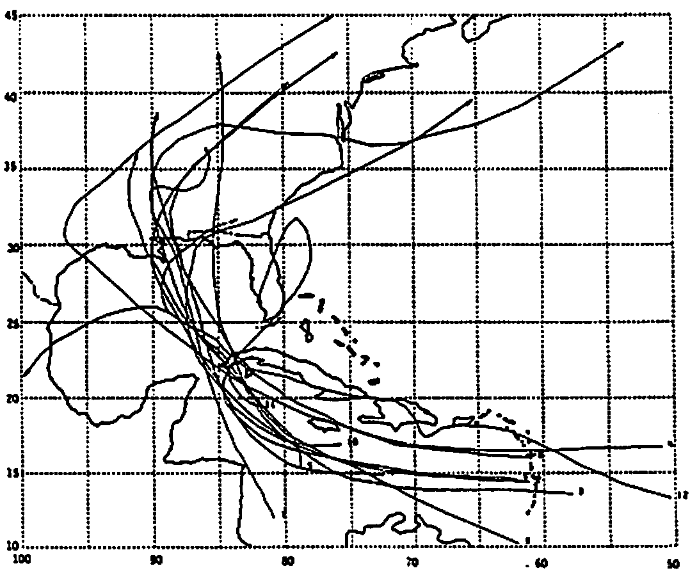


Fig. 5 Hurricane tracks of Group 4.

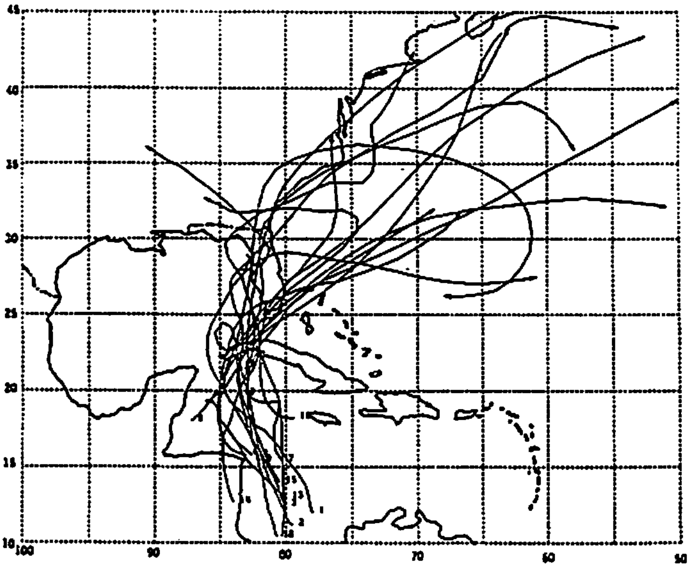


Fig. 6 Hurricane tracks of Group 5.

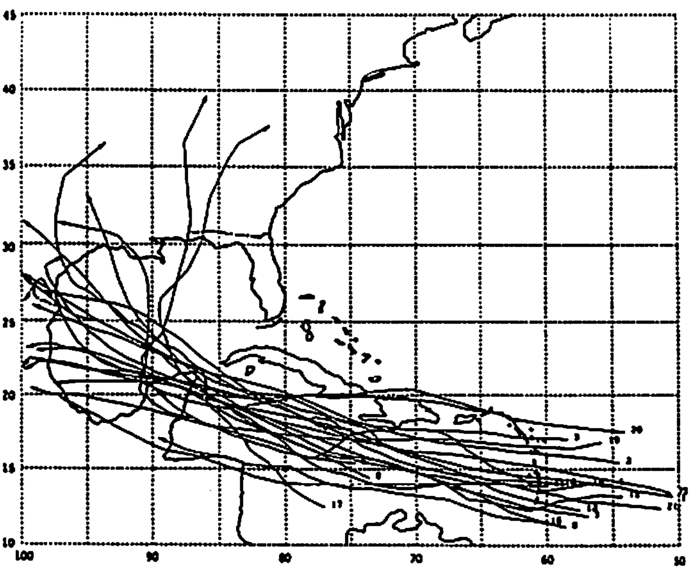


Fig. 7 Hurricane tracks of Group 6.

Vertical Land Movements in Coastal Washington: Implications for Coastal Erosion and Sea Level Rise

Hugh Shipman
Washington Department of Ecology

Introduction

Shoreline erosion is a continual source of concern for planners trying to manage and protect coastal development. Erosion can also threaten public safety, restrict public access to the shoreline, and threaten natural resources. Although efforts are often made to physically stop the shore from eroding, often the most appropriate solutions lie in careful planning and anticipation of problems.

The Shorelands Program of the Washington Department of Ecology, which has management and planning responsibilities for the state's coastal zone, is interested in identifying the factors that influence our coast in the long-term. During the last two years, the Program has examined the ramifications of an accelerated rise of sea level that might result from climate warming. One element of that project has been to characterize vertical land movement patterns in the state (Shipman, 1989).

Increasing concern about climate warming due to the "greenhouse effect" has raised the prospect of accelerated sea level rise. Existing estimates range from a few centimeters to several meters of global sea level rise by the year 2100 (National Research Council, 1987). Such a change in sea level would have dramatic impacts on the coastal zone and on shoreline erosion in particular. Vertical land movements are an important component of local sea level change and may influence regional erosion patterns.

Vertical Land Movements and Sea Level Rise

Global sea level has been rising at 10-20 cm/century during the last century, but the change at any particular location depends on local vertical land movement. If the land is rising faster than the sea, as is occuring along large parts of the US west coast, sea level will actually fall relative to the land surface. If the land is sinking, as it is along much of the Atlantic and Gulf Coasts, this will compound the effect of global sea level rise.

Vertical land movements arise from a number of causes, including large-scale interactions of tectonic plates, isostatic forces resulting from changing distributions of weight on the earth's crust, the settling and compaction of recently deposited sediments, and human influences such as the withdrawl of groundwater and hydrocarbons from beneath the Earth's surface.

Vertical land movements in the State of Washington were rapid during and following the last glaciation as a result of isostatic adjustments to the large load of the ice. The ice retreated 12,000 years ago and most present vertical movement is the result of plate tectonic interactions.

Vertical land movement may be detected in a number of ways. The presence of marine terraces raised above the present shoreline may indicate uplift of the land, whereas thick peat deposits in coastal marshes may reflect subsidence of the land. Vertical land movements can be inferred from archaeological and historical records of changing sea level, but often the reliability of the data is poor. Modern rates of vertical movement are derived from tide gauge records or from leveling surveys, but the small magnitude of the rates makes high precision crucial. Clearly, most of these methods require isolating the contributions of global sea level changes from those of vertical movement.

Vertical Land Movements on the Outer Coast

Washington's Pacific Ocean coast comprises a range of shoreline types. The rugged northern section, along the western shore of the Olympic Peninsula, is carved from highly deformed Tertiary sedimentary rocks. Resistant headlands separate short sand and gravel beaches. The southern section consists of extensive sand beaches that form large spits seaward of the Grays Harbor and Willapa Bay estuaries. A transitional zone between the northern and southern sections consists of widely separated rocky promontories and long, straight beaches fronting bluffs of poorly consolidated Quaternary terrace deposits.

Vertical motion along the state's outer coast is largely related to the subduction of the Juan de Fuca Plate eastward beneath the edge of the North American Plate. Uplifted estuarine deposits and raised marine terraces along the coast indicate that the net uplift rate has been less than 10 cm/century during the late Pleistocene. An 80,000 year-old marine terrace varies in elevation from sea level to over 50 meters, implying that the amount of uplift has varied considerably along the coast. Maximum rates of uplift have been along the northernmost section of the coast.

Records from tide stations along this coast during the last fifty years show that mean annual sea level has fallen slightly, consistent with the geologic evidence. Astoria, at the mouth of the Columbia River, is emerging at a rate of 3 cm/century, and Neah Bay, at the northwestern tip of the state, is emerging at about 10 cm/century (see Figure 1).

The history of vertical motion along the state's outer coast has been complicated by recent studies of marsh stratigraphy that suggest that the gradual uplift has been punctuated by sudden subsidence events linked to great subduction-zone earthquakes. Atwater [1987] has found evidence of at least six buried marsh surfaces in coastal peat sequences. The plant assemblages indicate that emergent marsh surfaces were lowered abruptly into the intertidal zone, a drop of 0.5 to 2.0 meters. The recurrence interval averages about once every 600 years, but is highly irregular. The most recent event occurred about 300 years ago.

Vertical Land Movements in the Puget Lowland

Puget Sound, the San Juan Islands, and the Strait of Georgia lie in a broad Tertiary downwarp that corresponds to the forearc basin of the Cascade Volcanic Arc. Although the basinal structure is evidence of long-term net subsidence, much of the geologic history has been obscured by repeated Pleistocene glacial advances into the Puget Lowland. The most recent glaciation reached a maximum about 15,000 years BP (before present), and retreated from the region by 12,000 years BP.

Vertical land movements were rapid following the retreat of the ice. The land rebounded upward over 200 m in the area around Vancouver, British Columbia, and 50-100 m in the central Puget Sound region. As the large ice sheets melted, global sea level rose rapidly, approaching its current levels about 6000 years BP. In the northern Puget Lowland, the rate of isostatic rebound exceeded the post-glacial rise in sea level and the land surface rose relative to the sea. Rebound slowed by 8000 years BP and eustatic sea level rise began to dominate. In the southern Puget Lowland, the rise in sea level was always more rapid than the rebound, and submergence prevailed throughout the early and mid-Holocene.

Marsh stratigraphy from Puget Sound confirms continued submergence of several meters during the late Holocene, whereas the record from the northern Lowland and the San Juan Islands indicates relative crustal stability. Tidal records from the last several decades show that sea level at Friday Harbor in the San Juans has risen at about the same rate as global sea level rise, suggesting minimal vertical land movement. Sea level has risen more rapidly at Seattle, in central Puget Sound, as a result of greater rates of subsidence (see Figure 1).

Leveling surveys in western Washington confirm the basic eastward down-tilting of the region, but also suggest large regional variability (Holdahl et al., 1989). Neah Bay, in the northwestern corner of the state, is rising the most rapidly, whereas the southern parts of Puget Sound are subsiding the fastest.

Implications for Changes in Relative Sea Level

The data indicate that vertical land movements in coastal Washington range from uplift of 25 cm/century at Neah Bay to subsidence of 24 cm/century near Tacoma. If global sea level is rising at about 12 cm/century (Gornitz et al., 1982), then Neah Bay is emerging at 13 cm/century and Tacoma is submerging at 36 cm/century.

Vertical land movements will remain a significant component of relative sea level change for the near future. Relative sea level will continue to fall along much of the outer coast, and will continue to rise in Puget Sound. Sea level will rise at the global average rate in the northern Puget Lowland.

In the event of accelerated sea level rise due to greenhouse warming, we can expect the long-term pattern of uplift at Neah Bay to be reversed early in the next century. Present rates of submergence in Puget Sound will increase (Figure 2). Under a scenario of 100 cm of global sea level rise by the year 2100, sea level will be 120 cm higher in Seattle than at present, and 70 cm higher in Neah Bay.

There will be no clear signals that accelerated sea level has begun to occur. The tide measurements are noisy and it will take many years of record to establish changes in the trend. Planning for rising sea levels will have to occur in the absence of incontrovertible evidence.

The impacts of accelerated sea level rise will include increased magnitudes and frequencies of coastal flooding, increased sea water intrusion into coastal aquifers, inundation and loss of wetlands, and increased rates of coastal erosion. Many of these are existing problems and accelerated sea level rise only increases the urgency in dealing with them.

Implications for Coastal Erosion

Erosion problems along Washington's coast are minor as a result of slow rates of shoreline recession and relatively low densities of shoreline development. Problems are expected to increase as the level of development increases in the region, even if sea level does not rise appreciably.

Shoreline recession and erosion are partially a function of sea level rise, but also depend on many other variables. Sediment budgets, wave conditions, and human modifications to the shore may all affect rates of accretion and erosion. If all of these factors were held constant, rates of shoreline recession would be expected to reflect changes in sea level. The general trends of erosion in Puget Sound and accretion along the ocean beaches are consistent with, but not necessarily a result of, submergence of the interior waters and emergence of the outer coast.

Erosion of the Ocean Beaches

The extensive sand spits at Long Beach and Ocean Shores have accreted laterally throughout the late Holocene, leaving a series of shore-parallel dune ridges. The westward accretion has continued during this century at rates of more than 6 m/yr in some locations. This seaward growth of the beaches is consistent with an emerging coastline, but is better attributed to the high flux of sediment from the Columbia River.

The beaches consist of fine sands and silts and have very gradual slopes. A small increase in relative sea level would have a significant impact on the position of the shoreline, if it were not for the overriding influence of sediment supply. The historic rate of accretion has slowed in some locations during the last decade, possibly reflecting a decreased supply of sediment from the now-dammed Columbia (Phipps, 1990). If sea level rise accelerates, we might expect to see accretion rates slow, and possibly reverse, during coming decades.

Coastal Erosion in the Puget Lowland

Shorelines in the Puget Lowland consist largely of moderate to high banks of poorly consolidated glacial drift. This material erodes easily and the shoreline has steadily retreated since the area was deglaciated, largely in response to rising sea level. Much of the shoreline still reflects the glacially-formed topography.

This irregular shoreline leads to complex patterns of longshore sediment transport. Erosion occurs rapidly at headlands through a process of wave undercutting and oversteepening of unstable bluffs. The eroded sediment is transported along the shore and eventually to deeper water or to numerous small depositional shoreforms. Regional, chronic erosion in the Puget Lowland is fundamentally a function of an easily eroded shoreline out of equilibrium with rising sea level, but local patterns of erosion are more related to longshore sediment movement, local geology and hydrology, and human activities (Keuler, 1988).

Bulkheading and riprapping are the typical responses to erosion around the Puget Lowland, but this hardening of the shoreline restricts the amount of material provided to the littoral system, and may aggravate erosion problems downdrift. As sea level rises, the pressures to protect property from erosion will increase. Unfortunately, the effectiveness and the cumulative impacts of the resulting shoreline hardening are poorly understood.

Conclusions

Upward landward movement on Washington's Pacific Ocean coast is more rapid than global eustatic sea level rise, and thus relative sea level is falling. This, along with high sediment fluxes from the Columbia, contributes to long-term accretion of the broad beaches of southwest Washington. In Puget Sound, the land is subsiding, effectively increasing the rate of sea level rise. This steady rise in sea level is a factor in the chronic shoreline recession throughout Washington's interior waters.

If sea level rise accelerates as a result of greenhouse warming, the historic accretion of the southwest coast may slow or reverse. Rates of erosion will increase in the more highly developed Puget Lowland. The impacts on shoreline habitats, public access, and aesthetics may be severe, particularly in those areas where the shoreline is hardened. We anticipate a greater need for nonstructural responses to shoreline retreat, including progressive setbacks and improved construction guidelines for coastal development.

References

Atwater, B.F. 1987. Evidence for great Holocene earthquakes along the outer coast of Washington State. Science, 236:942-944.

Gornitz, V., S. Lebedeff, and J. Hansen. 1982. Global sea level trend in the past century. Science, 215:1611-1614.

Holdahl, S.R., F. Faucher, and H. Dragert. 1989. Contemporary vertical crustal motion in the Pacific Northwest. Pages 17-29 In: Cohen, S.C., and P. Vanicek, (eds), Slow Deformation and Transmission of Stress in the Earth. IUGG/American Geophysical Union Geophysical Monograph 49, v. 4.

Keuler, R.F. 1988. Map showing coastal erosion, sediment supply, and longshore transport in the Port Townsend Quadrangle, Puget Sound Region, Washington. U.S. Geological Survey Miscellaneous Investigations Map I-1198-E.

Lyles, S.D., L.E. Hickman, Jr., and H.A. Debaugh, Jr. 1988. Sea Level Variations for the United States, 1855-1986. U.S. National Oceanic and Atmospheric Administration, 182 p.

National Research Council, Committee on Engineering Implications of Changes in Relative Mean Sea Level. 1987. Responding to Changes in Sea Level-Engineering Implications. National Academy Press, 148 p.

Phipps, J.B. 1990. Coastal accretion and erosion in southwest Washington: 1977-1987. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Washington, 33 p.

Shipman, H. 1989. Vertical land movements in coastal Washington: implications for relative sea level changes. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Washington, 37 p.

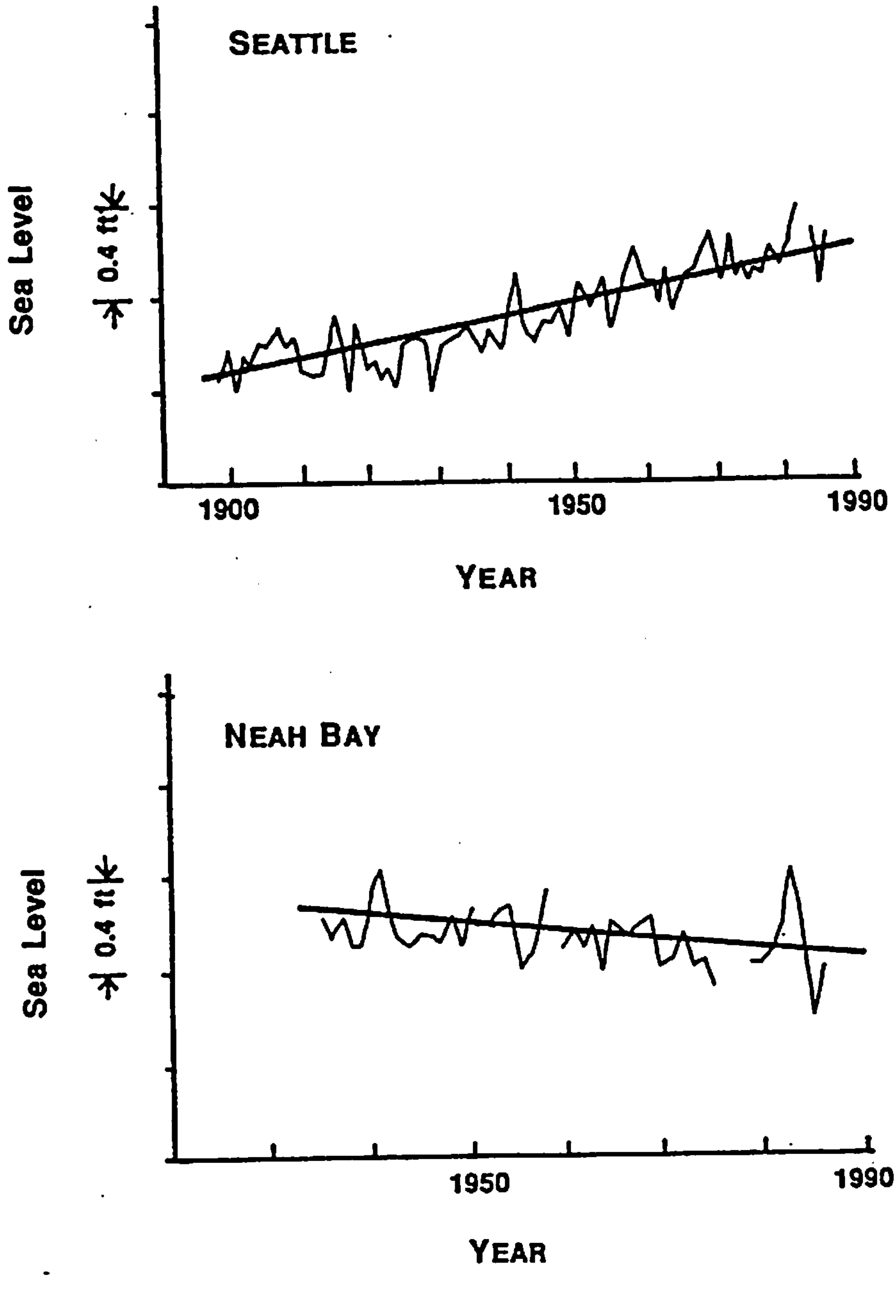


Figure 1. Trends of mean annual sea level at Seattle and at Neah Bay, Washington. (from Lyles, 1988)

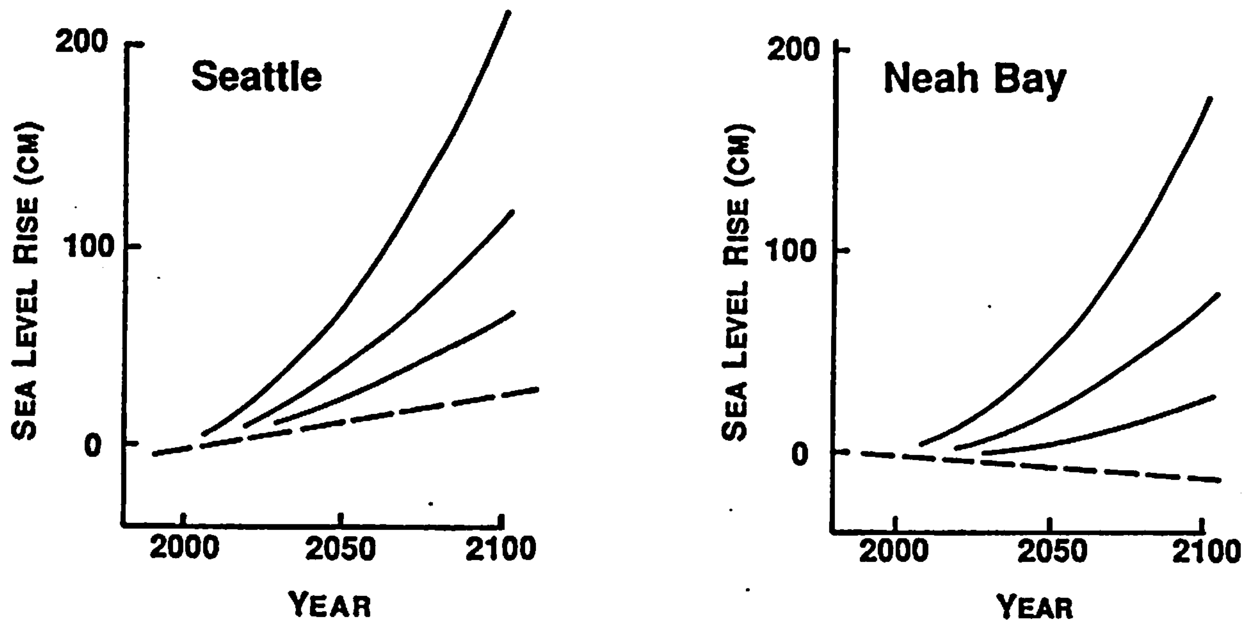


Figure 2. Scenarios of future sea level at Seattle and Neah Bay. Dashed line is current trend. Solid curves are accelerated sea level scenarios of 50, 100, and 200 cms of rise by the year 2100.

VII. THE DYNAMIC COAST

Transport and Movement of Suspended Sediment in a Partially mixed Estuary, Charleston Harbor, South Carolina

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Abstract

A well-defined turbidity maximum zone (TMZ) exists upstream of the entrance to Charleston Harbor, South Carolina, on the Cooper River, where the salinity varies between 5-15%. The TMZ is characterized by 40% light transmission over a 5 cm path-length near the bottom, as compared to 60-80% light transmission elsewhere. The range of total suspended sediment (TSS) concentration varies from 60-100 g/m^3 in the TMZ, while 10-40 g/m^3 is the common TSS concentration elsewhere in the estuarine portion of Charleston Harbor and the Cooper River. TSS was correlated with transmissivity using a second degree polynomial curve (r^2=0.79). TSS concentration depends largely on tidal stage and varies significantly from spring to neap tide. Spring tide TSS concentrations are 2-3 times greater than concentrations during neap tides. High tide concentrations are twice as great as low tide concentrations. The net downstream transport of suspended sediment is primarily a function of freshwater discharge, but is particularly large when flood events coincide with spring tides.

Introduction

Estuaries are complex dynamic systems that serve as a buffer between terrestrial and marine environments. Dynamic estuarine processes control how suspended sediments are distributed and transported. Estuarine processes occur over a range of time scales from burst events to systematic variations within tidal cycles, semidiurnal, diurnal, weather cycle, seasonal, and interannual cycles (Dyer, 1986; Kjerfve and Magill, 1990). The variability of freshwater discharge at the upstream boundary is a major control on sediment concentration and transport (Schubel and Pritchard, 1986; Sharp et al., 1986; Williams, 1989), together with tidal forcing at the downstream boundary (Uncles, 1983; Aubrey, 1986; Abraham, 1988). Freshwater discharge and tidal forcing produce gravitational circulation and salinity stratification within estuaries and can be directly related to the distribution of TSS concentration and the location of the turbidity maximum zone (TMZ).

The TMZ forms downstream of the interface between fresh and saline waters in most coastal plain estuaries. It is a region of high total suspended sediment (TSS) concentration compared to other parts of the estuary. The mechanism thought most likely to govern the formation of this zone is estuarine circulation (Festa and Hansen, 1978), though flocculation, deflocculation, and local resuspension are contributing mechanisms. To explain the distribution and dynamics of TSS in estuaries, it is imperative to understand the estuarine dynamics.

McCarthy et al. (1974), Hoskin et al. (1978), and others developed relationships between suspended sediment concentration and transmissivity using field and laboratory data. Despite limited success in particular systems, no universal relationship exists. However, a consistent relationship appears to be possible to define for individual estuaries (McCarthy et al., 1974), allowing TSS to be characterized in terms of light transmissivity. This is a more attractive technique of determining TSS on a routine basis compared with filtering water samples.

It is my objective to establish a relationship between TSS and light transmissivity for Charleston Harbor and the Cooper River, and use this to characterize TSS variability and the physical processes that influence sediment transport in the Charleston system. Longitudinal field measurements, spanning a four-year period, consisting of salinity, transmissivity and suspended sediment, collected during varying tidal and river flow conditions, are analyzed in the study. In addition, several cross-sectional sets of measurements were undertaken in the turbidity maximum zone.

Characterization of the Charleston Harbor System

Charleston Harbor is a major estuarine system along the southeastern coast of the United States (lat N 33° and long W 80°). The harbor is fed by three rivers, the Ashley, Cooper, and Wando (Fig. 1), with average freshwater discharges of 10, 3, and 127 m^3/s, respectively. The estuarine portion of the system covers 110 km^2 at Mean Low Water (MLW), and is surrounded by an extensive, frequently inundated, 160 km^2 brackish and salt marsh area. The water volume in the estuary measures 6.39 x 10^8 m^3 at MLW.

The Cooper River has been the site of a number of water diversion projects (Kjerfve, 1976, 1989; Kjerfve and Magill, 1989a, 1989b, 1990), where the mean freshwater discharge was altered, primarily in response to the need for generation of electricity. Completion of the Cooper River Diversion project in 1941 increased the freshwater runoff from 2 m^3/s to 418 m^3/s, whereas the Cooper River Rediversion project in 1985 caused a reduction of the average freshwater discharge to 127 m^3/s (Kjerfve and Magill, 1989b). As a result of the 1985 rediversion, salinity increased, tidal intrusion affected the system further upstream, and the sediment regime adjusted. The Cooper River still contributes the majority of freshwater input to the system (127 ± 75 m^3/sec) and most of the suspended sediment input. The Ashley and Wando rivers have discharges of 10 m^3/s and 3 m^3/s, respectively. All three rivers are tidally driven to their upstream ends, which in the case of the Cooper River is to the Pinopolis Dam, 89 km upstream of Fort Sumter at the Charleston Harbor entrance.

Sediment Environment

Sediment studies in Charleston Harbor were done by Neiheisel (1966), Neiheisel and Weaver (1967), Meade (1969), and van Nieuwenhuise et al. (1978). These investigations occurred before rediversion and provide the opportunity to compare sediment characteristics in Charleston Harbor prior and subsequent to the rediversion.

Since the 1985 rediversion, the riverine input of clay sediments has decreased and oceanic sands have become the dominant sedimentary feature in the lower harbor (USACE, 1987). This is mainly due to increased landward bottom tidal currents associated with rediversion. Clay minerals are still abundant within the Cooper River and are the main component of the suspended material associated with the turbidity maximum zone.

Changes in the sediment environment are important for the management of the estuary, including dredging. The U.S. Army Corps of Engineers presently spends \$3 million annually to dredge the main navigation channel of 3×10^6 m^3 of material and an additional \$7 million to dredge the harbor entrance (between the jetties). Shoaling, as well as salinity intrusion, has been attributed to the dredging and deepening of channels (Festa and Hansen, 1976; Nichols, 1988). With the proposed increase of the main channel depth to 13.5 m, increased sedimentation in the estuary is expected.

Tides

The tide in Charleston Harbor is semi-diurnal with a range that varies from 1.15 m during neap tides to 2.05 m during spring tides. The tidal range can be amplified during spring equinox to 2.5 m in the harbor. Time-height curves are symmetrical in the harbor, but a marked asymmetry develops upstream, prolonging the ebb and reducing the flood duration (SCWRC, 1979). In the upper reaches of the Cooper River, high tide lags the tide at the harbor entrance significantly buty has almost the same range. For example, at the Tee (55 km upstream), high tide lags the harbor tide by 4 hours but has only 0.25 m lower range. For most of the river, high and low water correspond closely to slack currents. The tidal prism for the entire Charleston system varies from 1.85×10^8 m^3 during neap tides to 3.12×10^8 m^3 during spring tides.

Gravitational Circulation

Hansen and Rattray (1965) define gravitational circulation as the nontidal circulation associated with maintaining the salinity distribution in estuaries, controlled by a seaward flow of river water and tidal mixing, and induced by density differences between fresh and saline waters. Charleston Harbor is a partially-mixed estuary that exhibits gravitational circulation. The gravitational circulation within the system was stronger before rediversion, but is still an effective means of transport (Kjerfve and Magill, 1989a). Tidal currents within the estuary are on the order of 1 m/s for peak flood and peak ebb but regularly exceed 2 m/s in the harbor entrance during spring tides. Residual currents associated with the gravitational circulation usually attain speeds of 0.2 m/s. Rutz (1988) found that far-field forcing from the coastal ocean is an important mechanism in changing mean sea level in the Charleston system and causing salinity intrusions far up the Cooper River.

Field Measurements and Data Reduction

To characterize sediment distribution in Charleston Harbor subsequent to the 1985 rediversion project, a field program was carried out. The investigation included systematic profile measurements of TSS, CTD, and transmissivity at numerous stations along Charleston Harbor and across the TMZ on the Cooper River. In addition, current vanes (Kjerfve and Medeiros, 1988) were used to measure profiles of current velocity.

Field sampling consisted of two separate studies: (1) longitudinal sampling at 19 stations from Fort Sumter to the Tee on the Cooper River following the upstream progression of high tide, and in a few instances following the upstream progression of low water and (2) time series sampling at a fixed station near the mean location of the TMZ.

Longitudinal sampling was carried out sequentially from Fort Sumter to the Tee by following the progression of high water tide from station #1 to #19. At each station, a Sea Bird CTD with a bundled Sea Tech transmissometer (5 cm path-length) was used to measure instantaneous vertical profiles of temperature, conductivity, and light transmissivity. Data were recorded eight times per second as the CTD-transmissometer was lowered and raised. In addition, a 0.5 l Niskin water sampling bottle was lowered to and raised from the main shipping channel or deepest part of the river channel. Samples were collected at each station one meter below the surface, at mid-depth, and one meter above the bottom. Data were collected from April 1987 to April 1990.

Time series sampling consisted of measurements of current profiles using a current vane (Kjerfve and Medeiros 1989), CTD profiles, and collection of water samples over one tidal cycle at a single station located near the center of the turbidity maximum zone. Anchored buoys were positioned in the left, center, and right parts of the channel cross-section. At hourly intervals, from each buoy, the CTD and the Niskin bottle were lowered and raised from the bottom, collecting the same data as in the longitudinal sampling (except that only 250 ml of water were collected instead of 500 ml). In addition to the CTD and Niskin bottle, a current vane was used to measure current velocities at each buoy.

After each day of sampling, data were transferred from the CTD unit to a portable microcomputer and converted to depth-averaged bins using various FORTRAN programs in such a way as to produce longitudinal and cross-sectional plots of density, salinity, temperature and transmissivity. Measured suspended sediment concentration, velocity and flux of salt and suspended sediment were also converted into useful longitudinal and cross-sectional plots.

Water samples for suspended sediment analysis were brought to the University of South Carolina for drying and weighing. The techniques of Schubel (1967) for measuring suspended sediment concentrations by filtration were followed. Pre-weighed, dried, and desiccated glass fibre 1.2 μm pore size filters (Fisher brand) were used. In each case, up to 500 ml of water was pumped through the filter. Each filter with filtrate was dried, desiccated, and reweighed. The weight per volume (mg/l) of total suspended sediment (TSS) was calculated for each sample from the difference in before and after filter weights divided by the volume of the water sample.

The Turbidity Maximum Zone

The turbidity maximum zone is a very distinct feature in Charleston Harbor characterized by suspended sediment concentrations between 60-100 mg/l. The location of the turbidity maximum zone is a function of high salinity variability and gravitational circulation. The general position of the turbidity maximum zone is between 20-45 km upstream of Fort Sumter. Its mean low tide position is between 27-36 km upstream of Fort Sumter. Its mean high tide position is between 30-42 km upstream of Fort Sumter.

Figure 2a shows the RMS salinity variation along the Cooper River. The largest variations occur between 20-35 km upstream of Fort Sumter. A A correlation thus exists between net transmissivity (Fig. 2b) and RMS salinity in this region. Where the largest deviations from the normal mean salinity occur, it can be expected that large amounts of suspended sediment will be found. By knowing the location of the high RMS salinity zone, the location of the TMZ can be estimated.

Variation in the Location of the TMZ

The variability in the location of the turbidity maximum zone between tidal amplitudes of the same magnitude is very small (between 1-2 km) under normal conditions, but under storm and episodic conditions the position of the TMZ changes dramatically, being pushed further downstream.

Variation in the location of the turbidity maximum zone, between spring and neap tides can range from 5-12 km depending on the height and phase of the tide, and the discharge. If the comparison is between a spring high tide and a spring low tide, the variability can exceed 12 km. If the comparison is between neap high tides and neap low tides,the variability does not exceed 5 km. The horizontal movement of the turbidity maximum zone between high and low tides is 3-13 km, but can be higher during episodic events. The phase of the tide is also an important factor in this comparison.

It is evident that the turbidity maximum zone moves during the tidal cycle (Figs. 3a & 3b). Movement of the TMZ during the tidal cycle is dependent upon the salinity regime as well as the strength of the gravitational circulation. The TMZ moves downstream during ebb tide and back upstream during flood tide, creating a sloshing effect. It is during these periods of movement that the highest concentrations of suspended sediment are found. It can also be generalized that during the movement, riverine sediments are carried downstream during ebb and marine sediments are carried upstream during flood.

Transmissivity Versus Suspended Sediment Concentrations

The relationship between transmissivity and suspended sediment concentration in estuaries has not yet been found to have a universal relationship. However, such a relationship appears possible to define the Charleston Harbor, allowing TSS to be characterized in terms of light transmissivity ($r^2=0.79$)(Fig.4). By using a second degree polynomial curve, the following equation can be used in relating TSS (mg/l) to transmissivity (%):

(1) $TSS = 122.06 - 2.47x + 0.013x^2$

This relationship is important in that it allows the oceanographer to get turbidity measurements in terms of TSS, by using transmissivity, without having to go through the difficult task of filtering water samples. It must be noted that this relationship is only calibrated for Charleston Harbor and should not be taken as the norm for other estuarine systems.

Conclusions

The study of Charleston Harbor's TMZ has shown that it is a complex and dynamic part of the estuarine system. The location of the TMZ is dependent upon the type and stage of the tide as well as varying freshwater discharge. The position of the TMZ will shift according to the stage of the tide as well as tidal amplitude. Transmissivity and TSS have been found to be directly related when a second degree polynomial curve is fitted.

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References

Abraham, G. 1988. Turbulence and mixing in stratified tidal flows. Pages 149-180 in: J. Dronkers and W. von Leussen (eds.), Physical Processes in Estuaries. Springer-Verlag, Berlin.

Aubrey, D.G. 1986. Hydrodynamic controls on sediment transport in well-mixed bays and estuaries. Pages 245-258 In: J. van de Kreeke (ed.), Physics of Shallow Estuaries and Bays. Springer-Verlag, Berlin.

Dyer, K.R. 1986. Coastal and Estuarine Sediment Dynamics. John Wiley and Sons, Chichester. 342 pp.

Festa, J.F. and D.V. Hansen. 1965. Gravitational circulation in straits and estuaries. Journal of Marine Research 23:104-122.

____ and ____. 1976. A two-dimensional numerical model of estuarine circulation: the effects of altering depth and river discharge. Estuarine, Coastal and Shelf Science 4:309-323.

____ and ____. 1978. Turbidity maxima in partially mixed estuaries: a two-dimensional numerical model. Estuarine and Coastal Marine Science 7:347-359.

Hoskin, C.M., D.C. Burrell and G.R. Frietag. 1978. Suspended sediment dynamics in Blue Fjord, Western Prince William Sound, Alaska. Estuarine and Coastal Marine Science 7:1-16.

Kjerfve, B. 1976. The Santee-Cooper: study of estuarine manipulations. pages 44-56 In: M.L. Wiley (ed.), Estuarine Processes, Vol. 1, Academic Press. 541 pp.

____. 1989. Physical processes in Charleston Harbor. Pages 13-24 in: Charleston Harbor: Issues, Resources, Status, and Management. NOAA Estuary-of-the-month seminar series 16. Washington, DC. 62 pp.

____ and C. Medeiros. 1989. Current vanes for measuring tidal currents in estuaries. Estuarine, Coastal and Shelf Science 28:87-93.

____ and K.E. Magill. 1989a. Hydrological changes in Charleston Harbor, South Carolina. Pages 2640-2649 In:Proceedings of the 6th Symposium on Coastal and Ocean Management/ASCE, Charleston, South Carolina.

____ and K.E. Magill. 1989b. Hydrological changes in Charleston Harbor, South Carolina. Pages 2640-2649 In: Proceedings of Coastal Zone 89. Vol 3:2640-2649.

____ and K.E. Magill. 1990. Salinity changes in Charleston Harbor. Journal of Waterway, Port, Coastal, and Ocean Engineering 116:153-168.

Meade, R.H. 1969. Landward transport of bottom sediments in estuaries of the Atlantic coastal plain. Journal of Sedimentary Petrology 39:222-234.

Neiheisel, J. 1966. Significance of tidal hydraulics. Committee on Tidal Hydraulics. Corps of Engineers, U.S.Army. Technical Bulletin 10. 30pp.

_____ and G.E. Weaver. 1967. Transport and deposition of clay minerals in southeastern United States. Journal of Sedimentary Petrology 37:1084-1116.

Rutz, S.B. 1988. Post-rediversion longitudinal water elevation and salinity variability in the Cooper River, SC. M.S. thesis, Marine Science Program, University of South Carolina. Columbia, SC. 58 pp.

South Carolina Water Resources Commission. 1978. Cooper River controlled low-flow study. Report 131:1-353.

Schubel, J.R. 1967. On suspended sediment sampling by filtration. Southeastern Geology 8:85-87.

____ and D.W. Pritchard. 1986. Response of upper Chesapeake Bay to variations in discharge of the Susquehanna River. Estuaries 9:261-269.

Sharp, J.H., L.A. Cifuentes, R.B.Coffin, J.R. Pennock, and K.C. Wong. 1986. The influence of river variability on the circulation, chemistry, and microbiology of the Delaware estuary. Estuaries 9:271-282.

Uncles, R.J. 1983. Modeling tidal stress, circulation and mixing in the Bristol Channel as a prerequiste for ecosystem studies. Canadian Journal of Fisheries and Aquatic Sciences 40:8-19.

United States Army Corps of Engineers. 1987. Ports of Charleston and Georgetown, South Carolina. Port Series 13:1-73.

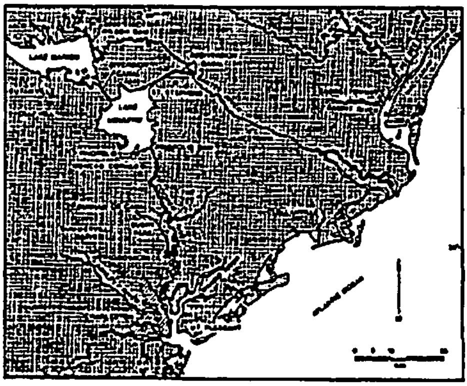
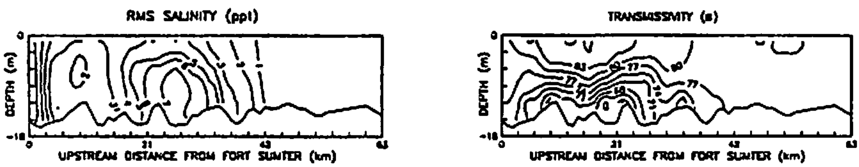


Figure 1. Charleston Harbor is located along the southeastern coast of South Carolina, U.S.A. The major tributaries of the system include the Ashley, Cooper and Wando Rivers.



(a) (b)

Figure 2. High tide longitudinal distribution of (a) RMS salinity (ppt) and (b) net transmissivity (%) for the Cooper River.

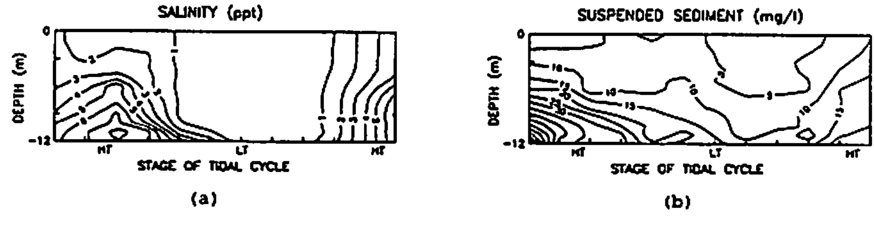


Figure 3. Variation over tidal cycle of (a) salinity (ppt) and (b) suspended sediment (mg/l), in the mean location of the turbidity maximum zone.

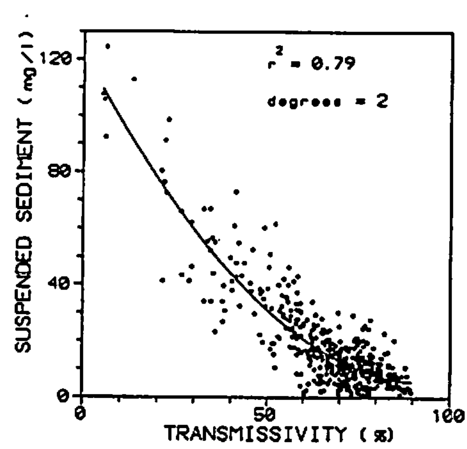


Figure 4. Relationship between transmissivity and suspended sediment using a second degree polynomial curve (r^2 = 0.79).

Coastal Marsh Nourishment Through Freshwater Diversions In Southeast Louisiana

Jack Moger
Kenneth Faust
Brown & Root, USA, Inc.

Background

Delta formation

The Mississippi River drains parts of 32 interior states and southern Canada and brings fresh water laden with nutrients and sediment to the Mississippi deltaic plain. Extensive research over the last 40 years has indicated that southeast Louisiana was formed by the Mississippi River making four major course changes in a period stretching over the last 6,000 years. This process resulted in the formation of four delta systems: the Teche Delta; the St. Bernard Delta; the LaFourche Delta; and the Modern Delta. This system of wetlands contains approximately 40% of the coastal wetlands in the lower 48 states of the United States.

Natural and commercial benefits of wetlands

The range, diversity, and productivity of plants and animals, including endangered species, that inhabit the Louisiana coastal zone is extraordinary (Viosca, 1927 and 1928; Conner and Day, 1987). This zone supports the largest coastal finfish and shellfish production annually -- 30% of the U.S. annual commercial fishery harvest. (Fruge, 1980; Coupe, 1985; Davis, 1983). The Louisiana coastal zone is the largest fur producing region in North America, with 40% of the national wild fur and hide harvest annually. It is also the wintering ground for two-thirds of the ducks and geese that migrate along the Mississippi Flyway.

Disruption of natural process

Throughout this century, the Mississippi deltaic plain has experienced net deterioration owing to the synergistic effects of natural deltaic decline and man's activities (Morgan, 1973). To protect settlers from flooding and to accommodate navigation, levees were constructed. This resulted in the rich nutrients and sediment of the Mississippi flowing into deep waters off the continental shelf rather than replenishing the wetlands. Levees, soil compaction, sea level rise, and dredging of navigation channels throughout the marshes have decreased deltaic formation and allowed the waters of the Gulf of Mexico to erode southern Louisiana at a rate exceeding 35 mi^2 per year.

The resulting increase in salinity, reduction in quantity and quality of intertidal lands, and decrease in river-borne nutrients have been associated with decreases in various forms of estuarine production (Gunter, 1952; Chabreck, 1981).

Mitigation measures

Several mitigative measures have been proposed to slow the deterioration of the deltaic plain (Gagliano et al. 1973). These measures include: fresh water diversion from the Mississippi River for the purpose of salinity control or subdelta growth through sediment transport; installing saltwater barriers in tidal passes, navigational channels, and oil field channels; filling open water areas with dredged material; and restoring and stabilizing barrier islands through beach nourishment. Of these options, controlled fresh water and sediment diversions seem to offer the greatest long-term benefits at the lowest relative cost.

Managing salinity

The major concept of freshwater diversions is to replicate the natural processes of the Mississippi River. Diversions create favorable salinity conditions and contribute nutrients and sediments to the estuary that enhance vegetative growth, reduce land loss, and increase production of fish and wildlife. Salinity is perhaps the single most important factor determining the distribution limits and abundance of the majority of estuarine organisms (Gunter et al., 1974), and the importance of identifying how best to manage salinity cannot be overstated.

Two boundaries for salinity management

Identifying a specific salinity management scheme that would result in maximum estuarine productivity is a difficult task. Despite the limitations, the U. S. Army Corps of Engineers, in developing feasibility studies, estimated desirable salinity conditions so that suitable diversion sites and capabilities could be determined. These studies included the development of salinity management schemes for both the Barataria and Breton Sound Basins. An important factor in developing these schemes was the location of the 15 parts per thousand (ppt) isohaline at different times of the year. Desired locations for this boundary were established to complement two resources: the "Ford Line" for fisheries productivity and the "Palmisano Line" for wildlife productivity after T. B. Ford and A. W. Palmisano, their primary authors (U.S. Army Corps of Engineers, 1970) (See Figure 1).

In both Barataria and Breton Sound Basins, the Ford Line is located just seaward of the maximum concentrations of historically productive oyster reefs. The tolerances and requirements of oysters weighed heavily in the determination of this boundary because it is believed that an environment that is conducive for the production of oysters is also beneficial to other fisheries resources (Lindall et al., 1972). The Ford Line defines the position of 15 ppt mean isohalines from spring through fall.

The Palmisano Line for wildlife defines the location above which salinities greater than 15 ppt should not occur more than 5% of the time throughout the year. This condition pertains primarily to marsh salinities since plant growth and composition are directly correlated with wildlife productivity (Palmisano, 1973).

Diversion Program for Plaquemines Parish

Using these two sets of boundaries, a freshwater diversion plan was established for Plaquemines Parish, Louisiana (see figure 2). This plan takes advantage of Plaquemines Parish being located in the modern delta and having direct access to the Mississippi River. Surrounding Plaquemines Parish are three major hydrologic basins: Breton Sound Basin to the east; Barataria Basin to the west; and Mississippi River Delta at the mouth of the river. A freshwater diversion program has been established for each of these basin.

Breton Sound

Four structures are feeding the wetlands of Breton Sound

1. Caernarvon freshwater diversion structure

The structure is a federal/state project that is presently under construction and should be in operation by January, 1991. The structure is located at the north end of the basin. It consists of five 15'x 15'reinforced box culverts approximately 381 feet in length with prefabricated cast iron sluice gates passing under the mainline Mississippi River levee. The structure will divert an estimated flow of 6,600 cfs into the wetlands of Breton Sound via Lake Big Mar.

2. White's Ditch siphon diversion

The present White's Ditch freshwater diversion structure was constructed in 1963 by Plaquemines Parish Government and consists of two 400' 50-inch diameter siphons that cross over the Mississippi River levee and outfall into Breton Sound via Belair Canal. The present structure diverts approximately 300 cfs during high river stages of the Mississippi, usually January through August. State and local plans are to double the flow to 600 cfs by adding two additional 50-inch siphons.

3. Bohemia Spillway

The spillway was constructed in 1969 to provide a flood relief measure to the City of New Orleans during high river stages. However, the structure was rarely used and is now out of service. State and local plans are to utilize this structure as a freshwater diversion to nourish the marshes of Breton Sound. The structure consists of four gated 60-inch diameter corrugated metal pipes, each 90' long. Estimated flow through the structure is 736 cfs at high river stages of the Mississippi.

4. Bayou LaMoque freshwater diversion

This structure, constructed in 1956, consists of two separate gated structures that divert Mississippi River water into Breton Sound via California Bay. During high water seasons, the flow of the two structures is estimated to average 13,000 cfs. This structure is a state-operated project and is currently in operation.

Barataria Basin

The Barataria Basin is fed by three structures:

1. LaReussite and West Pointe a la Hache freshwater diversions

These structures are state/local projects that are presently under construction and should be in operation by early 1992. When built, each structure will consist of eight 72-inch diameter siphons that will divert Mississippi River water over the river levees and into the marshes of the Barataria Basin. High water flow is 2,000 cfs for LaReussite and 2,100 cfs for West Pointe a la Hache.

2. Davis Pond

This is a federal/state project that is currently under design and is projected to be operating by 1995. The project is located at the north end of the Barataria Basin. It is estimated to divert an average of 11,000 cfs of Mississippi River water during average high river stages.

Mississippi River Delta

Diversion into the Mississippi River delta:

Pass a Loutre wildlife management sediment diversions

Three sediment diversions were constructed in 1987 and six more in early 1990 in the Pass a Loutre Wildlife Management Area for the purpose of marsh creation in the Mississippi Delta. In 1987, diversions were placed in South Pass, Pass a Loutre, and Loomis Pass. Surveys were taken in 1988 and showed that the 1987 diversions produced up to 70 acres of new wetlands through crevasse splay development. In 1990 six more diversions were constructed in this area using the same concept of breaching the natural banks of the passes. Three were placed in South Pass and three were placed in Pass a Loutre. These sites were strategically placed in areas that had the greatest possibility of maximizing land growth.

Modeling Freshwater Diversion

At present, Plaquemines Parish, in conjunction with the State of Louisiana Department of Natural Resources, the Army Engineer Waterways Experiment Station (WES), and the U. S. Army Corps of Engineers, New Orleans District is developing comprehensive numerical models for both the Breton Sound and Barataria Basins. These models will be constructed using the TABS-2 numerical modeling system for hydrodynamics and transport of freshwater and sediments. Predictions can then be made utilizing these models in achieving targeted flow patterns and salinity boundaries.

As part of the modeling procedures, an extensive monitoring plan is being established. This monitoring plan includes the collection of hydrodynamic parameters such as water velocity and tidal fluctuations, as well as salinity and water quality. These parameters will be used for verification of the model.

During and after each high water season, different outfall management schemes will be studied to help improve the chances for success of the program. These studies will involve investigating different operational plans as well as changing flow patterns by the construction of hydraulic structures in the outfall.

References

Chabreck, R. H. 1981. Freshwater inflow and saltwater barriers for management of coastal wildlife and plants in Louisiana. Pages 125-138 In: R. D. Cross and D. L. Williams, editors. Proceedings of the National Symposium on Freshwater Inflow to estuaries. U. S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-81/04. October 1981.

Conner, W. H., W. R. Slater, K. McKee, K. Flynn, I. A. Mendelsen, and J. W. Day, Jr. 1986. Factors Controlling Vigor of Commercial Wetland Forests Subject to Increased Flooding in the Lake Verrett, Louisiana Watershed. Center for Wetlands Resources, LSU, Final Report, Board of Regents Research and Development Program.

Davis, D. W. 1983. Economic and cultural consequences of land loss in Louisiana Shore and Beach.

Fruge, D. W. 1981. Crisis in the coastal marsh. Louisiana Conservationist 33:4-7.

______ and R. Ruelle. 1980. A planning aid report on the Mississippi and Louisiana estuarine areas study: U. S. Fish and Wildlife Service, Lafayette, Louisiana.

Gagliano, S. M., P. Light, and R. E. Becker. 1971. Controlled Diversions in the Mississippi Delta System: An Approach to Environmental Management. Coastal Resources Unit, Center for Wetland Resources, Louisiana State University. Hydrologic and Geologic Studies of Coastal Louisiana Report No. 8.

Gunter, G. 1952. Historical changes in the Mississippi River and adjacent marine environment. Publications of the Institute of Marine Science, University of Texas. 2(2):119-139.

___, B. S. Ballard, and A. Venkataramiah. 1974. A review of salinity problems of organisms in United States coastal areas subject to the effects of engineering works. Gulf Research Reports 4(3):380-475.

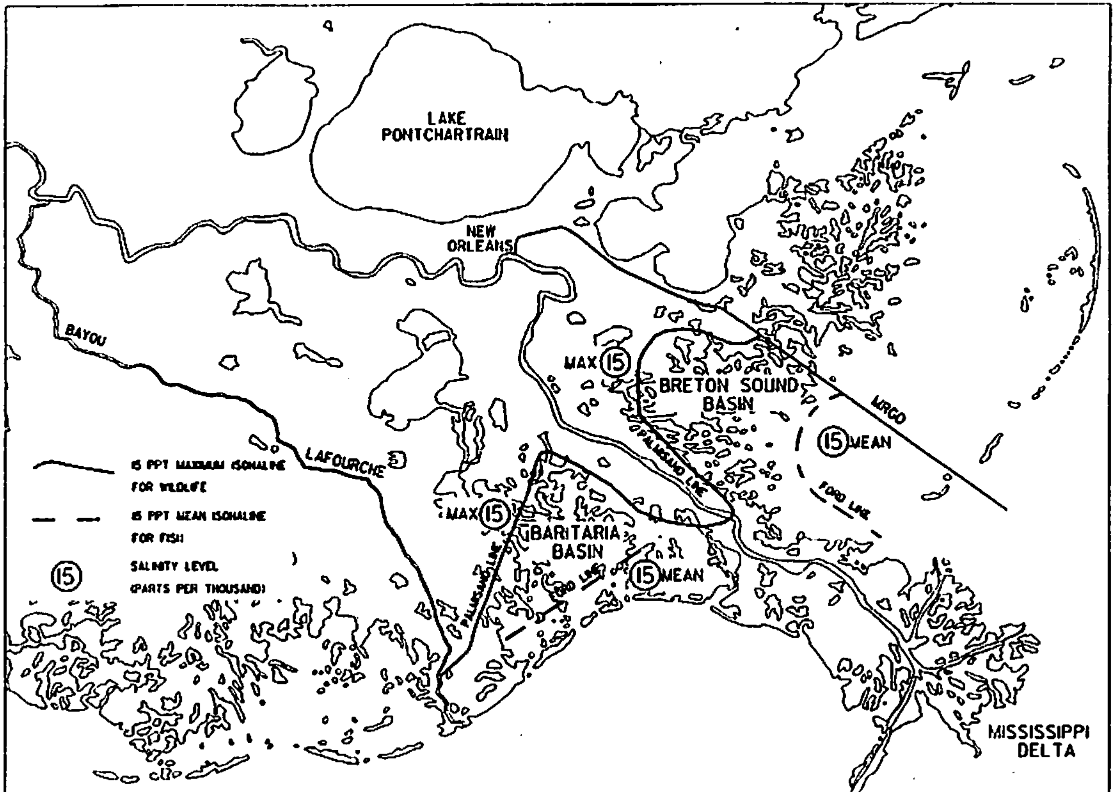
Lindall, W. N., J. R. Hall, J. E. Sykes, and E. L. Arnold, Jr. 1972. Louisiana coastal zone: analyses of resources and resource development needs in connection with estuarine ecology. Prepared by National Marine Fisheries Service Biological Laboratory, St. Petersburg Beach, Florida, for Department of the Army, New Orleans District, Corps of Engineers. Contract No. 14-17-002-430.

Palmisano, A. W. 1973. Habitat preference of waterfowl and fur animals in the northern Gulf Coast marshes. Pages 163-190 In: R. H. Chabreck, editor. Proceedings of the Second Coastal Marsh and Estuary Management Symposium, Louisiana State University, Baton Rouge, Louisiana.

U. S. Army Corps of Engineers, New Orleans District. 1970. Report on Mississippi River flow requirements for estuarine use in coastal Louisiana, New Orleans, Louisiana.

Viosca, P., Jr. 1927. Flood control in the Mississippi Valley in its relation to Louisiana fisheries. Trans. Amer. Fish. Soc. V.57.

____ 1928. Louisiana wetlands and the value of their life and fishery resources. Ecology 9(2): 216-229.



LAKE PONTCHARTRAIN
NEW ORLEANS
BAYOU
LAFOURCHE
MAX 15
BRETON SOUND BASIN
15 MEAN
MRGO
PALMISANO LINE
FORD LINE
MAX 15
BARITARIA BASIN
PALMISANO LINE
FORD LINE
15 MEAN
MISSISSIPPI DELTA
15 PPT MAXIMUM ISOHALINE FOR WILDLIFE
15 PPT MEAN ISOHALINE FOR FISH
15 SALINITY LEVEL (PARTS PER THOUSAND)

FIGURE 1

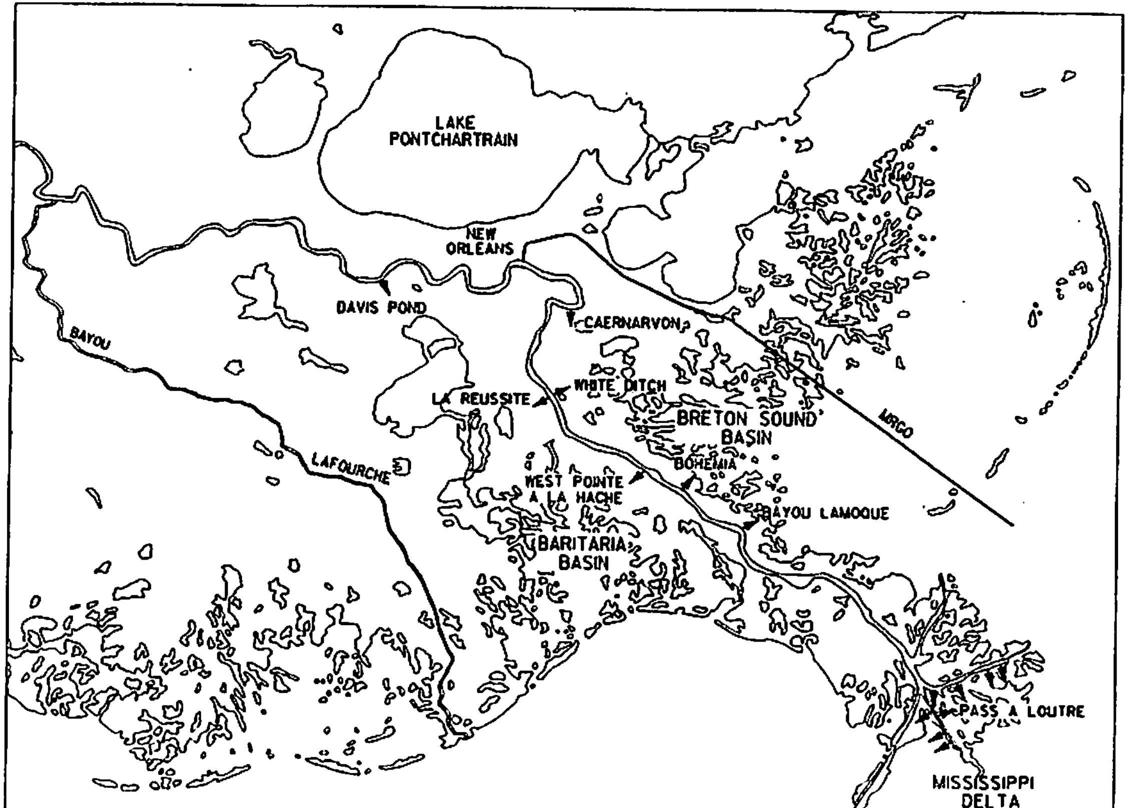

LAKE PONTCHARTRAIN
NEW ORLEANS
DAVIS POND
CAERNARVON
BAYOU
WHITE DITCH
LA REUSSITE
BRETON SOUND BASIN
MRGO
LAFOURCHE
BOHEMIA
WEST POINTE A LA HACHE
BAYOU LAMOQUE
BARITARIA BASIN
PASS A LOUTRE
MISSISSIPPI DELTA

FIGURE 2

Wetlands Creation as a Treatment for Shoreline Erosion in Galveston Bay, Texas

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Abstract

The shoreline of Trinity Bay and East Galveston Bay, Texas, is eroding at an average rate of four feet/year. Land losses to these coastal properties will continue unless low-cost, effective measures for shoreline erosion control and wetland habitat enhancement are developed and implemented. Once established, smooth cordgrass, Spartina alterniflora Lois, provides an effective means of shoreline erosion protection. In 1985, Trinity Bay Soil and Water Conservation District initiated a project to study the impacts of shoreline erosion and to test cost-effective, vegetative erosion control measures in Galveston Bay, Texas. Smooth cordgrass was transplanted in four sites along the affected shoreline and adjacent coastal waters. Turbidity levels were measured during high and low erosion conditions. Sediment accretion was also measured within the study area. Relative abundance of fish species was documented at each site during the study. Technical assistance was provided by the Soil Conservation Service, the Texas Agricultural Extension Service, and the Texas A&M University Sea Grant College Program. Funding was provided through grants from The Moody Foundation, The Brown Foundation Inc., Texas A&M University Sea Grant College Program, Galveston Bay Foundation, and The Port of Houston.

Introduction

The principal study area is the shoreline of East Galveston Bay, Trinity Bay and its associated waters in Chambers County, Texas. The sites chosen for the trial plantings are on the north shoreline of East Galveston Bay and a small tidal lake. The erosion rate on the shore of East Galveston Bay is 1-3 m/yr. The erosion rate on the inland lake is somewhat less. The average fetch on the Trinity Bay site is greater than 9 km and the longest fetch is more than eighteen km. The shoreline geometry is meandering with a silty or a very fine sandy sediment in the swash zone. Using the U.S. Corps of Engineers Vegetative Stabilization Site Evaluation Form, the East Galveston Bay site has a cumulative score of 200 and a potential success rate of 30%. Most of the shoreline is unvegetated. Only in a very few locations is smooth cordgrass found. One small area of smooth cordgrass that was established in 1958 is still expanding and has remained stable (USACE, 1968). Local landowners have been concerned about erosion for more than 30 years. Attempts have been made using car bodies, concrete pipe, rip-rap, and used automobile and tractor tires to halt the erosion rate. Attempts at transplanting cordgrass have also been tried, but failure rates have been very high. In 1984, the authors began a joint effort to address the erosion problem and develop a method of planting smooth cordgrass to increase the rate of transplant survival. The erosion not only represents a physical loss of land, but it also has a detrimental effect on the marine ecosystem. The resulting sedimentation stymies beneficial aquatic vegetation through increased water turbidity. The lack of intertidal vegetation has resulted in a loss of nursery area for shrimp, Penaeus sp., redfish, Sciaenops ocellata L., speckled trout, Cynoscion nebulosus Cuvier, blue crabs, Callinectes sapidus, spot, Leiostomus xanthurus Lacepede, tidewater silversides, Menidia beryllina Cope, and numerous other marine organisms. These nursery areas play a critical role in providing sites where juvenile stages of these species can hide, feed, and grow. The physical loss of land causes intrusion of saltwater into freshwater marshes, drastically reducing their desirability as waterfowl habitat and in grazing management. Continued erosion along Texas bays and the resulting loss of vegetation can be devastating to the future of the sport and commercial fishing industries in the Gulf of Mexico and surrounding waters.

This study is intended to be a pilot project to evaluate the feasibility of using smooth cordgrass as an alternative erosion control method. This pilot project also is set up to measure the long-term effects of vegetation on sedimentation and turbidity in the Galveston Bay system.

Description Of The Study Area

Chambers County is in the extreme southeastern part of Texas. It is bordered on the south by Trinity Bay, Galveston Bay, East Galveston Bay, and the Gulf of Mexico. The county covers a total area of 224,000 ha., of which 152,527 ha. is land and 71,393 is water. The area selected for the erosion control studies is located on the north shoreline of East Galveston Bay and Lake Stephenson, an adjacent tidal lake in southern Chambers County. The area is predominantly Gulf Coast Saline Prairie (USDA, Soil Conservation Service, 1981). The plant community is dominated by Gulf cordgrass, Spartina spartina Screb. Lesser concentrations of marshhay cordgrass, S. patens Muhl, are found in the area. The predominant soils found in the study area are Harris Veston association (Crout, 1976). When bare and unprotected by plant cover, these soils are very susceptible to erosion. Sparse natural stands of smooth cordgrass are found in the intertidal zone at only a few sites. The majority of the shoreline in East Galveston Bay lacks any intertidal vegetation. The land-water interface is characterized by a 1 m-high bare bluff at Sites #1, #2, and #3. Site #4 possesses a 0.5 m-high bluff. The shoreline at Sites #1, #2, and #3 has a shallow shelf with very little drop off from the shore seaward. Site #4 has a similar land slope. Many species of marine organisms inhabit inshore waters in the study area. Juvenile marine shrimp, Penaeus sp., Gulf menhaden, Brevoortia patronus Goode, blue crabs, bay anchovies, Anchoa mitchilli Valenciennes, Atlantic croaker, Micropogon undulatus Linnaeus, striped mullet, Mugil cephalusLinnaeus, and Gulf killifish, Fundulus grandis Baird and Girard, are the predominant organisms found at all sites. Turbid water conditions prevail at Sites #1,#2, and #3, with somewhat less turbidity found at Site #4. Erosion rates vary between the sites. Sites #1 and #3 erode at an average annual rate of 1.8 m/yr. Site #2 erodes at an average rate of 2.6 m/yr. Site #4 erodes at an average rate of 0.5 m/yr (Table 1). An 11.3 km fetch of water across East Galveston Bay exists at Sites #1, #2, and #3. The fetch across Lake Stephenson at site 4 is 0.8 km.

Materials And Methods

Transplanting Techniques

The transplants were acquired from existing native stands of smooth cordgrass growing in the immediate vicinity on East Galveston Bay. Cordgrass transplants were dug and separated. An effort was made to minimize root disturbance by keeping wet soil around the plant roots. Moist transplants were transported in a washtub to the study sites. Transplanting methods followed those outlined by Cutshall (1985). A 0.66 m space between plants and rows was allowed. Transplants were planted at a water depth of 15.2 cm in the intertidal zone, approximately 6.1 m seaward of the shoreline. No fertilizers were applied in this study.

Wave Barrier Protection

Temporary wave barriers were constructed to minimize wave impacts on young transplants (Table 2). Three different materials were used to construct these barriers. A double row of used Christmas trees were tied trunk-to-trunk with parachute strap, laid parallel to the shoreline, and staked on the seaward side of the transplants at Site #1. A single row of plastic snow fence was used as a wave barrier at Site #4. Fence posts were driven in a line on the seaward side of the transplants, and the plastic snow fence was attached to the posts. The plastic snow fence was obtained from American Excelsior Company and provided a suitable barrier that also can be reused. A double row of used cargo parachutes acquired from the Texas Surplus Property Agency were used as a temporary wave barrier at Site #2. A double row of 10 m-long, 1 m-wide strips of the parachute material was attached by parachute strap end-to-end to fence posts driven in a line parallel to the shoreline seaward of the young transplants. The parachutes were inexpensive and easy to install. Site #3, with no wave barrier protection for the transplants, provided a control to assess the effect of the wave barrier structures on transplant survival. Although there may be other wave barrier protection measures, the measures selected by this project were chosen because they are removable. The authors feel that a removable barrier would be aesthetically desirable and would not interfere with the nutrient cycling that makes the salt marsh beneficial to the marine estuary.

Salinity

Salinity data was documented by site over time during intense planting efforts in 1986. Salinity measurements were taken a Yellow Springs Instrument Model 33 salinity-conductivity- temperature meter. Readings were measured to the nearest g/l (ppt) at the water surface and averaged by month.

Sedimentation

Sedimentation was measured at two sites beginning in August, 1988. Reference stakes were established at Sites #1 and #2 and cross-sections were taken from the reference stakes seaward at 20-foot intervals. Readings were taken to the nearest .01 ft.

Turbidity

Turbidity was measured at each site weekly. Readings were taken with a standard 6-inch Secchi disk and recorded to the nearest centimeter. Readings were also taken at other locations in Galveston Bay to determine the range of water conditions at other eroding areas.

Fisheries

Fish and shellfish were collected using a 32 m bag seine having a 1.9 cm mesh. The seine was pulled approximately 50 meters along the seaward side of the Spartina stand parallel to the shoreline at Sites #2 and #3 on 23-24 August 1988 and 25-26 October 1988. Fish and shellfish were also collected by a 1.24 m cast net at the same time. Random throws of the cast net were conducted on each sampling date at Sites #2 and #3. Relative abundance of fish and shellfish species was determined and compared by site and sampling date in the study. Due to the amount of rubble disposed in the sampling area and the prohibition of the use of gill nets and trammel nets in coastal waters of Texas, no other gear types were used in the study.

Results and Discussion

Transplanting Techniques

Single stem transplant survival at Sites #1,#2, and #4 was very good. The survival rates varied from 60-70 % (Table 2). New shoot development appeared to depend on the care of the transplant stock. There also appeared to be some difference in growth of transplant stock taken from different locations planted concurrently. More work needs to be done on the selection of planting materials used in shoreline erosion control. Further investigations concerning transplant survival in various soil types might be warranted. The transplanting methods outlined by Cutshall (1985) were adequate for transplanting at all sites in the study area. The complete failure of transplants on Site #3 demonstrates that smooth cordgrass is very difficult to establish at these sites without some type of wave protection (Table 1). Transplants at Site #3 were exposed to constant wave action and lacked sufficient root development to withstand the wave forces. The U. S. Army Corps of Engineers Vegetative Stabilization Site Evaluation for this site gave it a 30% potential success rate.

Wave Barrier Protection

There appeared to be little effect of alternative wave protection devices on survival rates of transplants. The used Christmas trees worked successfully but had several drawbacks. The seasonal availability of Christmas trees is a problem. The utilization of the trees is the most labor-intensive method of barrier protection evaluated in this study. They were also difficult to collect and transport to the site. The cost of the snow fence is quite high and may be expensive for large-scale treatments. The used cargo parachute strips were the most effective wave barrier material tested in the study. There is little doubt that the three types of wave barriers tested in this study enhanced the success of smooth cordgrass transplant establishment.

Salinity

Salinity ranged from 4-18 ppt across all sites during 1986. The highest reading (28 ppt) occurred at Site #2 on 02 May 1986, while the lowest reading (2 ppt) occurred at Site #4 on 01 August 1986 (Table 3). Salinity appeared to have little effect on transplant growth and development. Relative growth of transplants and shoot development appeared to be more directly related to the existence of wave barrier protection than salinity level during intense planting efforts in the study.

Sedimentation

The preliminary data show a slight accumulation of sediment on Site #1 from August to December 1988. Gosselink and Mitsch (1986) indicate that one of the primary functions of a salt marsh is to accumulate sediments from off-site and incorporate them into the marsh ecosystem. It is anticipated that the artificial salt marsh created during this study will function in the same way as a naturally occurring marsh. If so, theoretically, some of the poor water quality conditions caused by shoreline erosion will gradually improve in the marsh created during this study.

Turbidity

Results of the turbidity level measurements in this study show a direct correlation between high erosion conditions and high levels of suspended sediment in the water column. There was no significant difference in turbidity levels between Sites #1, #2, and #4 that were transplanted and Site #3 which has no vegetation. Since the shoreline of East Galveston Bay is over 60 km in length, it is doubtful that the transplanted vegetation from this study had any effect on the overall turbidity of East Galveston Bay. Between wetlands surveys of 1956 and 1979 of the bay, the estuary lost approximately 16% of its marshes and an estimated 95% of its submergent vegetation (Galveston Bay Seminar Executive Summary, 1988). The entire shoreline of East Galveston Bay contributes to the highly turbid water conditions found in all sites during the study. Table 3 shows a sample of the data taken from August 1988-March 1989.

Fisheries

Results of this study indicate that marine organisms readily utilize stands of smooth cordgrass within the study area. A total of 87.3 % of the marine finfish and shellfish in this study were collected from Site #2, a transplant site. A significant difference in relative abundance of catch was noted in Site #2 versus Site #3 (87.3 % and 12.7 %, respectively). The predominant species found at Site #2 during both sampling periods were white shrimp (33.6 %), Gulf menhaden (31.6 %), and striped mullet (15.2 % of the total catch) (Table 4).

The remaining 12.7 percent of the marine finfish and shellfish in this study were collected from site #3, the control site with no vegetation present. Gulf menhaden (53.6%) and striped mullet (31.0%) comprised the majority of the catch at Site #3 (Table 6). Although the sample size is fairly low, these data likely indicate a representative sample of both habitats.

Species composition remained remarkably similar between sites #2 and #3 during the study. Several bay anchovies were collected only from Site #2 and one Gulf kingfish was collected only from site #3.

Conclusions

The utilization of wave barrier protection methods outlined in this paper to protect smooth cordgrass transplants until colonies can establish themselves will take time. Overall estuarine enhancement, a by-product of this vegetative erosion control project, may take years to develop. It is well-documented that fish and shellfish resources inhabit smooth cordgrass stands in the Galveston Bay salt marsh for food, cover, and nursery areas (Gosselink et al., 1973; Zimmerman et al., 1984; Zimmerman and Minello 1984; Texas

Parks and Wildlife Department, 1989). The role of the estuary in supporting fisheries productivity depends on the endemic species and other factors, including developmental stage, time of year, geographic location, and physical and chemical characteristics of the estuarine waters. All estuarine habitats are utilized to some extent and each may be critical to some life stage of a marine organism. Shallow open-water areas, like those found in Galveston Bay, support large numbers of juvenile marine organisms. Small bayous and channels also provide access to intertidal marshes and refuge from stranding during periods of low water.

High turbidity levels in East Galveston Bay drastically affect the primary productivity of the estuary (Texas Parks and Wildlife Department, 1964). The high turbidity levels reduce water quality by shading out beneficial phytoplankton and zooplankton organisms in the water column and therefore reduce the total food web productivity in the estuary.

Sedimentation in East Galveston Bay caused by shoreline erosion has historically had a negative effect on water quality. Shoreline erosion has been a problem since the 1930's (Paine and Morton, 1986). The preliminary results of this study show some benefits in reducing shoreline erosion. The short-term results of the cross-sectional data indicate a slight increase in sediment accumulation within the transplanted grass colony. It is not known whether this trend will continue or if the data reflect a seasonal variation. Long-term sedimentation studies are needed to determine potential impacts and benefits in sediment accumulations in the intertidal zone. High sedimentation rates are known to cause mortality in oyster reefs in East Galveston Bay (Texas Parks and Wildlife Department, 1964). Sediment collects in the gills of the oyster, drastically reducing pumping efficiency and oxygen uptake capability.

The importance of estuaries for U. S. commercial and recreation fisheries, combined with accelerations in habitat loss due to shoreline erosion in these estuaries, will require attention in the future. The disruption of the marsh ecosystem in the study area, through erosion created by man's intervention or natural processes, drastically affects the overall marsh production. Additional research is needed on how estuarine habitats function for marine organisms. The long-term effects of re-creating marsh habitat lost through erosion are obvious. The landowner ceases to lose valuable bayfront property to the forces of erosion. Concurrently, commercial fishermen benefit greatly from marsh revegetation through increased harvests of commercial seafood products, and recreational fishermen benefit by experiencing more successful fishing trips.

References

Crout, J.D. 1976. Soil Survey of Chambers County, Texas. U.S.D.A. Soil Conservation Service, 53 p.

Cutshall, J. 1985. Vegetative Establishment of Smooth Cordgrass (Spartina alterniflora) For Shoreline Erosion Control. Technical Note. U.S.D.A. Soil Conservation Service. 6 p.

Gosselink, J.G. and W.J. Mitsch. 1986. Wetlands. Van Nostrand Reinhold Company. New York.

Gosselink, J.G., E.P. Odom, and R.M. Pope. 1973. The Value of the Tidal Marsh. Institute of Ecology Work Paper No. 3. University of Georgia. Athens, Ga. 31 p.

P.L. Knutson and W.W Woodhouse. 1983. Shore Stability with Salt Marsh Vegetation. Special Report No. 9, Coastal Engineering Research Center, U.S. Army Corps of Engineers, Ft. belvoir, VA, 95p.

McHugh, J.L. 1966. Management of estuarine fishes. Pages 133- 154 In: A Symposium on Estuarine Fisheries. American Fisheries Society Special Publications Number 3.

Paine, J.G. and R.A. Morton. 1986. Historical Shoreline Changes in Trinity, Galveston, West and East Bays, Texas Gulf Coast. Bureau of Economic Geology. University of Texas at Austin.

Sheridan, P.F., R.D. Slack, S.M. Ray, L.D. Mckinney, and E.F. Klima. 1988. Biological Components of Galveston Bay. Executive Summary--NOAA Estuary of the Month. TAMU-SG-88-114.

Texas A&M University Sea Grant College Program. 1973. The Estuarine Zone......Uses and Concerns. Report TAMU-SG-71-108. 14 p.

Texas Parks and Wildlife Department. 1964. The Texas Oyster Fishery. Bulletin 40. 6p.

___________. 1989. A Report to the Governor--The Texas Shrimp Fishery. Coastal Fisheries Branch.

U.S. Army Corps Engineers. 1968. Texas Coast Shores Regional Inventory Report. Galveston District. Galveston, Tx. 26 p.

U.S. Department of Agriculture. 1981. Land Resource Regions and Major

Land Resource Areas of the United States. Agriculture Handbook 296. Soil Conservation Service. 156 p.

Zimmerman, R.J. and T.J. Minello. 1984. Densities of Penaeus aztecus, Penaeus setiferus, and other natant macrofauna in a Texas salt marsh. Estuaries 7(4A):421-433.

______and G. Zamora, Jr. 1984. Selection of vegetated habitat by brown shrimp, Penaeus aztecus, in a Galveston Bay salt marsh. Fish. Bull. 82:325-336.

TABLE 1. SITE CONDITIONS

SOIL TYPE	EROSION RATE m/yr	AVERAGE SALINITY 0/00	WAVE BARRIER PROTECTIONS
Site #1 Veston Soils (mostly clay)	1.4 - 2.2	10	Double Row Christmas Trees
Site #2 Veston Soils (mostly clay)	1.9 - 3.1	13	Double Row Parachutes
Site #3 Veston Barrier Soils (mostly clay)	1.6 - 2.0	11	No Wave Protection
Site #4 Harris Clay	0.3 - 0.7	9	Single Row Plastic Snow Fence

TABLE 2. TRANSPLANT SURVIVAL COMPARISONS BY SITE AND DATE

DATES TRANSPLANTED	NUMBER OF SHOOTS TRANSPL	SURVIVAL AS OF MARCH 87	SHOOT PERCENT SURVIVAL	NUMBER SHOOTS/ TRANSPL
Site #1 Jan. 13-17,1986	850	510	60	2.39
Site #2 Aug.18-27, 1986	620	410	66	2.84
Site #3 May 20-22, 1986	250	0	0	0.0
Site #4 July 15-23, 1986	600	440	70%	2.09

Table 3. Turbidity Levels by Site. (Secchi disk readings in cm)

Date	Weather Conditions	#1	#2	#3	#4
09/09/88	slightly choppy	19	20	20	31
10/14/88	calm	43	44	44	29
11/11/88	very choppy	19	18	18	13
12/13/88	choppy	26	26	26	13
01/30/89	calm	30	30	30	43
02/17/89	slightly choppy	21	21	21	27
03/17/89	very choppy	13	13	13	9

Table 4. Relative Abundance (%) of Marine Organisms Collected by Seine and Cast Net During the August 23-24 and October 25-26, 1988 Sampling Periods--Site #2

Species	Number	Percent Abundance	Rank
White Shrimp	195	33.6	1
Gulf Menhaden	183	31.6	2
Striped Mullet	88	15.2	3
Gulf Killifish	34	5.8	4
Atlantic Croaker	20	3.4	5
Blue Crab	18	3.1	6
Tidewater Silverside	18	3.1	7
Bay Anchovy	14	2.4	8
Spot	9	1.6	9
	N = 580	100.0	

Table 5. Relative Abundance (%) of Marine Organisms Collected by Seine and Cast Net During August 23-24 and October 25-26, 1988 Sampling Periods--Site #3

Species	Number	Percent Abundance	Rank
Gulf Menhaden	45	53.6	1
Striped Mullet	26	31.0	2
Blue Crab	6	7.1	3
Gulf Killifish	3	3.5	4
Tidewater Silverside	2	2.4	5
White Shrimp	2	2.4	5
	N = 84	100.0	

On the Loss of Estuarine Bay Areas Due to Barrier Island Migration

David Basco
Old Dominion University

Introduction

When viewing barrier beach coasts and formulating public policy regarding our coastal resources, we need to consider both the barrier island and the estuarine-bay-lagoon system behind the island as an integrated whole. The key assumption implied in our present policies is that wherever barrier islands are migrating landward (transgression) due, e.g., to sea level rise, the mainland shoreline migrates at the same rate to maintain a constant surface area in the bay. Therefore, migrating barrier islands will not cause further reduction of estuarine habitat. Our limited evidence as presented in this paper shows this assumption to be incorrect. The mainland coastline remains relatively fixed as the barrier island moves, resulting in a loss of estuarine-bay-lagoon surface area. A national assessment effort is needed to put this relative loss in perspective.

Figure 1 schematically summarizes historical trends in U.S. national polices toward the coastal zone. Prior to World War II, navigational requirements for ports and harbors governed a relatively simple coastal policy. Since the 1950's, revelations in coastal geomorphology and marine biology/ecology have resulted in major public policies being separately established for barrier islands and estuary-bay systems. These policies are herein summarized as paradigms of conventional wisdom as we enter the last decade of the 20th-Century. Coastal zone management is far more complex now that environmental and ecological concerns, recreation and tourism needs, and other multiple uses of coastal resources are included. The final section of this paper discusses a new, integrated island-bay public policy that will require an expanded, elevated, and shifted view of the coastal zone, a new paradigm.

Revelations from Coastal Geomorphology Since the 1950's

Barrier beach-bay systems make up about 35% of the U.S. coastline. Barrier beaches are nature's mechanism for protecting the bays, lagoons, and estuaries that lie behind them. The reduced wave energy environment characteristic of these protected areas permits the retention of cohesive sediment and grasses in tidal marsh areas. Since the 1950's, coastal geologists have done an outstanding job of explaining the dynamic nature of and the many types of barrier beach systems found along our coasts (see, e.g. Leatherman, 1988 for an introduction). In many locations, landward migration (transgression) of barrier beaches is occurring and is attributed to sea level rise, as depicted in Figure 2 (from Dolan and Lins, 1987).

Two mechanisms for landward migration have been put forward: rollover due to washover events during storms and the creation of new tidal inlets and sand trapping in the tidal deltas. Leatherman (1988) has concluded:

> "Overwash is not the dominant process by which most barriers move landward since the amount of sediment transported by this means is too small. Inlet formation, when tidal currents cut a channel below sea level, moves far greater quantities of sediment into a lagoon over the longterm and is the major process for barrier migration" (p.63).

In either case, the picture emerges of a moving barrier beach and estuarine bay system as depicted in Figure 2. A key assumption (often implied) is that the mainland boundary also migrates at the same rate to maintain a constant surface area in the estuary-bay-lagoon system. This assumption is the main focus of this paper.

Research by coastal geologists, oceanographers, and other scientists is producing a better understanding of the migration mechanism and developing models to predict potential breaching and new inlet formation. However, what we here call the "barrier migration paradigm" has served to fundamentally change public policy over the past 30 years regarding management of the coastal zone.

Public Policy Decisions Based Upon the Barrier Migration Paradigm

In 1977, the U.S. Department of the Interior ordered a study of over forty federal government programs that impacted upon barrier island development. These studies were the direct result of the revelations of coastal geomorphologists, i.e. the "barrier migration paradigm," that were brought to a focus in the famous position paper of a number of notable contributors in 1981 (Pilkey et al., 1981). The political impact of these efforts was immediately focused and resulted in the Coastal Barrier Resources Act (CBRA) of 1982 (P.L. 97-348) that established a system of 186 coastal barriers along the Atlantic Ocean and Gulf of Mexico. This law prohibits most federal expenditures that encourage development on barrier islands (e.g., for road, sewer, and water supply systems).

At the risk of over-simplification, the argument for no construction stems from the belief that island migration landward is dominated by the rollover mechanism due to washover events. Therefore on "natural" islands with no fixed reference lines (roads, water towers, buildings, etc.) by which to measure shoreline movements, no coastal shoreline retreat, recession, or "erosion" is taking place because the entire barrier island system is moving as one entity. It is only after humans "draw a line" (e.g., construct a road) on the moving system that coastal erosion can occur. There is no coastal erosion of a moving barrier beach reference system until a fixed line is drawn by which to reference the movement.

Once development has been permitted, some form of shore protection measure is often undertaken at specific locations when the shoreline recession threatens permanent resources (roads, bridges, buildings, etc.) and if the benefits exceed the costs over the design life of the project. Three options exist for shore protection: strengthening dunes and beach renourishment; sand trapping systems to widen beaches; and coastal armoring. Combinations of one or more of these options are also possible. Coastal armoring includes seawalls, bulkheads, and revetments, and will be referred to as "seawalls" or the "hardfacing" option. Because of their great expense, seawalls are usually only constructed along highly developed shorelines experiencing a recessional trend and subject to storm-induced water level rise with accompanying wave energy. In many cases, recreational beaches are also present in such areas.

The degree to which a seawall affects the adjacent beach is the focus of much recent attention (e.g. Kraus and Pilkey, 1989). To some, the entire blame for shoreline erosion is directed toward seawalls, e.g. "...seawalls actually increase erosion and destroy the beach" (Pilkey and Wright, 1988). In effect, the seawall has become the readily available "fixed reference line" to measure shoreline recession. An equal case could be made for the first road constructed on the moving system since shrinking beach widths result when the road gets close enough to the shoreline. Is the road "...increasing erosion and destroying the beach?" Basco (1990) has shown that the offshore boundary conditions (bathymetry, wave climate) must also be considered whenever field studies of "hardfacing" versus "soft" sections of coastlines and resulting shoreline movements are conducted. Much additional research is needed to understand the short-term and storm-related interactions of seawalls and adjacent beaches. Two states (North Carolina, Maine) have passed legislation prohibiting the hardfacing option for mitigating problems associated with shoreline recession.

We may summarize this public policy as follows. Let the barrier islands migrate landward. All efforts to stabilize migration are economically unsound in the long run when (only) the value of property built on the barrier is considered. The federal government should not subsidize an economically unsound policy. Further reading on recent development in barrier island processes and management can be found in Stauble (1989).

<u>Revelations from Coastal Marine Biology and Ecology Since the 1950's</u>

As stated above, barrier beaches are nature's mechanism for protecting the bays, lagoons, and estuaries that lie behind them. Since the 1950's, coastal marine biologists and ecologists have also done an excellent job of explaining the dominant role that estuaries play in the coastal ecosystem (see, e.g. Bean, 1978). The estuarine system (adjacent ocean waters, tidal inlet, estuary, bays, lagoons, and freshwater inflows) results in salinity and current patterns over space and time that dominate the lifecycles of many marine animals. Simply stated, fish and crustaceans require various salinity and energy levels (waves and currents) during various stages in their development cycles. They also require the nutrients found in the waters and marshes of the estuary to sustain growth. The estuary, bays, lagoons, etc. and their adjacent wetlands are breeding grounds for much of marine life as we presently know it. They are also important nurturing areas for water fowl and breeding grounds for wading birds. The biological productivity of the estuarine coastal zone is the highest of all ecosystems on the earth.

Research is continuing by marine biologists, biological oceanographers, coastal ecologists, and fish and wildlife experts, etc. to better understand the role that tidal and nontidal wetlands play in the food chain of the earth's ecosystem. However, what we herein call the "wetlands value paradigm" has served to fundamentally change public policy over the past 30 years regarding management of the coastal zone.

Public Policy Decisions Based Upon the Wetlands Value Paradigm

In 1979, the U.S. Department of Interior (Fish and Wildlife Service) also began a study called the "National Wetlands Trends Analysis" to quantify the changes in wetlands that had occurred over a 20-year period (mid-1950's to 1970's) through natural and man-made influences. The main finding or conclusion was an estimated 458,000 acres of net annual national wetlands loss. The study distinguished between coastal (tidal) and inland (nontidal) wetlands and lakes. The vast majority (96.5%) of the total wetlands losses, during this period, 11.5 million acres, were in nontidal, inland areas (forested wetlands, shrub swamps, and freshwater marshes). The escalating demands for agricultural lands accounted for 87% of total wetland losses.

The significant trends in tidal, coastal wetlands (vegetated marshes) showed a net loss of 372,000 acres over the study period, much of which was due to conversion into open water bays and sounds in Louisiana, Texas and Florida. For example, most of Louisiana's losses are due to relative sea level rise, subsidence of the coastal plain, levee construction, channelization, and oil and gas extraction. Man's direct contribution to losses of coastal wetlands occurs primarily in urban areas due to dredging and filling operations for developments. Florida's coastal wetlands loss is primarily due to such development.

Coastal marine scientists led the effort to enact legislation against marsh filling by developers. The result was passage of estuarine/marsh mitigation legislation (1982) requiring the U.S. Army Corps of Engineers review for permitting purposes and basic rules for replacement of lost wetlands with newly created wetlands areas of equal value---called mitigation. The replacement area must be equal to or greater than that lost to development for new roads, schools, houses, etc. The permit process has grown to include other federal government agencies (EPA, FWS, etc.) and was extended to nontidal (freshwater) wetlands in 1988. It was encapsulated in the phrase "no net loss of wetlands" during the presidential campaign of 1988.

In summary, this public policy regarding wetlands says: America's wetlands are shrinking. Alterations must be monitored and any losses mitigated to conserve existing wetlands. The federal government is opposed to all destruction of coastal marshes. Further reading on recent developments in the estuarine sciences and management policies can be found in the proceedings of the coastal zone management conferences (i.e. Magoon, 1990).

<u>Estuarine/Marsh Area Losses Due to Barrier Island Migration-Some Examples</u>

We now wish to review a few examples where the above-stated paradigms and resulting public policies toward coastal zone management are in direct conflict. The barrier islands are moving landward primarily as a result of tidal inlet formation and this has resulted in the shrinkage of the bay surface area behind the island, with subsequent loss of coastal wetlands. The net result is that one public policy toward managing barrier islands is negatively impacting another public policy aimed at preserving wetlands. Part of the problem is the often implicit assumption that the mainland shoreline migrates with the barrier shoreline to preserve a constant surface area of the estuarine bay system. This assumption is incorrect, as evidenced in the examples described below. A second consideration is the relative value of the loss of coastal wetlands through their transformation into open, high-energy, ocean areas at tidal inlets.

Sinepuxent Bay at Assateaque Island, MD.

The August, 1933 hurricane along the eastern seaboard of the U.S. created a new tidal inlet at Ocean City, MD. Shoreline movements along Assateague Island south of the inlet were examined by Leatherman et al. (1987) for pre-inlet, post-inlet (with jetties), and projected future conditions. Figure 3 shows the shoreline position in the 1840's and in 1980. Prior to formation of the new inlet, average shoreline recession was about 3m/yr. Creation of the new inlet caused a 3-fold increase in this recession rate, a rate also affected by the construction of jetties and the absence of sediment bypassing to mitigate entrapment by the updrift (northern) jetty. The large impoundment offset at Ocean City and its acceleration of erosion rates along Assateague Island's northern end has resulted in recent studies of alternatives to mitigate the problem by the National Park Service, caretakers of the Assateague Island National Seashore. Leatherman, et al. (1987) discuss the major impacts and benefits of each alternative and also the potential for formation of another new inlet that would leave the Ocean City Airport directly exposed to the Atlantic Ocean before the year 2020.

But what about Sinepuxent Bay? For the bay north of the causeway, our estimates show that 923 acres (1.44 sq.mi) of surface bay area have been lost between 1840/50 and 1980. This amounts to almost 25% of the original bay area in about 135 years. In this analysis, we have maintained the barrier width (400-700 feet) and a fixed mainland bayshore position as found by Leatherman (1984).

The major impacts and benefits cited by Leatherman et al. (1987) for the alternatives studied to mitigate erosion problems on Assateague Island (including no action) fail to include any major impacts and benefits to Sinepuxtent Bay. The mitigation alternatives studied were various combinations of initial beach nourishment, annual beach renourishment for maintenance, and artificial dune formation to either maintain the existing or restore the 1965 shoreline (when the National Seashore was established). Stabilizing the barrier island position would also result in a stable surface area for Sinepuxtent Bay and prevent the continued loss of estuarine benthic habitat and coastal marsh areas.

Metompkin Bay at Metompkin Island, VA.

Metompkin Island is one of 14 barrier islands located along the outer coast of the Delmarva Peninsula, or the "eastern shore," south of Ocean City, MD. Analysis of the historic shoreline position between 1852 and 1988, along with the decrease in average barrier island width over this time, has been performed by Byrnes et al. (1989). Behind the island lies Metompkin Bay. We have assumed no movement of the mainland shoreline in the bay in our analysis of bay surface area but have included the given reduction in mean island width (i.e. 650m wide in 1850's down to 150m in 1980's). The net loss of bay surface area is 17.3 acres over a 136-year period. Frequent tidal inlet creation after 1955 has created a prominent mid-island offset due to differential rates of shoreline retreat (low in the north and high south of the inlet).

These historic trends are compared with storm-induced changes in Metompkin Island resulting from Hurricane Gloria in 1985 by Byrnes and Gingerich (1987). Evidence in this paper supports the overwash mechanism for island retreat associated with this storm event.

Pleasant Bay at Nauset Beach Spit, Chatham, MA

The barrier island spit called Nauset Beach separating Pleasant Bay from the Atlantic Ocean at the town of Chatham, MA was breached during a severe "northeaster" on 2 January 1987. The break occurred very near the location where beach renourishment had been recommended in 1968 by the U.S. Army Corps of Engineers to strengthen the island (Army COE, 1968) and just south of the location predicted by Giese (1978) for the next breach of the spit. Analysis by several investigators suggested a cyclic process with a period of 140-150 years for (1) tidal inlet formation, (2) southerly drift of the inlet, (3) eventual disintegration of the southern segment, (4) continued southern longshore drift and spit growth, and (5) eventual re-establishment of a continuous Nauset Beach Spit as existed prior to the new breach in 1987.(Goldsmith, 1972; Giese, 1978, 1988; McClennen, 1979).

Fessenden and Scott (1989) described the formation of the tidal inlet, which was over one mile wide after 20 months. The most significant physical effects of the breaching were extensive shoaling and shoreline erosion along the interior coastline at Chatham, MA. Corps of Engineers efforts to marshall a joint team effort to address the problem were also discussed.

Giese et al. (1989) reported on their monitoring efforts to understand the impacts of tidal inlet formation on the physical characteristics of this barrier beach-estuary system. These included morphology, tidal amplitude and phase, tidal circulation, wave pattern, and sediment transport within the system. The physical system has become controlled by the large tidal inlet which is forcing rapid adjustments in the system's biological and human-use characteristics. These authors also conclude:

> "As an alternative means of environmental management, communities may find that they are better able to preserve their coastal and estuarine resources by predicting and planning for tidal inlet changes than by attempting to prevent them"(Giese et al., 1989).

To the author's knowledge, extensive studies of the biological and ecological impacts of new tidal inlet formation have not been conducted for Pleasant Bay and Chatham Harbor. The joint study effort developed by the Corps and the scientific communities (Fessenden and Scott, 1989) fails to include those federal, state, and local agencies directly involved in tidal wetlands preservation and mitigation. The loss of vegetated wetlands (coastal marshes and bottom areas) due to conversion to open water, higher energy ocean environments must be placed in perspective by the marine biology and ecological scientific community. The conclusion quoted above from Giese et al. (1989) might be completly reversed if it is based on the balanced perspectives of both the "barrier island migration" paradigm and the "wetlands value" paradigm for coastal zone management.

Back Bay Behind Sandbridge Beach, VA

The final example considers the southeastern coast of Virginia that includes a narrow region of sandy coast which bridges the northern and southern mainlands fronting the Atlantic Ocean and Back Bay, VA. This narrow strip of sand, appropriately named Sandbridge, has experienced a long-term average shoreline recession rate of about 10ft/year (1858-1984) (Everts et al., 1983). This is due to local bathymetry, wave energy focusing, and net drift out of the region in both directions (nodal point). As a result, the barrier width is less than 720 ft in some locations.

As shown by Dolan (1985), Sandbridge Beach is narrower today than any of the barrier islands that were breached in the last 100 years along the mid-Atlantic coast. Consequently, a new tidal inlet is predicted to occur at Sandbridge as a result of a strong storm surge event.

The Corps of Engineers has completed a study of the economic benefits of a beach renourishment project at Sandbridge, primarily for flood damage mitigation (COE, 1989). The recommended project design had a benefit-cost ratio (B/C) of 1.16. Only the value of man's developed facilities (roads, utilities, homes, etc.) located on the barrier strip were considered in the B/C analysis.

Dolan (1985) performed a similar economic study for beach renourishment but included the value of some aspects of the back bay that would be damaged (or lost forever) should a new inlet form if renourishment is not undertaken. These additional benefits were for farming, property, recreation, fishing, utilities, and inlet closure. Dolan's B/C ratio was much higher (4.33). The addition of coastal wetlands protection and the potential for saving acres of wetlands loss to open, high energy ocean conditions was not considered by Dolan (1985). If included, the ratio of yearly benefits received to the annualized costs of a beach renourishment project at Sandbridge Beach would be even higher.

The Need for a Paradigm Shift in CZM

The Examples Revisited

We now need to step back (or fly a little higher) and view the entire coastal region as an integrated whole, as shown in Figure 1. We need to base public policy on a higher level (shifted) paradigm that embraces the revelations of both coastal geological and coastal biological/ecological sciences. We need to consider both the economic value of nature's ecosystem behind barrier islands and the economic value of human artifacts on barrier islands when making decisions regarding the stabilization of a migrating barrier beach. The government should promote policies that are shown to be economically sound when all the economic benefits are included and it is in the public interest. Benefits to humans regarding flood damage reduction and beach recreation and benefits to nature via the saving of the most biologically productive marine areas on earth in the estuaries, bays, and lagoons behind barriers must be considered.

From this perspective, consider again the four examples described above. Assateaque Island National Park is a valuable recreational resource and Sinepuxtent Bay is a valuable estuarine-marsh area. Economic decisions to justify initial beach renourishment and maintenance expenses of the northern end of the island should be based on the benefits* received to both resources.

A similar dual benefits analysis procedure might have justified renourishment of Nauset Beach Spit in the early 1970s at the site for potential breaching as predicted by Giese (1978). As it turned out, a federally-justified project was not economically feasible based solely on the benefits to the barrier island spit. We are now totaling up (since 1987) the economic costs to human-use activities and have yet to consider the economi costs resulting from the rapid change to an open ocean, high-energy environment and the loss of an estuarine-bay area environment. Strong potential exists for a similar breaching event to take place at Sandbridge, VA. Inclusion of some back bay benefits changed a marginally justificable project (Corps Perspective) into a strongly justifiable project (all federal agency perspective). The further inclusion of wetlands values into the benefits analysis would sjow an overwhelming need to immediately renourish Sandbridge Beach and would justify maintenance expenses over the life-cycle of the project.

The fourth example, the Metompkin Island and Bay system, is especially important for it illustrates a case where natural processes should be left alone. We are not calling for an illogical and economically unattainable massive effort to stabilize all moving barrier systems. And, we recognize that some further research and development will be required to implement a dual benefits analysis procedure.

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*In retrospect, if such a system of benefits analysis were in place in the 1930s as a consequence of knowledge about the barrier island migration and wetlands value paradigms, then an inlet sand by-passing system could have been economically justified at that time for Ocean City, MD.

Further Research, Development, and Policy Needs

Inventory - The relative magnitude of the problem of estuarine bay area loss to barrier island migration should be put in perspective through a natural inventory program. Surface area shrinkage due to migration by overwash processes should be separated from losses due to new inlet formation. The relative amounts of national vegetated wetlands (coastal marshes, bottom grasses, etc.) and open water, high energy, tidal inlet areas should be determined. On the water planet Earth, with over 75% of which is covered with deep water ocean, the relatively tiny percentage of protected estuaries, bays, and lagoons must not be lumped together and equated in ecological value with new, high energy, tidal inlets.

Breaching Site Prediction - Existing methods (e.g., narrowing of island widths) should be used to identify potential breaching sites for new tidal inlet formation. Numerical modeling methods should be developed, calibrated, and verified for predicting new tidal inlets in the future due to accelerating sea level rise, storm surge, wave action, and local sediment supply budgets.

Economic Value - Methods and procedures must be developed to place relative, quantitative economic values on coastal wetlands. Coastal marshes and valuable benthic communities in protected bays, estuaries, and lagoons must be given greater units of economical value than are assigned to open water, higher energy areas associated with tidal inlets. The relative ecological "cost" of a newly opened tidal inlet must be determined in a quantifiable way.

Consider the Outer Banks of North Carolina as an example. What would happen to the coastal ecology if "migration" accelerated due to the forming of many more tidal inlets? The question essentially comes down to the biological productivity potential (BPP) in the protected environment versus that in the high energy, ocean environment.

Public Policy - The final step is the elevation of public policy in a formal way to require the inclusion of the economic value of the "wetlands value paradigm" loss in all studies of the economic and environmental soundness of alternatives for stabilization of migrating barrier beach systems.

Openmindedness - The Need for a Paradigm Shift

Coastal zone planners and managers need to keep an open mind regarding the stabilization of migrating barrier beaches. All options should be evaluated, including the "hardfacing" option. The relatively narrow view spurred by the barrier beach migration paradigm must be expanded, elevated, and shifted to a new paradigm for public policy decisions that includes the total value of what is behind as well at what is on moving barrier islands in

the coastal zone.

References

Basco, D.R. 1990. The Effect of Seawalls on Long-Term Shoreline Change Rates for the Southern Virginia Ocean Coastline. Proceedings, 22nd ICCE, Delft, the Netherlands, July in press.

Bean, N.J. 1978. The Federal Role in Wetland Protection: An Overview. Proceedings, National Wetland Protection Symposium, FWS/PBS-78/97, US Fish and Wildlife Service, Office of Biological Services, Washington D.C., pp. 103-107.

Byrnes, et al. 1989. Temporal and Spatial Variations in Shoreline Migration Rates, Metompkin Island, Virginia. Barrier Islands: Process and Management, ASCE, New York, pp. 78-92.

____ and Gingerich. 1987. Cross-Island Response to Hurricane Gloria. Proceedings, Coastal Sediments 87, ASCE, New York, p. 1486-1502.

U.S. Army Corps of Engineers. 1989. Sandbridge Beach, Virginia Beach, Virginia. Supplemental Preauthorization Study, Norfolk D.O., U.S. Army Corps of Engineers, April.

Dolan, R.H. 1985. Sandbridge Beach and Back Bay Virginia. Tech. Rept., Coastal Research Assoc., Inc., Charlottesville, VA, 120p.

_____ and H. Lins. 1987. Beaches and barrier islands. Scientific American, 255(7): 68-77.

Everts, et al. 1983. Shoreline Movements: Cape Henry Virginia to Cape Hatteras, NC, 1849-1980. Rept. No. 1, Tech. Rept. CERC 83-1, WES, Vicksburg, MS, July, 123p.

Fessenden, F.W. and S.C. Scott. 1989. The Coastal Beach at Nauset Beach, Chatham, Massachusetts: A Case Study. Barrier Islands: Process and Management, ASCE, NY, p.138-149.

Giese, G. 1978. The Barrier Beaches of Chatham, Massachusetts. Rept., Provincetown Center for Coastal Studies, April.

____, 1988. Cyclical Behavior of the Tidal Inlet at Nauset Beach, Chatham, Massachusetts. Hydrodynamics and Sediment Dynamics of Tidal Inlets, (Aubrey, D.G. editor), Springer-Verlag, NY.

____, et al. 1989. Impacts of Tidal Inlet Formation on the Physical Characteristics of a Barrier Beach-Estuary System. Barrier Islands: Process and Management, ASCE, NY pp.150-158.

Goldsmith, V. 1972. Coastal Processes of a Barrier Island Complex and Adjacent Ocean Floor: Monomoy Island - Nauset Spit. Cape Cod, MA, unpubl. doctoral dissertation, Univ. Mass., 469p.

Kraus, N.C. and O.H. Pilkey (editors). 1988. The effects of seawalls on the beach. Journal of Coastal Research, Spec. Issue No. 4.

Leatherman, S.P, 1987. Shoreline and Sediment Budget Analysis of North Assateque Island, Maryland. Proceedings, Coastal Sediments; 87, ASCE, NY p.1460-1471.

________, 1988. Barrier Island Handbook, Laboratory for Coastal Research, Univ. of Maryland, College Park, 92p.

Magoon, O.T. et al. (editors). 1989. Coastal Zone 89, Proceedings, Sixth Symposium on Coastal and Ocean Management, ASCE, NY, 5 Vols., 4978p.

McClennen, C.E. 1979. Nauset Spit: Model of Cyclical Breaching and Spit Regeneration During Coastal Retreat. Pages 109-118 in Leatherman, S.P. (ed): Eastern Section Field Trip Guide Book; Cape Cod National Seashore, Boulder, Co.

Pilkey, O.H. et al. 1981. Saving the American Beach: A Position Paper By Concerned Geologists. Skidaway Inst. Oceanog., Savannah, GA.

____ and H.L. Wright III. 1988. Seawalls versus beaches. Journal of Coastal Research, Spec. Issue No. 4, 41-66.

Stauble, D.K. (editor). 1989. Barrier Islands: Process and Management, ASCE, Volume published as series of papers from Coastal Zone 89 Conference, July.

Tiner, R.W., Jr. 1984. Wetlands of the United States: Current Status and Recent Trends. Supt. of Doc., US Gov't Printing Office, Washington D.C.

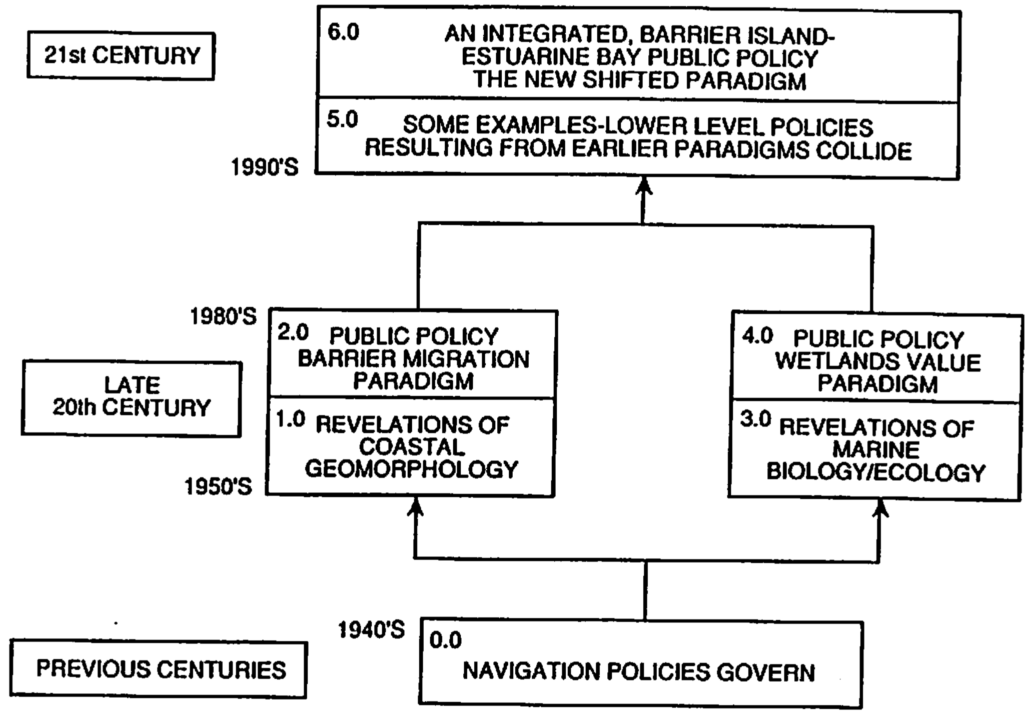

Fig. 1 Schematic representation of historical trends in U.S. policies toward coastal zone management. The numbers indicated within the boxes correspond to successive sections of this paper.

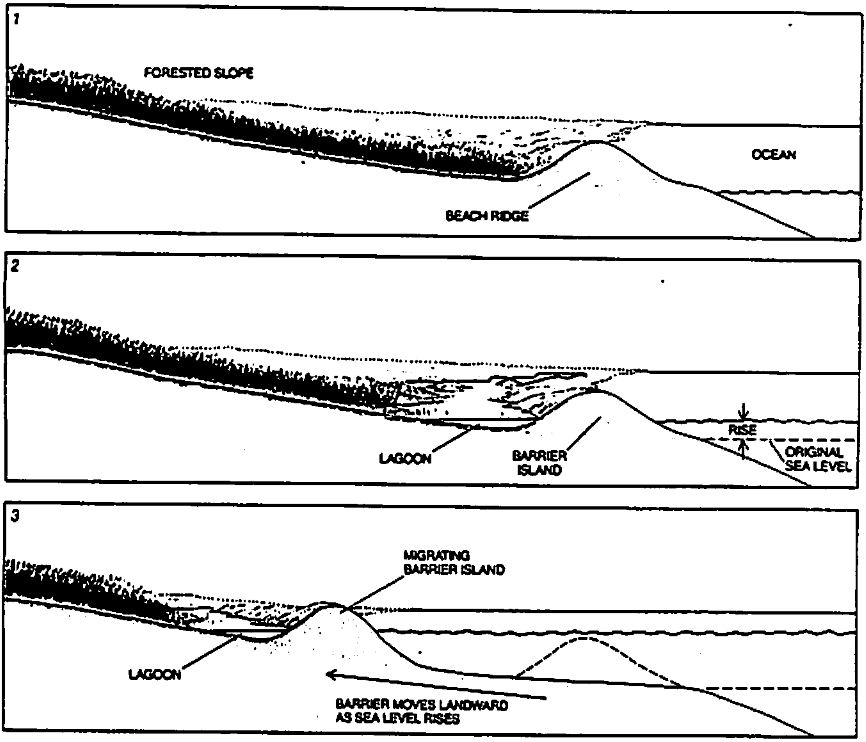

Fig. 2 Evolution of a barrier island from Dolan and Lins, 1987, p.72. At top (1) is the situation 15,000 years ago when sea level was 350ft lower. Rising sea level, middle (2) caused breaches in the beach ridge system flooding the back bays to form lagoons and bay-estuarine systems. As a result of continued rise in sea level,lower (3) depicts migrating barrier island and the shrinking of the lagoon surface area that in this illustration is only a schematic but perhaps the unconscious feelings of the authors.

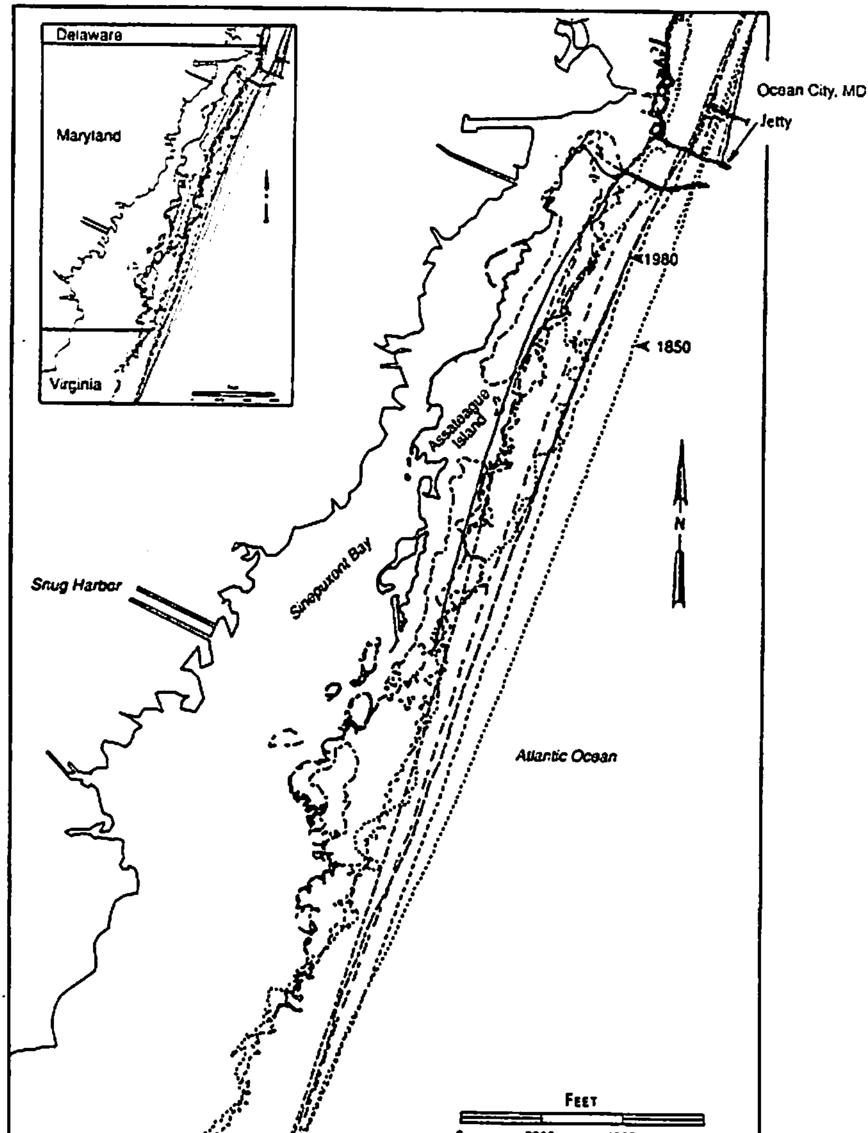

Fig.3 The rotation of the northern end of Assateaque Island between 1850 and the 1980's and the resultant shrinkage of Sinepuxent Bay. In 135 years, over 920 acres of bay have been lost which amounts to a 25 percent shrinkage of bay surface area due to barrier island migration.

Recent Advances in Physical Movable-bed Modeling at the Coastal Engineering Research Center

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Abstract

Recently, at the Coastal Engineering Research Center (CERC) of the U.S. Army Engineer Waterways Experiment Station (WES), numerous studies concerning problems associated with physical movable-bed models (MBM) have produced very important findings. These accomplishments will allow engineers and scientists to use these models as a tool for planning and designing coastal projects where storm-induced erosion is a major consideration. This is particularly important because the methods and procedures for movable-bed models are not widely accepted and numerous (often conflicting) guidances have been developed. The research described here has been conducted to test/develop/improve scaling guidance and to define limits for movable-bed physical models. Initial efforts involved evaluation of the research efforts of other laboratories and guidance developed by same. During the early 1980's, scaled tests were conducted to evaluate the predictive capabilities and accuracies of five different modeling guidances. This was done by attempting to reproduce prototype scale data generated in CERC's large wave tank by Thorndike Saville in the 1950's. The guidances evaluated were those of Noda, Vellinga, Hughes, Lepetit and Leroy, and Hallermeier. This research was followed by additional laboratory efforts to determine the effects of model sediment size and type. Results indicated that for modeling prototype sands, fine to very fine model sands give best results. These results led to the selection of the guidance currently used for certain movable-bed models at CERC. For simulation of sediment transport in very energetic physical environments, such as with wave-induced erosion, the following criteria should be met:

1) fall speed parameter (H/wT) similarity;
2) time scaled according to Froude;
3) model is undistorted; and
4) use fine sand (0.08 mm lower limit) at largest scale possible.

A scaled physical model was recently used to validate the above guidance by simulating prototype scale wave-induced scour in front of a concrete dike sloped at 1:4. The tests were conducted during fall and winter of 1988. Prototype data were obtained from the large wave tank tests done by Dette and Uliczka (1987) at the University of Hanover in Germany during 1985-1986. Based on the very successful results of this study, the modeling guidance was considered validated for the stated conditions. Following the

validation tests, the scaling guidance was used to simulate severe beach fill erosion associated with a winter storm at Ocean City, Maryland during March, 1989. The tests were conducted without prior knowledge of post-storm profiles. Model and prototype profiles showed good agreement, giving further credence to the scaling guidance and its ability to model energetic (erosive) wave action movable-bed situations.

Introduction

Recent studies at the Coastal Engineering Research Center (CERC) on various problems associated with physical movable-bed models have led to very important findings. The results of these studies will allow engineers and scientists to use these models as a tool for planning and designing various coastal projects where wave-induced erosion is a major consideration. This is particularly important because the methods and procedures for designing movable-bed models are not widely accepted and numerous (often conflicting) guidances have been developed. The research described here was conducted to test/develop/improve scaling guidance and to define limits/accuracies associated with movable- bed physical models.

Movable-Bed Modeling Considerations

Most MBM researchers agree that in order to accurately model sediment transport, it is necessary to simulate the forces which initiate motion, and, once the particles are dislodged, to simulate the way in which the particles return to the bottom. Thus, two different approaches have emerged for movable-bed modeling and most recent developments in movable-bed modeling have involved making model and prototype similar in one or both of two areas:

1) incipient sediment motion
2) sediment fall velocity (speed).

To model initiation of sediment motion, the movable-bed modeler is concerned with the total shear (bed and fluid) which resists sediment transport. The sediment fall speed parameter (H/wT) is typically used to simulate trajectories of the particles as they fall to the bottom. For this parameter, H is the wave height, w is the sediment fall speed, and T is the wave period. The fall velocity parameter is probably most appropriate in energetic surf zone situations where wave energy dominates. Incipient motion scaling would be more appropriate in deep water situations and less energetic wave action situations (accretionary) where transport occurs primarily as bedload. Regardless of the approach used, problems with MBM stem from the same root--an inability to geometrically scale fluid properties and sediments.

Model Sediments

The majority of MBM are used to simulate movement of relatively small prototype sediments which typically have small mean sediment diameters. When the prototype sediment is predominantly sand (mean diameters from 0.1 - 2.0 mm; most often are less than 0.5 mm), various constraints make it difficult to reduce sediment size in the model so that prototype sediment motion is accurately reproduced. This problem is less severe for laboratories having facilities with large wave generating capabilities since such facilities can usually operate at scales close to unity and geometric scaling of sediments is possible.

Various lightweight materials have been used to cope with the inability to geometrically scale MBM. Unfortunately, additional problems occur with these lightweight materials (differences between pore pressures, binding strengths, and settling paths), and many investigators feel that fine or very fine sands are best for MBM (Kamphuis, 1984; Vellinga, 1982; Hughes and Fowler, 1990).

In addition to the above, fine sands overcome the problem of "fluidization" of the bed, in which the lightweight sediments tend to "float" within the water column until the wave machine is turned off. When this occurs, the profile obtained is more a function of how the grains settle after the wave machine is turned off and does not reflect the real transport mechanism. In light of this, MBM physical studies done at CERC are conducted at the largest scale possible, with fine sand as the model sediment. The sand currently used at WES was obtained from the Ottawa Sand Company in Ottawa, Illinois and has a specific gravity of 2.65 and a 0.13 mm mean diameter.

It is not this author's intent to imply that studies done using lightweight modeling sediments cannot produce useful results. In fact, successes have been reported using lightweight materials such as walnut shells, bakelite, and plastics as either tracer materials or as model sediments. The majority of these studies, however, involved models where bedload transport dominated and geometric/time scales were based on model tests conducted to duplicate historical events.

Evaluation Studies - Previous Movable-Bed Modeling Guidance

During 1985-1986, Fowler and Smith (1986) conducted movable-bed tests to evaluate predictive capabilities and accuracies of five of the most commonly used MBM guidances. This was done by attempting to reproduce prototype-scale tests run in a large wave tank as reported by Saville (1957). The guidances evaluated were those of Noda, Vellinga, Hughes, Lepetit and Leroy, and Hallermeier. These tests indicated that the scaling guidances of

Vellinga and Hughes produced the best results. Athough exact duplication was not obtained with either method, results were good enough that these guidances formed the basis for scaling laws currently used at CERC. Both the Vellinga (1982) and Hughes (1983) guidances centered on the fall speed parameter. The Vellinga guidance specifically required that

$$\frac{N_h}{N_v} = \left(\frac{N_v}{N_\omega^{\,2}}\right)^{0.28} \qquad (1)$$

and time be scaled according to Froude as

$$N_t = N_v^{1/2} \qquad (2)$$

For the above, N_h and N_v are the horizontal and vertical scales,respectively, N_t is the time scale, and N_w is the sediment fall speed parameter scale. Since Equation 1 is empirical, it is only valid for the conditions from which it was developed. For an undistorted model, N_h/N_v = 1 and Equation 1 reduces to

$$N_v = N_l = N_\omega^2 \qquad (3)$$

In Equation 3, N_l is the arbitrary length scale, equal to horizontal and vertical scales for undistorted models. Hughes' guidance required that

$$\frac{N_h}{N_v} = \frac{N_v}{N_\omega^{\,2}} \qquad (4)$$

and

$$N_t = \sqrt{N_l} \qquad (5)$$

These two guidances combined to give the method which is presently used with much success at CERC:

1) fall speed parameter (H/wT) similarity;
2) time scaled according to Froude;
3) model is undistorted; and
4) use fine sand (0.08 mm lower limit) at largest scale

possible.

Two-Dimensional Scaling Law Validation Tests

A two-dimensional model was used to validate the selected scaling guidance for very energetic (erosive) wave conditions. The tests were conducted at CERC during the fall/winter of 1988. These tests were termed "validation tests" and consisted of physical model experiments to reproduce prototype-scale wave-induced erosion in front of a sloping concrete dike. The prototype data were large wave tank tests done by Dette and Uliczka (1987) at the University of Hanover in Germany in 1985 - 1986. The validation model was undistorted and constructed at a 1:7.5 geometric scale determined by the fall velocity parameter criterion. Fine quartz sand with a mean diameter of 0.13 mm was used as the model sediment and simulated prototype sand which was 0.33 mm in mean diameter. The CERC facility is constructed of concrete with a glass wall viewing section and has the following capacities:

Length	100.0 meters	Depth	1.22 meters
Stroke	0.66 meters	Width	1.83 meters

The laboratory procedure used for the validation tests was designed to reproduce the procedure of Dette and Ulickza. The tests were run with both regular and irregular waves which eroded a layer of sand fronting a 1:4 concrete slope. Prior to each series of tests, the sand was smoothed to an identical 1:4 slope and initial profiles were taken. Tests were run to "equilibrium" conditions for each case, and profiles were taken at intervals corresponding to the prototype tests. Figures 1 and 2 give profile comparisons between model and prototype for both the regular and irregular wave cases. Results indicated that for the specified conditions, the fall velocity parameter leads to favorable profile replication, particularly for the irregular waves, and the guidance shown above was considered validated.

Beachfill Erosion Study, Ocean City, Maryland

Following the "validation tests" series, the selected modeling guidance was considered validated, but had not been tested for an actual field situation. The acquisition of a high quality set of field data collected during severe beachfill erosion associated with a winter storm at Ocean City, Maryland in March, 1989 provided an opportunity to test the scaling guidance by simulating the storm event in a scaled movable-bed model. The pre-storm beach profile (January, 1989) was molded in CERC's mid-scale wave tank using 0.13 mm quartz sand at the 1:7.5 undistorted geometric scale determined from the guidance. The simulation was conducted using irregular waves without prior knowledge of post-storm profiles. To reproduce the measured prototype storm conditions as closely as possible, water level, significant wave height, and peak spectral period were varied (in three-hour prototype time increments) as the model storm progressed. Profiles were taken at various time intervals throughout the storm. Figure 3 shows model and prototype comparisons midway through the storm and Figure 4 shows profile comparisons at the end of the storm. The post-storm prototype profile was obtained in April, 1989. Model and prototype profiles show reasonable agreement, giving further credence to the scaling guidance.

Irregular/Regular Waves Equivalence Tests

Much of the established design guidance for coastal projects where sediment transport is a concern has been developed using movable-bed models run with uniform regular waves. Design guidances developed from such models typically represent natural irregular waves by a single statistical wave height parameter. This parameter is then taken as being equivalent to the regular wave height in the design formulae. Laboratory-generated irregular waves more closely represent natural conditions and are commonly characterized by either statistical or energy-based parameters. Typical statistical wave height parameters include: H_{avg} (mean wave height of all waves), H_{rms} (root-mean-square wave height), and $H_{1/3}$ (average of the highest 1/3 of all waves). The primary energy-based wave height designator is H_{mo}, which is directly related to the energy contained in the wave spectrum. H_{mo} is approximately equal to $H_{1/3}$ for deep water waves, but can be significantly different for shallow water waves (Hughes and Borgman, 1987).

Laboratory experiments were conducted to evaluate various irregular wave parameters to determine which provides the best match for the regular wave parameter used to develop design guidance. The tests were done in conjunction with the "validation tests" in which uniform regular and irregular waves were used to displace sand initially placed at a 1:4 slope in front of a concrete structure which had a similar 1:4 slope. Results were judged based on best bottom profile matches. Figure 5 is a comparison between bottom profiles when energy contents were matched ($H_{mo} \approx 1.4H_{1/3} = H_{reg}$), while Figure 6 compares the case when regular wave height is equal to the significant wave height ($H_{1/3} = H_{reg}$). Results showed that significant wave height, rather than H_{mo}, is the best irregular wave design parameter for matching results based on uniform regular wave tests. This suggests that the highest 1/3 of the waves in a given distribution are probably most important for sediment transport.

Summary

It is unreasonable to believe that a single scaling guidance will yield consistently good movable-bed modeling results for all cases of movable-bed models. Studies at CERC indicate that for modeling prototype sand transport, fine to very fine model sands give best results. The following criteria should be met for simulation of sediment transport in very energetic physical environments, such as those with wave-induced erosion:

1) fall speed parameter (H/wT) similarity;
2) time scaled according to Froude;
3) model is undistorted; and
4) use fine sand (0.08 mm lower limit) at largest scale possible.

Additional studies show that significant wave height, rather than H_{mo}, is the best irregular wave design parameter for matching results based on uniform regular wave tests. This suggests that the highest 1/3 of waves in a given distribution are likely most important for sediment transport.

Acknowledgement

The research presented here was sponsored by the Shore Protection and Restoration Work Program of the U. S. Army Engineer Waterways Experiment Station. The Office, Chief of Engineers, is acknowledged for authorizing publication of this paper.

References

Dette, H. H. and K. Uliczka. 1987. Prototype Investigation on Time-Dependent Dune Recession and Beach Erosion," Proceedings of Coastal Sediments '87, ASCE, 2:1430-1444.

Fowler, J. E. and E. R. Smith. 1986. Evaluation of Movable-Bed Modeling Guidance. Pages 1793-1802 In: S. Wang, H. Shen, and L. Ding, (eds.), Proceedings, Third International Symposium on River Sedimentation, Univ. of Mississippi.

Hughes, S. A. 1983. Movable-bed modeling law for coastal dune erosion," Journal Waterways, Port, Coastal, and Ocean Engineering Division, ASCE, 109(2):164-179.

____ and L.E. Borgman. 1987. Beta-Rayleigh Distribution for Shalllow Water Wave Heights. Pages 17-31 In: Proceedings of Coastal Hydrodynamics '87, ASCE.

____ and J.E. Fowler. (in press) Mid-Scale Physical Model Validation for Scour at Coastal Structures. Technical Report CERC 90-1. US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg, MS.

Kamphuis, J.W. 1984. The Development of Coastal Mobile Bed Model Technology. Prepared for a continuously updated lecture series. unpublished notes.

Saville, Jr., T. 1957. Scale Effects in Two-Dimensional Beach Studies. Pages A3-1 - A3-10 In: Proceedings 7th IAHR Congress, Lisbon, Portugal.

Vellinga, P. 1982. Beach and dune erosion during storm surges. Coastal Engineering, 6:361-387.

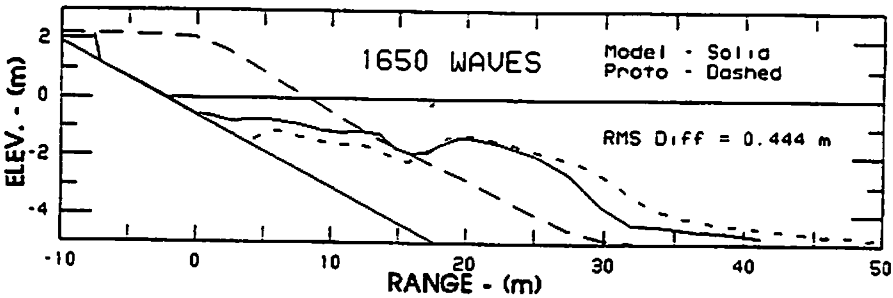

Figure 1. Regular Wave Tests Comparison, Validation Tests

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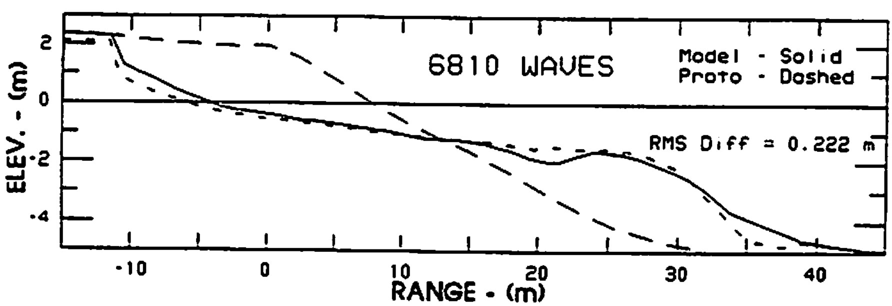

Figure 2. Irregular Wave Tests Comparison, Validation Tests

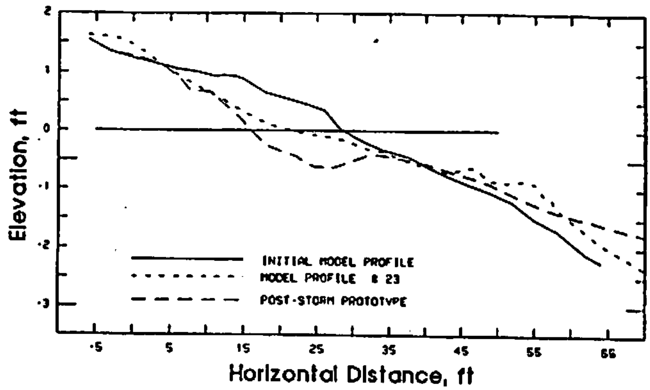

Figure 3. Mid-storm Model Profiles

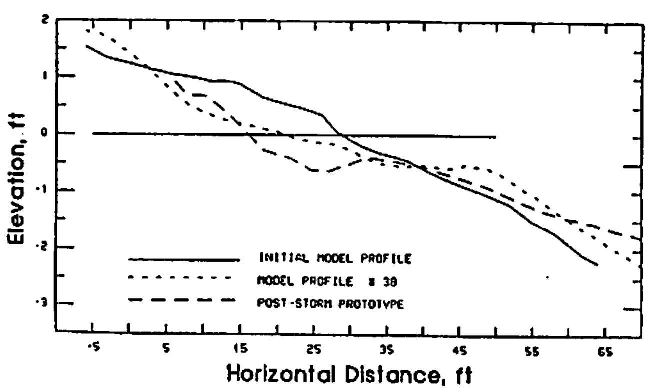

Figure 4. Post-storm Model and Prototype Profile Comparison

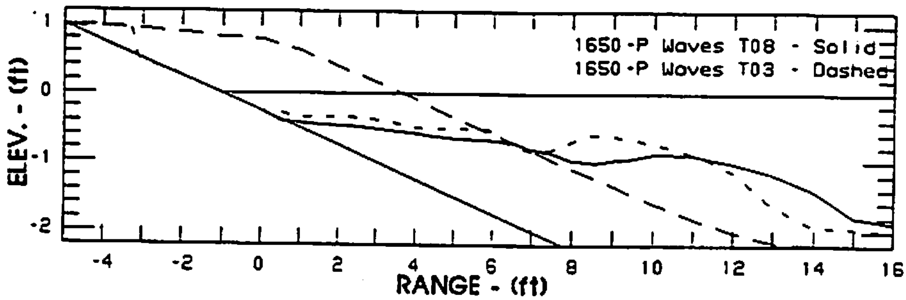

Figure 5. Profile Comparisons for H_{mo} versus H_{mono}.

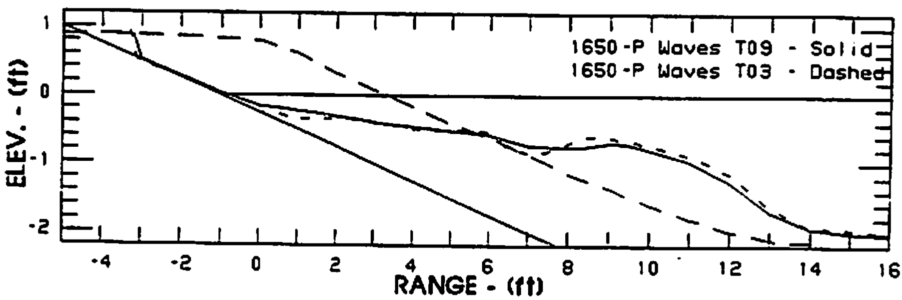

Figure 6. Profile Comparisons for $H_{1/3}$ versus H_{mono}.

Shoreline Determination Along Gently Sloping Shores: A Multidisciplinary Approach

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Abstract

Shoreline determinations along gently sloping coastal lands present challenges to both the scientific and legal professions. Along the extensive, gently sloping shores of the Laguna Madre of South Texas, there have been several legal controversies regarding land ownership and accurate shoreline boundary determination. At the heart of this problem lies the basic question: are the coastal areas often referred to as the "wind-tidal flats" of the Laguna Madre submerged, and therefore owned by the State, or are they not submerged and owned by the private owner of the adjacent uplands?

The determination of shoreline locations in areas with obvious relief is relatively simple. In contrast, accurate shoreline determination may be difficult in areas where wind-tidal flats are present. A wind-tidal flat is defined as a broad, barren flat that is partially inundated at irregular intervals by lagoonal or bay waters under the influence of wind-generated tides. Scientific complexities in the determination of shoreline locations in wind-tidal flat environments include lack of shoreline vegetation and difficulty in measuring normal astronomical tides, coupled with multi-directional and seasonably variable wind-tides. Surveyors have difficulty because of the geographic remoteness of the flats, the miles of level, featureless terrain, and the lack of tide gauges for determination of mean higher high tide or mean high tide. Attorneys are faced with determination of original land grant origin, interpretation of previous judgments, and negotiation and possible litigation with the state, which owns most submerged lands in Texas.

A multi-disciplinary approach has proven beneficial and effective as a means of accurately solving this complex problem. Attorneys, land surveyors, a geologist, and a biologist have worked independently and cooperatively to develop techniques and produce data and results that can facilitate shoreline boundary placement on the wind-tidal flats of South Texas.

Introduction

Special conditions in Laguna Madre

Approximately 360 mi^2 of wind-tidal flats are found adjacent to the shoreline of the Laguna Madre of Texas (Fig. 1) (Brown et al., 1976, 1977, 1980). These flats commonly have slopes on the order of 0.5 ft/mi. Astronomical tidal ranges in the adjacent Laguna Madre are usually less than 0.5 ft. and the flats are primarily affected by multi-directional wind-tides and storm waters. There is often no obvious shoreline or vegetation line.

Legal shore boundary in Texas

Texas state law defines the boundary between submerged lands belonging to the state and uplands belonging to the private land owner as the projection of the level of either mean higher high tide (MHHT) or mean high tide (MHT) on the sloping shoreface. If the land ownership dates from a Spanish or Mexican land grant, MHHT is used as the boundary. MHT is used as the boundary for land grants under common law after Texas independence.

Previous court cases in Laguna Madre

The Laguna Madre, and the boundaries of the adjoining upland, have been the subject of several state and federal lawsuits. These cases include, in chronological order: State v. Balli, 190 S.W.2d 71 (Tex. 1944); Sun Oil Co. v. Humble Oil & Refining Co. 190 F.2d 191 (5th Cir.) reh'g denied, 191 F.2d 705 (1951); Luttes v. State, 324 S.W.2d 167 (Tex.1958); and three separately filed lawsuits styled South Padre Land Co., et al. v. State, Cause Nos. 78-153-C, 78-154-C, and 78-155-C in the 197th District Court of Cameron County, Texas. The location of a segment of the shoreline of the Laguna Madre as it runs through the Land Cut area in Kenedy County is the subject of pending litigation in a case styled The John G. and Marie Stella Kenedy Memorial Foundation v. Garry Mauro, Commissioner of the General Land Office, and The State of Texas, Civil Action No. C-90-36, In the United States District Court for the Southern District of Texas, Corpus Christi Division. In analyzing the case law developed by these prior decisions, it is important to remember that tidal boundaries are, by definition, fluctuating boundaries and therefore subject to re-litigation, if the boundary changes position due to changes in the position of MHT or MHHT on the property.

Purpose of Multi-Disciplinary Approach

The attorney must determine the present ownership of the land and the history of ownership back to the time of the original grant. The attorney ascertains the legal principles which may affect the present boundary location.

Because of arguments frequently made by the state, it is often useful to acquire information about the historical topography and conditions of the disputed area.

The surveyor must find and study all historical maps and boundary documents and, when possible, find the old boundary lines on the ground. He/she must determine an appropriate value for MHHT or MHT, mark the present boundary on the ground, and map the boundary. The surveyor must assist the geologist and biologist with locations, elevations, and tidal data.

The geologist uses studies of sedimentology, topography, hydrography, and climate to provide a qualitative aid in helping to locate the present boundary position and to determine and explain the processes which have operated to change the position of the historical boundary to the present boundary, if it has changed in position. He/she assists the attorney in understanding the complex physical processes affecting the present and historical boundary positions.

The biologist provides qualitative assistance in supporting the location of the modern boundary position based on the presence or absence of inundation-sensitive plants and animals. He/she assists the geologist in faunal interpretation of surface and subsurface environments of deposition and explains the significance of biological indicators of shoreline position to the attorney.

Independent and Collaborative Methods and Results

Legal aspects

In defining the location of the legal boundary of the Laguna Madre, the source of the original grant of the adjacent upland determines the applicable standard (Luttes v. State, 324 S.W.2d 167 (Tex. 1958)). For grants issued by the Spanish or Mexican governments, the shoreline is defined as MHHT, while MHT determines the shoreline for lands granted under the common law or Anglo-American law (Id., 324 S.W.2d at 191). For most, if not all of the Laguna Madre, there is no practical difference between these two tidal values. Regardless of the applicable tidal value, resolving a boundary dispute along any portion of the Laguna Madre will invariably necessitate negotiation and possibly litigation with the General Land Office and the State of Texas. The State of Texas, as the owner of all submerged lands in the State of Texas, will generally be the adverse adjoining property owner. Understanding the jurisdiction, structure, and powers of the General Land Office is invaluable in resolving any boundary dispute along the Laguna Madre.

Under Sections 31.051, 31.052, and 31.063 of the Texas Natural

Resources Code, the Land Commissioner is authorized to manage, supervise, and determine the boundaries of submerged lands belonging to the State of Texas. In most boundary disputes along the shore of the Laguna Madre, the ownership of the minerals in place is a valuable asset of the property, in addition to the commercial development value of the property. The School Land Board, which is chaired by the Land Commissioner, has statutory authority to grant oil and gas leases for the development and production of oil, gas, and other minerals underlying submerged lands (TEX. NAT. RES. CODE § 32.061). The School Land Board is statutorily empowered to schedule a sale for oil and gas leases on submerged lands. There is a tract nomination process by which prospective lessees are allowed to nominate tracts for public bidding (See 31 TEX. ADMIN. CODE § 153.1 (West Supp. 1990)). The School Land Board selects the best sealed bid to purchase an oil and gas lease on a particular tract (See id. § 153.3).

Since the State of Texas is the adverse party in these boundary disputes, it is generally necessary that a private claimant obtain legislative consent to sue the state. The doctrine of sovereign immunity prevents a private claimant from suing the State of Texas to adjudicate title without legislative permission to sue. Consent resolutions can be introduced by a state senator or representative representing any of the five counties adjacent to the Laguna Madre. If a private claimant seeks legislative consent, it must adhere to the requirements set forth in the Texas Civil Practice and Remedies Code, Section 107.001 et seq. (Vernon Supp. 1990). If legislative consent is denied, the factual context of the particular boundary dispute may give rise to a constitutional claim for the taking of property without just compensation or the denial of due process under the Texas and U.S. Constitutions. A federal statute, 42 U.S.C. § 1983, provides a vehicle for asserting such a claim. Alternatively, a claim could be filed against the Land Commissioner under the principles of State v. Lain, 349 S.W.2d 579 (Tex. 1961).

Land surveying

The surveyor's task in a multi-disciplinary approach to shoreline mapping is to determine an elevation or elevations for the line of MHHT or MHT and to place and monument that line on the ground.

The Tides Branch of the National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA) is the primary source of information for determining an elevation of MHHT or MHT. Other public data sources include the U.S. Army Corps of Engineers, the Texas Water Development Board, and the Blucher Institute for Surveying and Science at Corpus Christi State University. Tide studies by private oil and gas lease holders may offer additional data.

Primary tide gauges which have been in place for a full tidal epoch of 18.6 years exist only at Port Isabel, Port Mansfield, and Corpus Christi (Claunch, 1987). Since the location of a tidal boundary is dependent upon the elevation of MHT or MHHT at the location of the property in question, and not at the location of a distant primary gauge, it may be necessary to install additional secondary tide gauges or staffs at the project site.

After the elevation for MHHT or MHT has been determined, the surveyor must monument that elevation contour on the ground. In addition to the problems associated with a scarcity of tidal data, there are few horizontal or vertical survey control benchmarks in the Laguna Madre area. On a shoreline boundary project of considerable length, the tidal boundary meander and other survey lines should be tied to the grid plane of the Texas Coordinate System and to the National Geodetic Vertical Datum (NGVD) (Bouchard, 1970). Monumentation of the national datum and horizontal control network may be distant from the project. The tie-in can be accomplished with conventional surveying methods, but use of Global Positioning System technology may be preferable if distances are long or terrain difficult. If the local survey is tied in with the national network, it will increase the probability of the survey lines being preserved for future use and reference, because they can be reconstructed if local monuments are lost.

In some areas of the Laguna Madre where the shoreface is of very low slope, the contour line representing MHHT or MHT may be difficult to locate. In those circumstances, the surveyor may place his line so that the actual line of MHHT or MHT is somewhat lagoonward of the line placed on the ground. Biological or geological evidence may provide support in these cases. Since a line of mean higher high tide or mean high tide is being placed on the ground, there will be times when bay water will be found landward of the line surveyed and times when dry land will be found lagoonward of the line.

Geology

The geologist assists in qualitatively determining the present tidal boundary, determining if there has been accretion or erosion and the rates of those processes, and evaluating the recent geological history of the area.

Rates of sedimentation can be estimated by collecting numerous short cores on transects across the study area. The cores are analyzed for environment of deposition, based on sediment type and remains of organisms present. Radiocarbon age dates on once-living organisms found in living position within the cores can be used to establish a date at which that level in the core was subaerially exposed. With this information, used in conjunction with the depth of the organism within the core, the long-term sedimentation rate at the site can be determined. Analysis of sedimentation rates throughout the study area, along with study of surface environments of deposition, Biology

The biologist must know the natural coastal environment well and be able to interpret which aquatic and terrestrial species of plants and animals are inherently associated with the shoreline. However, due to the lack of plants and animals normally seen along the central and lower Texas shoreline, wind-tidal flat shoreline determination by indicator species can be difficult. Salt marsh cordgrass (Spartina alterniflora), which normally inhabits the estuarine intertidal zone, is absent from most of the highly saline Laguna Madre. Therefore, the more salt-tolerant species, such as glasswort (Salicornia spp.), saltwort (Batis maritima), sea purslane (Sesuvium portulacastrum), and shoregrass (Monanthochloe littoralis) must be used. These may also be absent or they may grow on slightly elevated mounds along the shoreline. Furthermore, the main plant which exists on these flats (blue-green algae) has not been sufficiently studied to confidently relate growth forms or abundance to inundation frequencies or duration.

Barnacles, which leave their shells attached to hard substrates (e.g., pilings, fence posts) for years after their death, can aid in water-level determination. Relating barnacle size to growth rate can give an indication of the amount of time an area may have been inundated. However, care must be taken because barnacles can grow above the level of continuous inundation due to waves and splash, and growth rates can differ from one locale to another. Two species of acorn barnacles, Balanus eburneus and live B. amphitrite, within the Laguna Madre area. Their growth rates are slower during the colder winter months and during periods of hypersalinity.

Benthic (bottom) transects have been taken from aquatic areas extending across the apparent shoreline up onto terrestrial areas. Sieving of samples through a screen, then determining and enumerating living species present, allows plotting of species in either aquatic or terrestrial zones and determination of the shoreline according to their distribution. Most areas within the shallow waters of the Laguna Madre support extensive seagrass beds, predominantly shoalgrass, Halodule wrightii, and an associated, characteristic biota. Numerous species with considerable abundances characterize these grassbeds. A lagoon-margin sand commonly occurs between the grassbed and the shoreline, and it usually has fewer species than the grassbed, but may have high abundances. The terrestrial zone above the shoreline is typically barren, with only a few inconspicuous insects, including brine flies and small beetles.

Discussion and Conclusions

Due to the presence of extensive, nearly flat wind-tidal flats adjacent to the Laguna Madre and a tidal boundary legally defined to be the intersection of the elevation contour of the local MHT or MHHT with that processes of sediment transport, and sources of sediment supply may aid in determining if there has been accretion or erosion since the date of the original grant.

It may be useful to determine if relative sea level has changed in historical time. Age dating of depth-sensitive organisms within the cores may provide data which can be used to establish relative sea-level at past historical times. Long-term tide gauge records and examination of the scientific literature may also provide information useful in estimating the historical changes in sea level.

The recent geologic history of the coastal zone can be partially understood by examination of the scientific literature; however, it is often best to analyze numerous cores within the study area to determine the specific geologic history of the disputed tract. It is then possible to reconstruct the various environments of deposition on a three-dimensional diagram showing the changes in the location of each environment through space and time. If there is a detailed modern topographic map of the area, it may be possible to produce a probable topographic map of the area for any historical date by "eroding" the present topography back through time using sedimentation rates by which the surface built up to its present configuration. This enables the estimation of surface conditions at various times in the past.

The environments of deposition along the Laguna Madre shores include: continuously submerged shallow lagoon; intertidal lagoon margin; low wind-tidal flats submerged by wind-tides or by the highest seasonal astronomical tides; high flats where aeolian processes dominate, submerged only by storm tides; and vegetated mounds of various types, which are primarily aeolian in origin. Blue-green algal mats may provide a useful indicator, as they cannot live where continuously submerged by waters connected with the lagoon or where they are destroyed by grazing cerithid gastropods (Friedman, et al. 1973).

The geologist must educate the attorney on the geology of the tract and the surrounding areas. In addition, the attorney must be able to read and understand specialized geologic reports and papers and to understand and critically evaluate legal testimony by opposition geologists.

gently sloping surface, it is important to accurately place that boundary on the ground. A small error can result in a great horizontal displacement of the boundary and loss of considerable land to one of the owners. A multi-disciplinary team consisting of attorneys, surveyors, geologists, and biologists can be assembled to confirm the legal location of the boundary.

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References

Bouchard, H. 1970; Surveying, 5th.ed., International Textbook Co., Scranton, PA, 754 p.

Brown, L.F., J.C. Brewton, J.H. McGowen, W.A. White, C.G. Groat, and W.C. Fisher. 1976, Environmental Geologic Atlas of the Texas Coastal Zone - Corpus Christi Area, Bur. Econ. Geol., Univ. Tex. Austin, Austin, TX, 140 p., 9 maps.

_______. 1980. Environmental Geologic Atlas of the Texas Coastal Zone - Brownsville-Harlingen Area, Bur. Econ. Geol., Univ. Tex. Austin, Austin, TX, 140 p. 9 maps.

Brown, L.F., J.H. McGowen, T.J. Evans, C.G. Groat, and W.C. Fisher. 1977. Environmental Geologic Atlas of the Texas Coastal Zone - Kingsville Area, Bur. Econ. Geol., Univ. Tex. Austin, Austin, TX, 131 p., 9 maps.

Claunch, M.L. 1987. Surveying experiences along the Texas Coast: Symposium on Coastal Boundaries, The Conrad Blucher Institute for Surveying and Science, Corpus Christi State University, p.2 (abs.).

Friedman, G., A.J. Amiel, M. Braun, D.S. and Miller. 1973. Generation of carbonate particles and laminates in algal mats--example from sea-marginal hypersaline pool, Gulf of Aqaba, Red Sea. Amer. Assoc. Petroleum Geologists Bull. 57:541-557.

Pulich, W. and S. Rabalais. 1986. Primary production potential of blue-green algal mats on southern Texas tidal flats. Southwestern Naturalist 31:39-47.

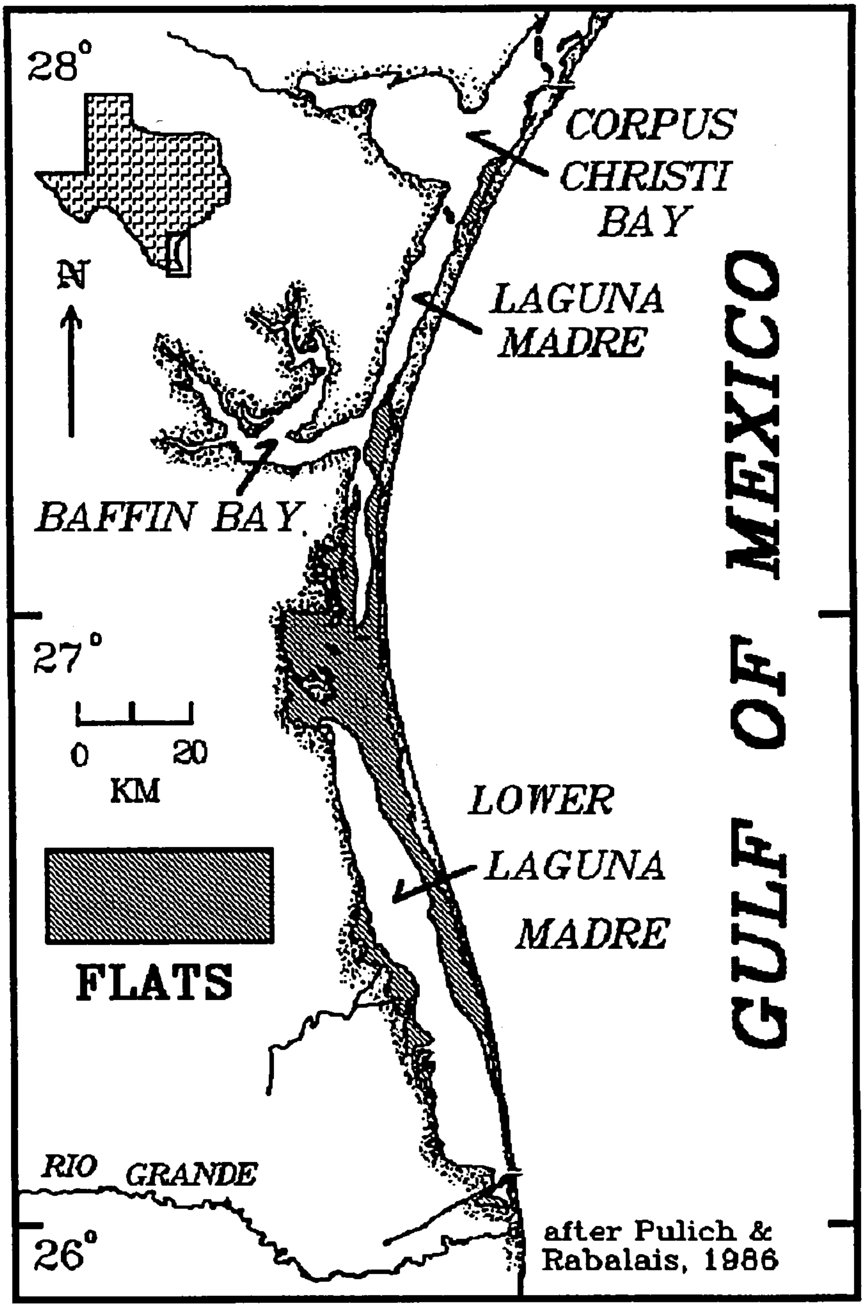

Figure 1.-- LOCATION MAP

VIII. COASTAL EDUCATION PROGRAMS

Coastal Management Approaches to Public Education

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Abstract

Public involvement is one of the fundamental components of the coastal zone management program. Effective public education and outreach efforts can be valuable tools for encouraging constructive public participation and building strong constituencies. State coastal programs have used a variety of tools to educate the public, including the development of coastal curricula for primary and secondary schools. Although states vary in their approach to developing and implementing educational programs, the success of these efforts seems to be tied to several common factors. These factors include early cooperation with teachers and other affected groups, steady funding, and feedback mechanisms. In general, these programs are a relatively inexpensive means of providing information to the public.

Introduction

Since the original passage of the Coastal Zone Management Act (CZMA) (16 U.S.C. 1451 et seq.) in 1972, public participation has been an important component of the coastal management program. Section 303(2)(H) of the CZMA declares that it is national policy to encourage and assist states in "the giving of timely and effective notification of, and opportunities for public and local government participation in coastal management decisionmaking" (emphasis added). Furthermore, section 303(4) states that it is also in the national interest to "encourage the participation and cooperation of the public...in carrying out the provisions of this title". Based on this direction, federal and state activities surrounding the development and implementation of coastal management programs have been conducted with significant opportunities for public participation.

Effective public participation can be enhanced through public education. An informed public with an understanding of coastal resources, processes, issues, and management programs can provide a valuable source of input for developing, implementing, and evaluating coastal management programs.

In addition, education and information programs are important tools for developing constituencies. In its 1978 report to the Secretary of Commerce, the Coastal Zone Management Advisory Committee (CZMAC) stated that:

"Clearly the evidence demonstrates the need for an ongoing educational effort to make the program more attractive. Coastal management agencies must continue to inform people and build citizen support through thorough studies and easily grasped explanations of their implications." (CZMAC, 1978).

Although this report is over twelve years old, the need for an ongoing educational effort has not diminished. The coastal management program continues to evolve and new coastal issues, such as plastics pollution and sea level rise, continue to emerge. In addition, the number of people living in and visiting the coastal zone continues to increase. Thus, an expanding populace and evolving issues are two factors which mandate continued emphasis on public education and information efforts.

State coastal management programs have approached public education in many different ways. Informing the public is an integral part of all state programs and has permeated many of their everyday activities. For example, many state programs have developed permitting and federal consistency guides. A significant number of states have also developed public access guides, newsletters, posters, and even videos on coastal resources. Due to the broad spectrum of these education and information programs, and their integration into everyday management activities, it is difficult to separate and analyze the complete range of state public education and information efforts. Thus, this paper focuses on one approach to public education: the development and implementation of coastal curricula for primary and secondary schools.

<u>Program Summaries</u>

Through discussions with state coastal program and Office of Ocean and Coastal Resource Management (OCRM) staffs, and review of grant files, I was able to identify the following nine coastal management programs which are playing, or recently have played, an active role in initiating and implementing coastal curriculum projects: Alabama; American Samoa; California; Commonwealth of the Northern Mariana Islands (CNMI); Delaware; Guam; Hawaii; Mississippi; and Puerto Rico. Due to the limitations of the grant files and institutional memories, this may not be an exhaustive listing; however, the listed programs provide a good range of types of curricula and experiences with development and implementation. In addition, other states may have developed similar curricula, through Sea Grant or other programs, without the involvement of the state coastal program.

The following section provides summaries of six of the projects listed above, including observations on why some programs work while others have not been as successful. The summaries are based on information obtained through conversations with state program personnel and review of grant files and performance reports.

Alabama

In FY 1985 and FY 1986, the Alabama Coastal Management Program (ACMP) provided funding for the initial development and implementation of a curriculum package for middle school students. Curriculum development was contracted out to the Marine Science Consortium, which assembled the curriculum with input from the Alabama Department of Education, the Sea Grant Advisory Service, and local school systems. The curriculum focused on coastal resource and use issues and was designed to supplement the state's standard earth sciences curriculum. Materials from existing textbooks and other educational materials approved for use within the school system formed the basis for the coastal curriculum.

Beginning in FY 1986, the ACMP also provided funding for in-service teacher training. The one week training course is conducted at the Dauphin Island Marine Lab and provides an opportunity for teachers to learn about and practice implementing the coastal curriculum. In three years, over 500 teachers have completed the training course. Currently, the state is planning to conduct an evaluation of the curriculum and training program, both to ascertain the extent of implementation and to solicit feedback from teachers.

American Samoa

The American Samoa Coastal Management Program (ASCMP) has taken a dual approach to coastal education. Under the Marine Awareness Program (MAP) initiated in 1981, the ASCMP has allocated approximately $10,000 to conduct an educational field trip to Rose Atoll for the Territory's eighth-grade students. Since its inception, over 5,600 students have been involved in the MAP, which uses the field trip as an opportunity to teach students about coastal and marine resources.

In 1989, the MAP was transferred to the Office of Marine and Water Resources, so that the ASCMP could focus its resources on the Coastal Awareness Program (CAP). Coastal management funds are allocated to the CAP for a number of activities, including the support of a Coastal Awareness Coordinator, a Marine Symposium Program, and the development of a curriculum for grades K-12. The development stage of the curriculum project, initiated in 1987, is practically complete except for the printing. There are, however, some outstanding questions about curriculum implementation. Teachers and the Department of Education have not played significant roles in developing the curricula, nor in planning for its implementation. Details such as incentives for implementation and acceptance by DOE have yet to be finalized. Thus, the prospects for future implementation of the curriculum are uncertain.

California

The California Coastal Commission (CCC) has supported a project which integrates educational opportunities with the concept of beach clean ups. In FY 1989, the CCC utilized approximately $163,000 of Section 306 funds to support its Coastal Conservation Education Program, which included, among other things, adaptation of an existing curriculum developed by the Oceanic Society that focused on the San Francisco Bay area, to the entire California coast. This curriculum is used in conjunction with the Adopt-a-Beach program, which encourages groups, such as schools and Boy and Girl Scout troops, to "adopt" sections of the coast. Through the Adopt-a-Beach School Education Project, a school or classroom adopts a section of the coast and takes care of it by holding beach clean ups, recycling, and promoting community awareness. Marine and coastal resource education in the classroom is tied closely to the students' field experiences at their adopted beach. The curriculum package is provided to teachers at no charge and includes a comment form to provide feedback to the CCC.

This program appears to be off to a good start. In three years, approximately 100 classrooms have adopted beaches, with the impending addition of 200 more classrooms. Several factors have probably contributed to this success. First, the CCCs' support for educational programs in general. For example, the FY 1989 grant was used to fund two full-time staff dedicated to information and education efforts. Second, the curriculum package was developed in conjunction with teachers and the Oceanic Society, is free to teachers, and provides a clear step-by-step approach to adopting a beach and integrating educational opportunities. Third, the Adopt-a-Beach School Education Program integrates two previously existing programs which had already been implemented successfully: the Oceanic Society curriculum and the statewide Adopt-a-Beach Program.

Delaware

Over the past six years, the Delaware Department of Natural Resources and Environmental Control (DNREC) has allocated approximately $40,000 per year under its section 306 award toward an environmental education program. The curriculum used in the Delaware program is provided through Project WILD, an international organization that supports education related to wildlife. The curriculum was developed by natural resource experts and teachers, and consists of a wildlife segment and an aquatic supplement. In addition, Project WILD continually updates the curriculum based on feedback obtained at teacher training workshops and through surveys of teachers and other users.

Coastal management funds are used to provide elementary and secondary workbooks and other educational materials to teachers who attend workshops on the Project WILD curriculum. These materials provide incentives for teachers to attend the workshop and to follow through in the classroom. Funding is also used to support a part-time position in DNREC to assist in the implementation of the Project WILD curriculum. Some of the funding is also used to supplement the seventh-grade curriculum by providing DNREC's quarterly magazine, Delaware Conservation, to each of the state's seventh-grade students.

In six years, approximately 1,500 teachers have gone through this program. This translates to approximately 40,000 students who have been exposed to this curriculum (NOAA, 1988). While sheer numbers of participants may not be a comprehensive measure of program success, they do indicate that the program has provided a large audience with education in natural resources over a significant period of time.

Guam

The Guam Coastal Management Program (GCMP) used approximately $66,000 in FY 1986 Section 306 funds to support an environmental textbook project. Textbooks and educational packets were produced for use by K-4 students, and covered the geography, geology, flora, and fauna of Guam. A senior planner for the GCMP served as the coordinator for this project, which also involved the Guam Department of Education and a group of volunteer teachers who were responsible for the actual writing of the curricula. The Department of Education took on the responsibility of implementing the curricula.

While the curricula have been implemented successfully to some degree, they have not yet achieved wide use. Use of the curricula may be inhibited by two closely-related factors: minimal incentives and lack of ongoing commitment. While the curricular materials are attractive to teachers because they are specific to Guam, and thus more relevant to their students, there is no other incentive for implementation. In addition, the GCMP has been only minimally involved in the implementation phase of this project. Responsibility for implementation lies with the Guam Department of Education, which has not made the coastal curricula a priority item.

Hawaii

In FY 1986, the Hawaii Coastal Management Program passed $34,000in Section 306 funds to the Hawaii Department of Education for curriculum development. The Department of Education, in turn, contracted with the Curriculum Research and Development Group at the University of Hawaii to develop curricula for both primary and secondary schools. The curriculum was designed to generate a more comprehensive understanding of coastal resources, including the natural resources, use conflicts, and management regimes.

Although the curriculum was completed in 1987, implementation has been a slow process. There appear to be two major impediments to widespread use of this program: funding and priorities. Currently, there is no source of funding to provide teachers with the materials necessary to present this curriculum in the classroom. Thus, there is no incentive for teachers to carry through with the curriculum. Hawaii is currently involved in a comprehensive review and revision of its coastal management program. This review, in a time of limited resources, has taken attention away from the curriculum project.

Puerto Rico

The Puerto Rico Coastal Management Program (PRCMP) has a very active public education program and was one of the first coastal programs to develop and implement a coastal resources curriculum. Beginning in FY 1982, the Puerto Rico Department of Natural Resources (DNR), lead agency for the PRCMP, has utilized Section 306 funding to develop, implement, and revise a science-based curriculum for high school students. The program was developed by a consultant in cooperation with the PRCMP and the Commonwealth Department of Education.

DNR's Office of Education has worked actively with both the Department of Education and the Association of Private Schools to promote implementation of the curriculum. The curriculum was originally implemented on a trial basis in five high schools. Since that time, significant parts of the curriculum have been adopted by the Commonwealth Department of Education as standard segments of the high school science curriculum. The PRCMP, in cooperation with the University of Puerto Rico and the University of Phoenix, also initiated a related training program for teachers. To interest teachers in this program, the training course was offered as a college credit course on coastal natural resources. The PRCMP's strong commitment to its education program, an innovative training program, and interaction with the Commonwealth Department of Education have all contributed toward the successful implementation of the curriculum.

Conclusion

The CZMA provides a mandate for public involvement in the coastal zone management program. Effective public education efforts can be valuable tools for encouraging constructive public participation and building constituencies. Coastal curricula projects are one means by which states may inform the public about coastal resources and issues.

As can be seen from the above examples, state coastal management programs have used varying strategies to develop and implement coastal curricula. Some programs, such as Puerto Rico's, are based on educational materials that have been developed de novo. Other programs, such as Alabama's, have adapted existing materials to suit their purposes. Involvement of the coastal management agency has also varied from the Hawaii Coastal Management Program's initial funding and support for the development phase, to the California Coastal Commission's strong participation throughout development and implementation.

These differing approaches have produced curricula that have achieved results ranging from wide use and acceptance to little or no utilization. Although specific strategies have differed, successful programs appear to share several common elements. These include: good communication and cooperationbetween the coastal program, teachers, and relevant state agencies; incentives for utilization; and ongoing commitment.

Not surprisingly, it is important to involve teachers and state education authorities throughout curriculum development and implementation. As can be seen from the Hawaii example, and is a potential concern in American Samoa, lack of early involvement and cooperation can lead to implementation problems. Delaware, on the other hand, provides an example of strong coordination between the coastal program and teachers. Teachers have been involved in both program development and implementation. Through an vigorous effort to solicit feedback, teachers continue to play an active role in updating the materials.

Incentives for teacher implementation are another important factor for curricula success. In the examples above, incentives range from providing free educational materials to teachers to developing college credit teacher training courses. The effectiveness of certain incentives will obviously vary from state to state. In California, for example, the provision of curricula materials has proven to be an adequate incentive to encourage usage. Guam, on the other hand, which provides a similar incentive, has yet to gain wide acceptance for its curriculum. Teacher training opportunities are an effective incentive. All of the state programs which provided teacher training in conjunction with the curriculum package have shown success in terms of curriculum utilization.

Ongoing program support is another important factor in determining curriculum success. States which have experienced success in curriculum implementation have provided some form of continuing support. For example, the Puerto Rico, Delaware, and California coastal management programs all fund education/information positions. Hawaii, on the other hand, has not been able to establish continued support for its coastal curriculum and this has significantly impaired implementation. The responsibility for program support does not have to remain with any one agency. In Alabama, for example, the ACMP supported initial curriculum development and implementation. However, the Marine Science Consortium has now taken on most of this responsibility.

As stated above, public education provides the dual benefits of enhancing public involvement and developing constituencies. With proper planning and execution, coastal curriculum projects can provide a relatively efficient means of providing public education. Implementation is enhanced through cooperation between affected parties, incentives for teachers, and consistent sponsorship.

This paper presents the views of the author, and does not necessarily represent the official views of the U.S. Department of Commerce or the National Oceanic and Atmospheric Administration.

References

Coastal Zone Management Advisory Committee, 1978. "Public Support for Coastal Zone Management Programs: The Implementation of the Coastal Zone Management Act of 1972,".

National Oceanic and Atmospheric Administration, 1988. Office of Ocean and Coastal Resource Management, "Coastal Management: Solutions to Our Nation's Coastal Problems".

Marine Extension Programs: Opportunities and Challenges

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Abstract

Marine extension programs have extended marine sciences, technology, and public policy information to a broad range of audiences during the past two decades in various forms. Marine extension education can be briefly defined as: 1) transferring information about marine resources, technology, and public policies to people who either need this information or are interested in it; 2) educating people so they can apply marine-related knowledge to their work, civic, or recreational activities; and 3) assisting people in applying research and experience-based knowledge to achieve the wise conservation, management, or utilization of marine resources.

This paper will provide definitions of major marine extension approaches and review the forms in which they are implemented through universities and other higher education institutions, public agencies at federal, state, and local levels, and environmental education programs and organizations.

Changes in public funding patterns, an increasing emphasis on basic research, and a public sense of accelerating environmental problems are influencing the rationale for various types of marine outreach efforts as well as society's ability to implement these programs. This paper will review the rationale for existing efforts, the impacts of current conditions and needs, and consider possible outreach directions for the 1990s.

Introduction

Marine outreach, advisory, and extension programs have extended marine science, technology, and public policy knowledge to a broad range of audiences for more than two decades. Since 1966, a federal government/academic community partnership has developed through the National Sea Grant College Program. Marine outreach, while an integral part of Sea Grant through its Marine Advisory Service programs, is much broader in purpose and form than just the Marine Advisory Service.

The definition of marine extension and outreach used here is:

Informal education (non-credit) programs that serve to:

1) transfer information about marine resources, technology, and public policies to people who either need the information or are interested in it;

2) educate people to enable them to apply marine-related knowledge to their work, recreation, and civic activities,

3) assist people in applying knowledge resulting in the wise management, conservation, and utilization of marine resources.

Marine extension and outreach educational programs have been developed by a wide variety of organizations including universities and colleges, federal and state natural resource agencies, environmental education programs, environmental organizations, and individuals. This paper will start by looking at early marine extension projects as well as views of Athelstan Spilhaus, John Knauss, and others whose pioneering efforts occurred during the late 1950's and 1960's. Their efforts resulted in passage of major federal marine research, development, and management legislation that initiated the formal extension and outreach education efforts of the past 25 years.

The 1970's were a growth period for extension and outreach education, with full development of a national Marine Advisory Service network and experiments with a variety of outreach forms. Some programs continued to develop over time while others withered on the vine. During the Reagan presidency, federally-funded outreach efforts struggled to survive. They offered needed educational programs in a period influenced by the Administration's hostility to federal programs directed at conservation, management, and use of marine and other natural resources and a growing environmental awareness that began to cross income and class lines.

The last decade of the 20th-Century promises to be a period influenced by continuing environmental concerns, difficult economic times, and increasing opportunities for marine extension and outreach education to play key roles in addressing marine resource and environmental issues facing people in the United States and across the globe.

The Beginnings of Marine Extension Work

The early 1960's saw scattered marine extension efforts develop across the United States. Several states (Alaska, Maine, Oregon, and possibly others) set up projects utilizing funds from the State Technical Services Administration of the U. S. Department of Commerce. (John Doyle, William Wick, and Walter Gray, Pers. com.). This program supported a broad range of technological assistance programs set up by state agencies.

Among the projects funded were a number focusing on marine and fisheries issues. Small fisheries extension projects were organized by the Maine Department of Sea and Shore Fisheries, the University of Alaska, and Oregon State University. These appear to be some of the earliest forerunners of university-based Marine Advisory Service projects supported by the

National Sea Grant Program Act, passed in 1966.

The University of Alaska Fisheries Extension Program started in 1963 with John Doyle organizing educational activities for the commercial fishing industry. Oregon State University initiated marine extension work in 1961, when Bill Wick, a Cooperative Extension Natural Resources Agent, began working in coastal Oregon organizing extension programs covering oystering, seafood processing, and estuarine issues (Wick, 1968). An early Oregon Extension television program addressed offshore fisheries issues. Oregon State University then hired Bob Jacobson as a full-time marine extension agent with State Technical Services funds from 1967-70.

Other early marine extension work included seafood marketing developed by Florida Cooperative Extension home economists, fisheries marketing and gear development efforts by the Bureau of Commercial Fisheries of the U. S. Department of the Interior, and fisheries education offered through two-year fisheries programs at the University of Rhode Island (URI) and Cape Fear Technical Institute in North Carolina. The URI fisheries program was funded by the U. S. Department of Health, Education, and Welfare at least three to five years before the start-up of Sea Grant's Advisory Service projects (Gray, pers. com.).

The New England Marine Resources Information Program (NEMRIP) received State Technical Services funds starting in 1967 and served to disseminate marine information to potential users (Gray, 1968). NEMRIP was initiated by URI as a multi-state effort. Its role was broadened in 1970 to include technical assistance and demonstration projects as a result of new support from Sea Grant. These examples of early marine extension work are meant to illustrate some of the early threads that contributed to broader and more comprehensive marine extension work in the 1970's, largely (but not entirely) through the development of the National Sea Grant Program network.

University-based outreach educators were preceded by industry field advisors with responsibilities covering troubleshooting and training for firms that purchased technical products. Advisors utilized workshops, classes, field visits, and advising in assisting clients in adapting new technology (Robert Shephard, pers. com.).

These early individual efforts can be viewed as reflections of marine public policy developments initiated in the late 1950's, that gathered steam in the mid-1960's, and reached fruition as major marine resources development and management legislation during the late 1960's and early 1970's. The combination of early marine extension and outreach projects and the 1960's/70's federal legislation created the foundation for today's extension/outreach programs.

<u>Development of Federal Marine Extension Policies</u>

Marine extension projects initiated during the early to mid-1960's developed during a period of increasing national interest in a stronger federal commitment to oceanographic and marine technological research and development. Athelstan Spilhaus described these developments and his role in conceiving the "Sea Grant College" concept in "Land is Just an Island" (Spilhaus, 1972).

The National Academy of Sciences Committee on Oceanography (NASCO) under the leadership of Harrison Brown, and later Spilhaus, recommended increasing the U. S. commitment to "concentrate on the applications of the good marine science to the proper exploitation of the sea for people" (Spilhaus, 1972). Spilhaus represented NASCO on the Interagency Committee on Oceanography and gave the keynote speech at the 1963 American Fisheries Society annual meeting, where he raised the question of creating Sea Grant colleges to do for the oceans and fisheries what the Land Grant colleges had achieved for agriculture (Spilhaus, 1972). He raised the idea of "county agents in hip boots," sowing a seed that eventually germinated with the creation of Marine Advisory Service programs in 28 coastal and Great Lakes states.

John Knauss, current administrator for the National Oceanic and Atmospheric Administration (NOAA), has played a key role in developing U.S. marine science programs, including marine outreach efforts, since the 1960's. His current national role with NOAA builds on his developmental role as Dean and Vice President of Marine Affairs at the University of Rhode Island, as well as service on the Commission on Marine Science, Engineering and Resources (Stratton Commission) which prepared the landmark report, "Our Nation and the Sea" (Commission on Marine Science, Engineering and Resources, 1969). Knauss has expressed the view that the public service activities of a marine-oriented university are broader than those conducted by the University's Sea Grant College (Knauss, 1972).

The late 1960's and early 1970's saw passage of marine legislation like the National Sea Grant College and Program Act of 1966, which provided federal support for establishing Sea Grant colleges and projects addressing research, education, and advisory services which contribute to the development of marine resources (Hanson et al., 1985). The Coastal Zone Management Act of 1972 recognized the related need to promote comprehensive management of coastal resources with federal, state, and local cooperation. "Our Nation and the Sea" (Commission on Marine Science, Engineering and Resources, 1969) recommended a wide range of marine extension and technology transfer activities with specific reference to Sea Grant Extension Services.

There are several conclusions which can be drawn regarding the broad development of marine extension/outreach education in the United States during the past thirty years. These are based upon a literature search, discussions with people involved with both early university-based marine extension efforts, and the 24-year history of Sea Grant Marine Advisory Services (MAS), and my own 16 years experience with MAS programs.

First, the National Sea Grant College Program has played the major institutional role in creating a national system of marine extension/outreach programs in 28 coastal and Great Lakes states and territories. Development of the Sea Grant MAS system took scattered independent outreach efforts and helped to mold them into a unified, cooperative network.

Second, marine extension/outreach is much broader than just the Sea Grant system, with educational projects being implemented by a wide range of organizations. This ties in to Knauss' concept of a college of marine studies being much broader than its Sea Grant Program component.

Third, marine extension/outreach education continues to develop institutional forms and methodologies that are applied to marine resource issues.

Extension/Outreach Forms

A variety of approaches have been utilized in developing marine extension/outreach educational programs. Several agency and organizational approaches will be reviewed with emphasis upon existing approaches. Several innovative forms will be discussed that existed for only a short time period yet provide food for thought.

-- Sea Grant Marine Advisory Service, NOAA
-- Cooperative Extension Service, USDA
-- U. S. Fish and Wildlife Service, Extension Programs
-- U. S. Environmental Protection Agency, National Estuary Program, public participation and education
-- Marine Sanctuary Program, NOAA
-- state natural resource agencies, extension programs
-- environmental educational programs
-- NOAA Programs - Ocean Service Center, NOAA Extension Program
-- Regional Aquaculture Centers, USDA

Sea Grant Marine Advisory Service

Sea Grant Marine Advisory Service (MAS) programs operate in 28 states and Puerto Rico carrying out marine outreach and informal educational activities with the objective of extending research-based knowledge to marine resource users and managers. There are approximately 300 MAS specialists and agents working from field and campus locations. MAS staff have several characteristics (Cato, et al., 1983):

-- "They are almost all associated with a university and have a strong and important relationship with researchers and teachers...

-- They are people-oriented and have special communications skills (and training in adult education techniques).

-- They have formal education in one or more marine-related subjects.

-- They believe strongly in the concept of human development and continuing education".

These MAS agents and specialists are the outreach and informal education arm of the National Sea Grant College Program, working with several thousand researchers, graduate students, marine educators, communicators, and administrators increasing society's understanding of marine-related knowledge and our ability to apply this knowledge in solving marine and coastal issues and problems.

Sea Grant MAS is the only national network of marine extension and outreach programs with a core of full-time staff dedicated to creating bridges between the nation's scientific community, marine industry, public officials, educators, and the general public.

Cooperative Extension Service, U.S. Dept. of Agriculture

Cooperative Extension Service marine programs are conducted through a combination of funding support from Sea Grant and other sources. About two-thirds of Sea Grant MAS programs (20) have a working relationship with their state Cooperative Extension Service. There is also extension work being conducted by non- marine staff that is being applied to marine issues through 4-H, home economics, community resource development, and leadership development extension programs.

Marine extension work is supported by some state and county governments. For example, Suffolk County, New York, totally supports a county marine extension program which is a spin-off of the New York Sea Grant Extension Program. County support for marine extension agent positions also occurs in several states e.g., Massachusetts, New Jersey, Florida, Oregon, and Texas.

U. S. Fish and Wildlife Service

The U. S. Fish and Wildlife Service administers a different form of extension/outreach than Sea Grant MAS and Cooperative Extension. It has an extension and publications office (titled "Region 8") which funds selected extension proposals which "develop, produce and distribute useful and informative materials about the fish and wildlife resource to specific or general audiences served by the Cooperative Extension System and Sea Grant Marine Advisory Program" (MacDonald, 1988). Funding is provided for competitive extension proposals submitted by Sea Grant MAS and Cooperative Extension staff. The U.S. Fish and Wildlife Service also requires that its research and development centers "produce at least one extension product every other year" (MacDonald, 1988, memo and 1988 status report). Extension projects have covered a wide variety of topics including:

- wetlands and values in the Northeast
- Columbia-Snake Rivers Fisheries Extension Education Program
- raising fish in cages
- 4-H leader development
- Great Lakes states fish materials
- sea turtle extension program
- coastal barrier islands
- lake trout: leave and let live
- net-pen aquaculture of striped bass
- Columbia River white sturgeon

<u>National Estuary Program, U. S. Environmental Protection Agency</u>

Public participation and education programs are an integral part of the National Estuary Program (NEP), established by the Water Quality Act of 1987 (EPA, 1990). NEP's major objective is to identify nationally important estuaries that are then targeted for improvements in their water quality. This is to be achieved through research and management activities culminating in development of Comprehensive Conservation and Management Plans (CCMP) for each estuary included in the NEP.

There are 12 estuary projects currently (1990) funded by NEP:

- Buzzards Bay - Massachusetts
- Narragansett Bay - Rhode Island
- Long Island Sound - Connecticut and New York State
- New York-New Jersey Harbor - New York State and New Jersey
- Delaware Bay - New Jersey, Pennsylvania and Delaware
- Delaware Inland Bays - Delaware
- Albermarle/Pamlico Bays - Delaware
- Sarasota Bay - Florida
- Galveston Bay - Texas

Santa Monica Bay - California
San Francisco Bay - California
Puget Sound - Washington State

Public participation and education efforts involve a variety of activities handled by public participation coordinators for each estuary program. Some programs have full-time coordinators (eg. Long Island Sound Study) while others utilize existing staff with contracting organizations. Activities include coordination of citizens advisory committees, organizing conferences and workshops, developing fact sheets and other publications, giving presentations at citizens organization meetings, and preparing public service announcements for radio and television.

Issues addressed by NEP educational programs include: impacts of economic development up environmental quality; nutrient loading and low oxygen levels (hypoxia); contaminants; floatables; non-point-source pollution; protecting living marine resources; and protecting human health.

State Natural Resources Agencies

Marine extension/outreach efforts are conducted by some state natural resource agencies. Several states along the Atlantic coast (Maine, Massachusetts, and Maryland) have extension agents who perform a variety of functions relating to coastal and marine resources issues. Responsibilities vary from solely educational activities to also serving an external public relations function for the agency's resource management and regulatory responsibilities. Fisheries extension agents in Maine and Massachusetts have worked on fisheries gear technology development and adoption by the fishing industry. Connecticut's Department of Environmental Protection carries out educational roles through the Natural Resources Center and the Information and Education Unit as well as publications developed by specific management divisions such as Coastal Resource Management.

Environmental Education Programs

Marine extension/outreach programs are being developed by a variety of environmental education programs and by environmental organizations carrying out specific outreach efforts. This includes programs where education is an important and well-directed organizational function to programs that are spontaneous and, at times, more scattered in approach.

Environmental education programs in Connecticut conducting some educational activities that can be placed within extension/outreach include Schooner, Inc. (New Haven), Thames Science Center (New London), Project Oceanology (Groton), and the Long Island Sound Task Force (Stamford).

The U. S. EPA published a Directory of Environmental Groups in New England that lists 50 environmental organizations, with many conducting informal educational projects. Also published by EPA is the National Directory of Citizen Volunteer Environmental Monitoring Programs (Lee and Ely, 1990) which lists and describes environmental monitoring projects. Many monitoring efforts involve educational instruction for the volunteers and, in some cases, volunteers presenting informal educational programs to surrounding communities.

Other Outreach Approaches

There are other marine outreach efforts associated with aquariums, museums (like the Mystic Seaport Museum), and state and national parks. Public agencies currently support a variety of outreach activities affiliated with national marine sanctuaries, the National Coastal Resources Research and Development Institute at Oregon State University, and five regional aquaculture centers supported by the U. S. Department of Agriculture. Previous outreach forms have included regional coastal information centers (1970's) and the NOAA Ocean Service Center in Seattle (1980's).

These examples illustrate the variety of forms and are not meant to cover all existing or historical approaches.

Opportunities, Challenges, and Future Directions During the 1990's

Marine extension programs have evolved from a small number of scattered projects in the early- to mid-1960's that focused primarily on fisheries issues. Today, a broad spectrum of marine extension/outreach programs and projects are developing educational activities in universities and colleges, natural resource agencies, environmental educational programs, environmental organizations, and adult education programs.

The efforts of a handful of pioneers about 30 years ago contributed to increased general public and marine industry awareness of marine resources issues and greater involvement with efforts to utilize marine science, technology, and public policy knowledge in conserving, utilizing, and managing marine resources and improving marine environmental quality. Current programs cover diverse issues relating to environmental protection, resolving marine resource multiple use conflicts, enhancing industry's utilization of marine resources while addressing environmental degradation issues, youth and adult marine education, addressing coastal development and public access, and working to restore coastal habitats.

The decade of the 1990's promises to be quite different from previous periods. The United States faces continuing demographic shifts toward an aging population, an increasingly diverse ethnic mix, and a continuing population shift toward the country's coastal regions. People will deal with the impacts of the 1980's budget deficits, the change from a creditor to the world's largest debtor country, and major shifts in income distribution with broader gaps between the wealthy and the poor (Phillips, 1990).

The foundation for effective marine extension and outreach education has been developed over the past three decades. The 1990's will be a period of tight economic conditions combined with increasing needs to effectively protect and utilize the country's marine and coastal resources. There are factors which will influence the ability of marine extension to contribute to the general well-being of the country's marine and coastal regions. University programs (Sea Grant Marine Advisory Service and Cooperative Extension Service) provide research-based education. It will be important to maintain marine extension programs with strong research ties. This extension-research model sets these two programs apart from most other outreach education approaches.

The Sea Grant Marine Advisory Service continues to play a central role in marine extension education with programs in 28 coastal and Great Lakes states and Puerto Rico as integral parts of Sea Grant college programs. These programs will have to contend with a number of issues during the 1990's. Many of these issues also relate to other marine extension/outreach organizations.

It will be important to:

1) maintain and strengthen the extension/outreach aspects of the Sea Grant College Program.

2) develop new ties with research-based knowledge sources (Sea Grant, land grant institutions, other university faculty and researchers, federal and state agencies, etc.).

3) strengthen ties with other informal education/outreach organizations (Cooperative Extension, vocational agriculture, adult education programs, museums and aquaria, etc.).

4) build programmatic flexibility into marine extension efforts. Educational projects should address key issues and reflect changing issues and priorities over time.

5) retain top professional staff who will vary with the different types of outreach programs, yet incorporate the following characteristics:

a) strong marine subject-matter competencies with an appreciation for or involvement in research methodology.

b) knowledge of adult and extension education philosophies and methods.

c) interest in developing educational programs in concert with a wide variety of people including marine resource users and industries, researchers, resource agency staff, educators, and the general public.

d) willingness to work on new issues over time and utilize a variety of educational approaches.

6) utilize a wide variety of funding to create a flexible, viable foundation for marine extension/outreach education. Core funding from Sea Grant or other funding sources should be complimented by funds from states and other agencies, foundations, and industry.

7) consider external factors like coastal demographics, electronic communications technology, increasing client sophistication, increasing complexity of resource issues, funding trends, research directions, and the evolution of education. (National Marine Advisory Service Committee, 1990 meeting.)

<u>Summary</u>

Marine extension programs have developed from small, independent projects in the 1960's to a broad system of information educational efforts throughout coastal and Great Lakes states and territories. These efforts vary from outreach arms of public agencies, university-based programs developed by Sea Grant colleges and Cooperative Extension Systems, to activities run by environmental education programs, environmental organizations, and adult education programs.

There are continuing needs for marine extension/outreach education with different roles to be carried out by these providers. The decade of the 1990's holds much opportunity for these efforts as well as major challenges in obtaining adequate funding. The need for these types of educational efforts will continue to exist as and will evolve over time. The challenge to effectively meet society's needs through such programs will be a source of opportunity for people interested in meeting these needs.

References

Cato, James, Norman Bender, Norman Doelling, William DePaul, James Murray, Michael Orbach, Robert Shephard, Fred Smith, William Younger, Stephen Wittman, Bland Crowder, Laura Colunga, Kathy Hart, Kathy Witt, Lillian Jarman, Tom Gentle, Christine Duerr, Tom Leahy, Patricia Peyton, Bruce Kantrowtiz, and Rich Lydecker. The National Sea Grant Advisory Service Serving the Nation's Marine Community. Madison: University of Wisconsin. March 1983.

Commission on Marine Science, Engineering and Resources. Our Nation and the Sea. Washington, DC. January 1969.

Gray, Walter. "Public Service in the Sea Grant College Program," Proceedings of the Second Sea Grant Conference. October 1968.

Hanson, Lynne, Bob Aaron, and John Kermond (Editors), Sea Grant: Past, Present and Future, Kingston, RI: Sea Grant Association and University of Rhode Island. October 1985.

Knauss, John. "Opportunities and Problems for the Sea Grant College," Proceedings of the Second Sea Grant Conference. October 1968.

Lee, Virginia, and Eleanor Ely. National Directory of Citizen Volunteer Environmental Monitoring Programs. U. S. Environmental Protection Agency and University of Rhode Island Sea Grant College Program. Third Edition. April 1990.

MacDonald, Duncan. Extension Proposal Guidance. Memo. Washington, DC: U. S. Department of the Interior, Fish and Wildlife Service. June 1988.

MacDonald, Duncan. Status Report on Ongoing and Recently Completed Extension Projects. Washington, DC: U. S. Department of the Interior, Fish and Wildlife Service. April 1988.

Phillips, Kevin. The Politics of Rich and Poor. New York: Random House. 1990.

Spilhaus, Athelstan. "Land is Just an Island," EOS, American Geophysical Union, Vol. 53, No. 5. May 1972.

Wick, William. "Public Service in the Sea Grant College Program - with Emphasis on the Marine Advisory Program, Oregon State University," Proceedings of the Second Sea Grant Conference, Kingston, RI: University of Rhode Island, October 1968.

U. S. Environmental Protection Agency. Progress in the National Estuary Program. Washington, DC. February 1990.

U. S. Environmental Protection Agency. Directory of Environmental Groups in New England. Boston, MA. 1988.

Marine Science Education in American Samoa: A Palagi in Paradise

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Introduction

The National Marine Sanctuary Program in American Samoa operates cross-culturally. Educational programs have been developed to take advantage of the cultural milieu of the typical Samoan. By utilizing cultural elements in education, concepts new to the people can be transmitted in an acceptable, non-patronizing manner. By focusing on the culture itself and its reliance on the natural world for cultural continuation, the marine science educator can portray the ecological relationships that shape a Samoan's perceptual world.

The Background

American Samoa comprises seven, small tropical islands in the South Pacific. A remote and relatively isolated territory of the United States, it has the distinction of harboring both a National Park and a National Marine Sanctuary on the main island of Tutuila. Tutuila is a tropical high island shrouded in rainforest and surrounded by a fringing reef.

Fagatele Bay National Marine Sanctuary (FBNMS) preserves and protects a 163-acre embayment with a spur-and-groove type coral reef system. The National Marine Sanctuary Program operates under the National Oceanic and Atmospheric Administration. The program has a four-fold mandate: to protect marine areas of a special or threatened nature; to encourage marine research within the sanctuaries; to provide recreational opportunities that do not conflict with the management of the site; and to promote marine science education. Above all, the protection of the site is the primary imperative.

The Challenge

The educator in Samoa has two major challenges to confront: distance and culture. American Samoa is about 2,500 miles from Hawaii, and roughly 5,500 miles from the mainland United States. Distance poses innumerable problems, most especially in communication and resource access. At the same time, these problems force reliance on local resources and resourcefulness. The resultant extended time scale can be a continual frustration to the schedule-bound "palagi" (a Western culture, non-Samoan).

The true challenge to the science educator, however, is the culture. Samoans have retained much of their ancient ways, moreso than most other Polynesian groups. They did not experience Western colonialism to the extent endured by the inhabitants of the other South Pacific islands. They have heartily embraced Western materialism, weaving the trappings of America into their own culture. However, the language and customs continue to thrive and evolve in a Samoan context. Having survived Western colonialism, more by stubborn tenacity and cultural elitism than by lack of Western persistence, Samoans, particularly the older generation, are vigilant watchdogs of their ways, the faUaSamoa.

To the palagi, the eternal outsider, breaching the cultural barriers in an effort to teach Western scientific ideas provides a continual challenge. Concepts must demonstrate merit and be taught within a cultural context that makes sense to a Samoan. The educator must realize that the Samoan context may in no way resemble his/her own.

For example, legislated resource protection is a concept abhorrent to a culture so firmly tied to the land and sea. To tell a fisherman that he is not permitted to take as many lobster as his matai (chief) demands for a family obligation is absurd to him. Social and economic pressure insures his loyalty to his matai. The reef and its resources have always belonged to his family and no government can change that. It seems as if the cultural loggerhead of traditional practices vs government land/sea use regulations is unresolvable. Yet Samoans have always practiced some resource protection. When a valued resource became limited or endangered, the matai imposed a sa, or taboo, which forbade the use of that resource until it recovered. To break sa even today can bring heavy fines and, in the old days, death. Having the matai impose a sa on overutilized resources may be far more effective than government legislation, particularly in villages that still retain a strong cultural tradition.

Samoans value their land and its seaward extensions. Their chiefly titles are tied to land claims (which traditionally extend out beyond the reef) and these two institutions, titles and land, are of prime importance to any Samoan. For example, in Samoan tradition, the most serious crimes are crimes insulting someones title and, even today, the most volatile arguments begin over land disputes. By focusing on this love of the land and sea, the marine educator can draw on traditional experience and lore in an effort to make marine science more relevant to the average Samoan. By demonstrating that the land and sea are at risk because of poor land use practices, destructive fishing methods, etc., the educator will alert the people to the personal impact that the resultant losses would produce.

Finally, as with any culture, it is the youth that provide the source of the swiftest changes in Samoa. Samoan youth have adopted aspects of the American youth culture with enthusiasm, to the frequent dismay of their elders. Since the U.S. educational system has operated here for over 25 years, a generation has grown up with at least a minimal exposure to Western scientific thought. Many young Samoans are comfortable with both the faUaSamoa and the faUapalagi, the Samoan and western ways of life.

Approaches and Directions

FBNMS is a young program and a long-range plan for marine education in the South Pacific from the standpoint of the Sanctuary Program has yet to be developed. Presently, education development has been handled by the local Program Coordinator, which means that education has been relegated to spare time. However, in the past few years, several projects have presented the marine education issue to the Samoan public, some by a conventional approach and some experimenting within a Samoan context.

News Column

There are two newspapers in American Samoa, the daily Samoa News and the weekly Samoa Journal and Advertiser. Both papers are widely read and both feature articles in Samoan and English, although the majority of the articles in both papers are in English. Most adults in Samoa speak and read English. Currently in the Samoa News, FBNMS runs a bi-monthly feature column titled, "Marine Sanctuary," which presents general interest topics in marine science, topics of interest to the program such as dynamite fishing and site regulations, and information about other Sanctuary sites. The articles are written for the general public and, since the newspapers are frequently pored over from cover to cover (by thousands of government workers during extended coffee breaks!), there is a high probability that the articles are actually being read.

Newsletter

In cooperation with the American Samoa Coastal Management Program, the Sanctuary produces a joint newsletter, O Lau Samoa. The newsletter features articles about each program and is fully bilingual. The newsletter is aimed at government, business, and community leaders in an attempt to educate these decision-makers in marine and coastal environmental issues as well as local program development.

Marine Science Summer Camp

This year, under a cooperative agreement, the Department of Education and FBNMS offered the first marine science summer camp. Over 50 ninth grade students participated in the camp's two sessions. Each session lasted two weeks and featured lectures, laboratory techniques, field trips, and guest presentations. In addition, each student was taught the basics of swimming and snorkeling, a skill that added another dimension to the camp (ironically for an island people, most Samoans are unable to swim and there are several drownings every year). Each student was responsible for developing, carrying out, and reporting on a research project, something none of them had ever done before. Three teachers from DOE were employed and they developed the curriculum and taught the course.

There were some major frustrations in the development of the camp. Although supplies were ordered well ahead of time, even by local standards, laboratory materials did not arrive in time. The teachers improvised. Shopping forays to various stores provided glass, PVC, silicone sealer and screening(for aquarium building), stockings, super glue and wire (for plankton nets); the syllabus was revised accordingly. Students built or supplied their own equipment when nothing else was available. Fortunately, the masks and snorkels were purchased on-island and each day the students would hit the beaches to glean for plankton, invertebrates, and coral for their experiments.

Students unanimously expressed their enjoyment of the camp; several even attempted to attend the second session after finishing the first, though both were identical. Most of the students had never had any summer school activities offered to them before (last summer only 8 public school summer courses were offered and only two were non-remedial; Samoa is woefully lacking in youth programs). The summer camp program filled a definite need. Next year, the course will be offered again and may be expanded, with more classes.

Traditional Fishing Workshop

Samoans have always been firmly tied to the sea. They arrived in the islands over the ocean and have maintained their maritime culture. Samoa has a rich and extremely varied body of fishing lore. Fishing practices have evolved over several millennia and there appears to be a specific method for almost every animal or plant harvested from the sea (Buck [1935] documented well over 75 separate techniques). Much of that lore has been forgotten. Few youngsters have the time to learn and develop the techniques and there are easier ways to get one's fish for Sunday toonai (feast). Most people get their fish at the market, supplied by a few local commercial fishermen.

In an effort to encourage the practice of traditional fishing methods (the only type of fishing permitted within the most restricted zone of Fagatele Bay), FBNMS is cosponsoring a Traditional Fishing Workshop. The workshop was originally scheduled for March, 1990, during the Folk Arts Festival, but our first hurricane in 25 years occurred in February. The festival has been rescheduled for two days in mid-November.

A pamphlet has been prepared that will describe some of the more common traditional fishing methods. Printed in Samoan and English, the text will compliment the workshop. When planning for the workshop, we interviewed several fishermen and were staggered by the variety of methods employed and by the understanding of the ocean habitat possessed by the fishermen. Fish behaviors that researchers spend years documenting are common knowledge to the fisherman - not a surprising fact, but one often undervalued by the scientific community. Of course, myth and superstition color the accounts of their favorite prey, but in general, the fisherman's lore often compliments scientific conclusions and can offer accurate insights.

The goal of the fishing workshop from the Sanctuary's standpoint is three-fold: to encourage the use and perpetuation of traditional Samoan fishing methods; to discourage the use of the traditional, but now illegal fishing methods of dynamiting and fish poisoning; and to advertise the Sanctuary program and regulations to the local people. We also hope that the workshop ignites some younger people to try their hand at the traditional methods of fishing and gleaning.

Faleaitu

The faleaitu is the Samoan version of the morality play. Savagely funny, always raucous and bawdy, the play, usually performed by young villagers, is an accepted medium for social criticism. Issues and people who are normally above criticism in Samoan society are leveled by the players. The faleaitu always has a righteously Christian ending and the outrageous acts of the most humorous characters must be paid for in the end, but not before cultural jabs have been driven home to the audience. Faleaitu are not performed much anymore: video and TV have devalued the medium and family obligations prevent the long rehearsals. Occasionally, high schools will hold faleaitu contests and it is there that the Sanctuary is sponsoring an environmental faleaitu contest to be held in conjunction with the annual science fair. The plays must feature an environmental theme with a marine emphasis. They will be filmed and aired on the local television station. Here again, the modern scientific topic will be expressed through a traditional, culturally valued, medium.

Other Projects

Some other culturally appropriate projects that are proposed include singing and dancing contests, a fishing implements show at the museum, and a fishing implements workshop for youngsters during the summer, probably in conjunction with the show. Singing and dancing contests may seem a weird way of delivering marine education, but these contests have some similarity to the faleaitu. The songs and dances follow a pattern; there are three or four styles of dance done in proper sequence and the melodies are Samoan standards. The words to the song are written to suit the occasion and, for the contest, they would be required to carry an environmental message. As in faleaitu, the entertainers can comment or insult with impunity and a well-aimed insult earns screams of laughter. Parody and humor can be wonderful educational tools and singing/dancing contests are Samoan favorites, a type of entertainment that has no analogy in Western culture.

Village Outreach

Samoa is still very much a village-centered culture with a strictly-defined hierarchy dominated by the family matais (chiefs). Aside from one's family and village, the other major social matrix that an individual inhabits is the church (work and school are a distant fourth to family, village, and church). Within the village and church structures exists an effective forum for educational outreach. Unfortunately, it is a forum that FBNMS has not been able to utilize as there are no native speakers on staff yet. Although an English presentation, such as a slide show, to a village fono or a church youth group would not be worthless, the same presentation in Samoan, using the Samoan contextual references and allowing for an extended discussion afterwards, also in Samoan, would be far more valuable.

Speech is the most valued medium in the Samoan culture. Samoan talking is a rich and many-layered art that few palagis can appreciate. Analogy and metaphor extend back thousands of years through many generations, often refer to privileged knowledge and are enhanced by more recent biblical references. Samoans have talking competitions that demand a rigid form, yet reward the complex intellectual and artistic style of the orator. Each high chief (ali'i) has his high talking chief (tulafano). This is the social and mental milieu of a Samoan adult. An effective educator should be comfortable in this milieu. Although there have been a few exceptions, it is not usually a way open to anyone brought up outside the Samoan culture.

To take advantage of this cultural phenomenon, the Sanctuary must have a Samoan speaker on staff. We are hoping in the next year to hire an education coordinator who will begin making presentations in Samoan.

Other Marine Education Programs in American Samoa

Elementary and secondary education. The Department of Education offers a variety of marine oriented programs:

All of the high schools offer a one- or two-semester course in marine science and 25-30% of the students choose that elective.

The Territorial Science Fair has a marine science category in addition to the 13 internationally recognized categories.

There is an annual Marine Symposium where local high school students present papers on their marine science projects. Winners participate in the Hawaii Marine Symposium.

Coastweeks is run by DOE and covers a three-week period with significant school and public participation. (Both the Symposium and Coastweeks are coastal awareness programs funded by the American Samoa Coastal Management Program.)

Sea Grant's Summer Ocean Studies in Hawaii usually includes 1 or two local students (although last year the applications arrived too late for anyone to participate).

Local elementary teachers are being trained in the Marine Science For Sea program developed in Washington State.

In general, the elementary and secondary schools offer a solid marine education base. That base comes strictly from a Western point-of-view and does little to incorporate the local cultural lore, however. In the past, there were locally produced curricula that taught from an island perspective, but the educational mandate has shifted to an English-speaking, American curriculum. The basic problems of resource access remain. Although resources are more available, most teachers, particularly those in the public school system, do not take advantage of them, nor are they inclined to improvise (Davis, 1990). So, many of the disadvantages persist even though there may be good materials available. (Even with improved supplies, resource availability cannot be compared to that in the U.S. where, on the average, four times as much money is spent on each child's education.)

Department of Marine and Wildlife Resources. Several programs focusing on marine education are offered by the Department of Marine and Wildlife Resources:

Boat trips are scheduled throughout the school year for all eighth grade students in the territory. During the trip, the students visit nearby FADs (fish aggregating devices) and do a little fishing.

Schools can request reef walks which are led by DMWR personnel.

The Rose Atoll Workshop - teachers can go on an annual boat trip to Rose Atoll, a U.S. Fish & Wildlife reserve, and participate in research projects.

DMWR also does education related to their hunting and fishing regulations.

Conclusion

We are still firmly at the idea/experimental stage for marine education at Fagatele Bay National Marine Sanctuary. However, the direction we are taking emphasizes teaching within a cultural context. Samoans are no less sensitive to social and environmental issues than anyone else, though one must not make the error of assuming their priorities.

What is important to a Samoan may be meaningless to a palagi and visa versa. To have the optimum impact on an audience, new ideas may travel more effectively through accepted cultural channels. Sensitivity to ethnic values will enhance transmission of those ideas. It will also allow for a clear and unambiguous assimilation of marine science and resource protection concepts into Samoan society.

References

Buck, Sir Peter H.1935. Samoan Material Culture. Bernice P. Bishop Museum Bulletin 75.

Davis, R. (1990) personal communication. Division of Curriculum and Instruction, Department of Education.

Evaluating Marine and Coastal Education Programs

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Introduction

This paper outlines a program evaluation process and makes some observations about it and about evaluation in general. It also provides information on how evaluation can assist, set, and maintain program direction. Program evaluation has been likened to an "acquired taste, and not an easily acquired taste" (Patton, 1990). Educational administrators may fail to evaluate because of costs or the fear of judgement or accountability. Coastal resource educators may fail to evaluate from the lack of incentive, knowledge, or both. Failure to evaluate, however, may reduce the credibility of program services and keep them unresponsive to needs. My intention is to point out several ways evaluation can be used to assist coastal and marine resource educators to "assess the past and confront the future" while providing educational programs that are credible and responsive to needs.

A Recommended Approach

Programs can be considered sets of resources and activities directed toward one or more common goals. Evaluation is a more or less systematic assessment of at least some aspect of a program. These definitions are as straight-forward as I can make them because my first recommendation is to keep things as simple as possible. Don't get hung-up on the definitions of the terms "program" or "evaluation." The real world is that we must and can produce results in areas where there are no uniform or consistently applied definitions to use in our work. How many of you have been involved with a group or committee trying to define planning? I have and it is not a pretty sight. The worst case is when program administrators watching staff going in definitional circles get turned-off or scared-off. This is not what you want when you are trying to institute evaluation in your agency, department, or program.

The bare bones delineation of an evaluation process I will be referring to follows Austin (1984):

1. Identify and involve stakeholders
2. Focus the evaluation
3. Design the procedures
4. Gather and analyze the data
5. Interpret and report the findings

Here is a general point about evaluation and the importance of step one. First and foremost is the notion of use. Evaluations, like plans, are not meant to be completed with a lengthy shelf-life expectancy. Evaluators must remember their efforts are not ends but means to improved decision-making or decision-aiding. Therefore, it is very important in evaluation pre- planning to establish a process for meaningful inclusion of those affected by the evaluation in the conduct of it. Those individuals are considered "stakeholders" in the jargon of the profession. Thus, step number one is very critical.

Focusing

Focusing means answering the questions of use. What use will be made of the evaluation effort? Who will use it? Are administrators interested in assessing program effectiveness and efficiency, or program impact? Are unintended outcomes important? Evaluations can answer various questions; it is always useful to know what they are up-front, without surprises at the end. In coastal education programs, we are probably most interested in answering questions such as "is this program effective?" Have we "reached" program participants with our message? Has learning taken place as anticipated? Evaluations can be focused by the use of steering committees that should contain major stakeholders.

Design

When it comes to evaluation design, the universe of procedures can be intimidating. Evaluation encompasses a broad range of activities and methodologies. Because evaluation has been considered applied social science research, the dominant approach is based on the experimental paradigm. Dependent and independent variables are established. Measurement after intervention is done quantitatively under controlled conditions, often to infer a cause and effect relationship. If your evaluation experience is similar to mine, you have found the higher echelons of federal government to be very unlike laboratories. Controlled conditions are generally absent, and decisions to begin, modify, terminate, or continue programs or activities are generally made in a non-experimental context.

The evaluation literature is replete with procedural examples based on qualitative assessment techniques. This is comforting and of importance to educators and others interested in evaluating coastal education programming. As educators we are aware that standardized tests will not measure all important benefits of educational programs or activities. Learning takes place outside the laboratory, too. There are other reasons for us to look away from the "scientific model" of evaluation for the results we seek. Educational initiatives in the coastal zone are usually associated with governmental and private programs, which are frequently characterized by uncertainty that mitigates against the use of standard evaluation techniques. This uncertainty is manifested in incomplete or unclear program structure, e.g.

goals and objectives that defy evaluation. Also, programs change during their implementation. Then there is the delay between so-called "cause" and "effect." We want some coastal education programs to change behavior. Don't litter on the beach. Don't walk or ride on the primary dune. Respect areas closed to protect shorebirds like the piping plover. We are educators, facilitating learning and sometimes hoping for behavioral change. This connection is not immediate in most cases and delays confound analysis. So, evaluators should not get hung-up on the intricacies of evaluation design because the real world works against it. Top-level administrators will probably not be hung-up on design, either. They tend to admire simple common sense approaches. In essence, probable and approximate answers are important to the development and implementation of coastal education programs.

Data Collection, Analysis, and Presentation

Data collection, analysis, interpretation, and presentation of findings are the final collective steps in the evaluation model I have been following. I decided for discussion purposes to lump and not split these facets of evaluation because they are so interdependent. Evaluations and evaluators can be pressed to death by the weight of information collected and presented. Decision-makers can be bored to death if they have to wade through lengthy explanations on approach, or qualifications to findings and recommendations. They may refuse to read evaluation reports because of the competing demands on their time. Useful evaluations are the quest, and utility and brevity often go hand-in-hand in a bureaucracy. Also, most of us will probably evaluate on-going programs for program improvement purposes. This is called formative evaluation; it will probably reveal remedial program improvement measures which do not surprise program participants or administrators. These should be presented as action items with little attention paid to lengthy report writing. A one-page approach to business here is a good idea.

Needs Assessment

Evaluation can be used to help establish program direction. The "needs assessment" is a common evaluative initiative. It captures the perceived difference between "actual" and "ideal" conditions by use of various techniques. Questionnaires are a common tool for gathering needs assessment information. Needs assessment has been used with some success prior to the establishment of three to five year aquatic education programs funded by the Dingell-Johnson/Wallup-Breaux (Sport fish Restoration) Act as amended). These programs, which are joint federal and state efforts, are ambitious additions to the coastal education scene. My experience administering these programs in Region One of the Fish and Wildlife Service indicates the needs assessment tool is beneficial as a direction-setting mechanism. It also indicates the need for training of state and federal personnel in this area. Needs assessment is not a cure-all, and there has been a fair amount written in the evaluation literature on the conceptual and practical shortcomings of this approach.

Maintaining Program Direction

Once established, program direction can be maintained by evaluation. Maintaining program direction relates to program control. Control of an aquatic education program can be enhanced by administrators and educators who conduct "Triple E" analysis or evaluation. Evaluation of effectiveness, efficiency, and economy fall under this umbrella. As one example, effectiveness evaluations seek to answer the question, "Are we doing the right thing?" Ordinarily, they are designed to assess the attainment or lack of attainment with respect to objectives. Coastal education programs are usually meant to attain educational outcomes pertaining to knowledge and skills, attitudes, interests, and appreciation. These are derived from Bloome's famous monograph on the taxonomy of educational objectives (1959). Examples are the National Aquarium's "Living in Water" and the State of Oregon's "Stream Scene." Learning outcomes are stated in the language of educational objectives. Students recognize, predict, identify, etc. Evaluating the effectiveness of these programs involves assessing whether objectives have or have not been met. Measuring attainment of these objectives can be accomplished by pre-tests and post-tests. If objectives are being attained, these programs can be judged educationally effective. Without evaluation this can only be inferred.

Conclusions

Evaluate your coastal education programs. Don't be hung-up on what evaluation is, nor on the finer intricacies of evaluation design. Think about how evaluations can be useful to you and others interested in program success. Get the people affected by the evaluation to work with you on it. Start with evaluating the accomplishment of your objectives. You may find new and improved objectives are needed. When you remedy this condition you will be more in control of your program, more accountable, and assured you efforts are making a difference.

References

Austin, M.J. 1984. Evaluating Your Agency's Programs. Beverly Hills: Sage Human Services Guide #29.

Baker, W. 1980. Triple E. Movement and productivity in Canada's Federal public service. Optimum. Volume 2, No. 3.

______, and P. Koppel. 1987. Control systems: the key to a productive public sector." Optimum. Vol. 18, No. 3.

Bloom, B.S. 1956. Taxonomy of Educational Objectives: Cognitive Domain. New York: David McKay.

Kosecoff, J. and A. Fink. 1982. Evaluation Basics. Beverly Hills: Sage Publications.

Patton, M.Q. 1990. The Challenge of Being a Professional. Evaluation Practice. Vol. II. #1.

IX. THE HUMANITIES AND THE COAST

Jack Rudloe's Coastal Walden: The Living Dock at Panacea

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When most people think of Henry David Thoreau's narrative, Walden, they think of the quiet body of water that gave the book its title: a sixty-acre freshwater pond thirty miles west of Boston. Neither the book nor the place would seem to have much relevance to the seacoast, particularly to the daily activities of a marine specimen collector. Yet Jack Rudloe, a self-educated marine naturalist, found in Thoreau's 1854 masterpiece both a philosophic guide and a literary model for, The Living Dock at Panacea, an autobiographical account of a year spent collecting marine specimens along Florida's panhandle coast. "If Thoreau can write a book about a pond," his editor told him, "you can write one about a dock." Rudloe complied with a chronicle of one year on his "living dock," a big wooden structure extending several hundred feet into Dickerson Bay at the little fishing town of Panacea on Florida's panhandle.

Dickerson Bay is as special to Rudloe as Walden Pond was to Thoreau. Its incredible fecundity gives birth to more fouling growths than almost anyplace Rudloe knows of, quickly covering the pilings with so many hydroids and barnacles that it seems alive, a "living dock" that provides many of the specimens Rudloe needs for his business. Like Walden Pond, Rudloe's dock is more than a place. It is a symbol of humanity's relationship to nature, a relationship that extends inward by encouraging meditation and reflection and outward to encompass the total environment--tide flats, salt marshes, and the sea itself. "A dock fills a need of mankind," Rudloe says; "it provides a bridge between land and sea" (Rudloe, 1977). Just standing on the dock, he continues, "makes trouble fade off into the background. All your problems are left on the dry land while you have almost all the security of land beneath your feet and all the openness of the sea before you" (Rudloe, 1977). Similarly, Thoreau saw Walden Pond as a place that connected the individual with the expansiveness of one's inner self, a self potentially as vast as the ocean: "there are continents and seas in the moral world, to which every man is an isthmus or an inlet," Thoreau wrote in his concluding chapter; " . . . it is easier to sail many thousand miles through cold and storm and cannibals, . . . than it is to explore the private sea, the Atlantic and Pacific Ocean of one's being alone" (Thoreau, 1854). For both Thoreau and Rudloe, to explore nature is to explore oneself, for the boundary between human beings and the natural world is less determinate than we realize. Life on the margins--whether the margin of a pond or the margin of a continent--exposes human beings to new worlds, new orders, and cycles of being that ordinary observers only dimly fathom.

Literary critics are expert at finding parallels and mutual influences between works of literature that seem remote to the ordinary reader. While such evidence is important in this case, this alone is not the aim of my paper. Rather, I think that reading Rudloe's work in the light of Walden highlights Rudloe's own attempts to formulate a philosophy of the coast, to move beyond the naturalistic record to a deeper understanding of man's relation to the environment. As collector and supplier of marine specimens, Rudloe could have been content merely to dredge the bottoms, cull the desired fish and crustaceans, and send them off to the university laboratories eagerly awaiting new subjects for experimentation and research. Indeed, a common theme that distinguishes Rudloe's activities from Thoreau's is the practical demands of commerce, the supplier's need to fill orders from distant laboratories in a responsible and timely way. Thoreau, a bachelor living temporarily on his friend Ralph Waldo Emerson's acreage, had no responsibilities and could always earn a few dollars by surveying a neighbor's land or picking up odd jobs of carpentry and day labor. Rudloe, a married man trying to establish a home and small company in a small fishing village, is more businessman than bohemian. He must profit, however modestly, from his work. Commercial values and demands thus motivate much of Rudloe's activities, and even affect his view of marine organisms. He avoids picking up a spider crab on one outing because, as he notes, they're easy to get and besides, they eat too much: "If you didn't watch them they'd eat the tanks barren," he writes. "I'd walk in some morning and see a one-dollar spider crab sitting there having lunch on a seven-dollar sea robin--it happened all the time" (Rudloe, 1977).

Such disarming frankness makes Rudloe, despite his commercial motives, similar to Thoreau. Both men recognize that, in different ways, they are part of the world they observe, that their human values intermingle with and color their observations of the natural world they are writing about. They recognize the distortions caused by human interaction with nature, and try their best to see nature unalloyed. And they realize that in so doing, they may be able to see humanity--or at least themselves--unalloyed as well.

The books share numerous formal characteristics that establish the conscious parallelism. Both are chronologically arranged around the seasonal cycle, Thoreau beginning in May and Rudloe in summer. This allows both authors to develop the commonplace theme of birth, maturity, death, and rebirth. As Thoreau exclaims in his penultimate chapter, "Spring," "Walden was dead and is alive again" (Thoreau, 1854), a theme Rudloe echoes when he notices the shrimp returning to Dickerson Bay in October: "It was good to see the bay alive again," he writes (Rudloe, 1977). Within this orderly pattern of seasonal change, both writers digress freely with anecdotes from past and future experiences, thus avoiding the potential monotony of a journalistic or diary-like account of their experiences. Both develop a scientific persona, a knowledgeable authorial voice that freely uses Latin names for species and gives numerous details about the natural history of particular flora and fauna as well as the surrounding environment. Although both are philosophic and meditative, neither sentimentalizes. They recognize that the larger cycle of life and death involves them as well as the creatures and natural phenomena they observe. Their common personal involvement with nature reveals a subtler and more important parallel: both books are dramas of self-discovery, accounts of their authors' movement from ignorance to knowledge of themselves and the world around them. In this sense, both works are experiments in living and writing, provisional accounts that observe, speculate, and meditate on humanity's complex connection with nature.

At the core of both books lies a central question: Is there any difference between the human and the natural? How one responds to this question might affect one's views on environmentalism, land management practices, or even coastal use policies. For Thoreau, the answer is yes. In a central chapter, "Higher Laws," he envisions humanity constantly ascending and developing until it reaches a more spiritualized state of existence. He admits to his own primitive instincts that motivated him in his youth to hunt and fish, and confesses to glimpsing a woodchuck and experiencing "a strange thrill of savage delight" that made him feel "strongly tempted to seize and devour him raw" (Thoreau, 1854). Once, in fact, he did kill a woodchuck that ravaged his beanfield and ate it "partly for experiment's sake" (Thoreau, 1854); and in the midst of his meditations on "Higher Laws," he says "I could sometimes eat a fried rat with a good relish, if it were necessary" (Thoreau, 1854). Thoreau acknowledges his kinship with nature: "We are conscious of an animal in us, which awakens in proportion as our higher nature slumbers" (Thoreau, 1854), and his whole experience at Walden Pond may be taken, at least partly, as an experiment in bringing this animal consciousness to the surface. Yet transcendentalist that he was, he finally attributes these base urges to man's current existence "in the larva state," and compares present humanity to gluttonous maggots and voracious caterpillars (Thoreau, 1854). We should look forward, he advises, to evolving into a higher, more spiritualized state of existence, like the butterfly, eventually overcoming our baser desires and needs and letting the "mind descend into [the] body and redeem it" (Thoreau, 1854). Mind over body--this is the "higher law" Thoreau posits and tries to follow, knowing how difficult it is and yet striving toward it in order to fulfill the highest promise of being human--absolute freedom and independence of thought.

Jack Rudloe addresses the question of the man-nature split another way, and so reveals his contemporary and original contribution to the philosophical dialogue with Thoreau. Unlike Thoreau, who was only dimly aware of man's effect on the environment, Rudloe sees continual evidence of the human threat to nature. The evidence of the gradually increasing pollution of Dickerson Bay, of the increased homebuilding along the sand dunes in St. Joe's Bay, and the steady encroachments of U.S. Army Corps of Engineer drainage projects on the marshlands that surround Panacea, dramatize to him that man is not evolving toward the higher law Thoreau posits, but is becoming increasingly predatory and gluttonous (Rudloe, 1977). He is concerned with the destruction of sea turtle habitats, and in his most recent book, The Wilderness Coast, recounts his efforts to keep loggerheads from being chewed up by a giant dredging machine (Rudloe, 1988). Yet, he recognizes his own involvement in this predation. His job requires him to dredge the fragile coastal seafloor and pull up thousands of pounds of sea life, only a small portion of which he can use. He realizes that he too is polluting the bay when the bilge pump from his shrimp boat sends oily water into the sea, or when he paints his dock with toxic anti-fouling chemicals (Rudloe, 1977). He knows that he too is a predator, as voracious as the sharks he catches for a living. As a permanent resident of the coast, one who makes his living there and relies on its resources, he cannot transmigrate so readily into the butterfly state envisioned by Thoreau. And this intimacy with coastal life provides a different answer to the central question. Is there a difference between man and nature? For Rudloe, the answer seems to be "no."

The best example of this is when he receives an order for a gallon of blood from a live shark. The going rate is $400 a gallon, and although sharks have proved unprofitable in the past, he needs the money. On his way out to the shark-fishing grounds, he reflects on the waste caused by sports fishermen, those who reel in a struggling shark, shoot it, and then cut it loose to sink. When this happens, Rudloe writes, "I feel there is some kind of crime against nature being committed. If the shark were used somehow--for food or for science--then somehow taking away its life wouldn't be as bad and wasteful" (Rudloe, 1977). This is the ethic of conservation--take only what you need or can use, destroy as little as possible, and leave the rest. It sounds workable, and is comforting to the specimen collector as he goes forth to kill a shark for one gallon of its blood.

After laying out the chum and dropping the heavily-baited hooks, Rudloe begins to feel the creeping presence of one of nature's most feared animals. He realizes that shark fishing arouses "some atavistic fear" in him (Rudloe, 1977), something going back thousands of years in the human species. While his rational self tells him the chances of shark attack are minimal, his subconscious mind recoils with that persistent "fear of being carried away in the jaws of a big shark." "Perhaps," he muses, "our atavistic memories have survived over the hundreds of millions of years from the time when we were tiny helpless creatures evolving in a sea of large fish with big nasty teeth. Down through the millennia, through the vast expanses of time, we have been eaten again and again and again" (Rudloe, 1977). In contrast to Thoreau, when Rudloe meditates on the relationship between man and nature his thoughts move back in time, not forward. His reflections propel him toward evolutionary and moral descent, not ascent, toward the primitive shark, not the transcendent butterfly.

With two of his employees helping him, Rudloe hooks an eight-foot tiger shark and hauls it into the little tunnel boat, suspending it, still living, from a small metal stern boom. While one helper cuts into the tail to sever an artery, Rudloe holds a plastic jug to catch the blood. Just as the jug is nearly filled, the shark whips its tail one last time, knocking the jug from Rudloe's hands and spilling the precious blood all over the deck. "I looked at this big creature of the open seas that had died in vain, and I felt lousy," writes Rudloe (Rudloe, 1977). He has violated his own ethic, his most basic principle of conservation. He has wasted, not used. He is at this moment no better than the sports fishermen he condemned earlier. Rudloe and his mates soon catch another shark and fill the order, learning to lash the tail securely before they cut it and drain off the blood. Now that he's learned how to manage live shark blood collection, he'll do it again if another order comes in. Despite feeling "lousy" about the waste, he admits that "there was still a lure and a challenge that sharks presented, one I couldn't resist" (Rudloe, 1977).

In this incident, Jack Rudloe personifies Thoreau's "man in the larva state." Even though he distinguishes his predation from that of the sports fishermen, he feels a "lure and a challenge" to killing sharks that goes beyond rational scientific or commercial aims. The atavism he experiences is practically a blood-lust, in fact. Rudloe is the one who shoots the sharks with a .22 caliber pistol, the one who administers the deadliest blow. When he misses once and wounds the first in the heart, he causes the excessive bleeding that diminishes the supply of the resource he came to collect. Business motives--profit and customer satisfaction--combine with the "lure" and "challenge" of shark-fishing and drive him to slaughter two huge marine animals for nothing more than their blood.

Thoreau, of course, would have condemned Rudloe for this act, even though he would have understood it. While he was writing Walden, he paid a few visits to Cape Cod and experienced firsthand what he called "this voracious beach" (Thoreau, 1864), a wild and desolate place where death seemed commonplace. On his way there he saw human corpses washed up from a recent shipwreck, and at the Cape itself he found carcasses of all sorts. Once, he came upon a dog eating the offal from a rotting cow. Although he recognized the predation of nature, he could not accept it, and never completed his book on his Cape Cod, almost as if the harshness of the coast was too much for him to bear. But Jack Rudloe did complete his work--he has written five books about the north Florida Gulf Coast, in fact--and in doing so he distinguishes a contemporary and perhaps peculiarly maritime view of the human-nature question.

Though he dislikes the predatory impulses of human beings, even his own, Rudloe gives them their due. In his self-dramatization, he is as guilty as any top-chain predator, thus implicating himself in the natural environment much more fully than Thoreau. But if he is more guilty, he is also more innocent, for he is performing in harmony with nature rather than attempting to rise above it. He is accepting nature, including human nature, on its own terms, admitting to his atavistic impulses even when he dislikes them. Such self-honesty is important when it comes to dealing with shrimpers, for example, whose cooperation he needs when tagging sea turtles or horseshoe crabs. He is one of them, a man who makes his living from the seacoast and realizes its odd mix of fragility and fecundity. In "Higher Laws" Thoreau wrote, "Nature is hard to be overcome, but she must be overcome" (Thoreau, 1854). Rudloe would ask, Overcome by what? At the coast, where human beings can blend so readily with the wildest element on earth, the sea, the interdependence of man and nature--really, the immersion of man in nature--is brought home with full force. Unlike Thoreau, who turned his back on Cape Cod, we realize today that the sea, particularly the coastal marshes, tideflats, and estuaries, are a necessary part of human existence. Our destinies are intimately intertwined with sea life, as Rudloe realizes when he laments human depredations of the coast: "When sea turtles no longer crawl up on the beaches to lay their eggs because they have all gone into cans of soup," he writes, "the end of the world cannot be too far off. Empty seas, without the enormous diversity of life, birdless skies and cultivated land occupied only by people and a handful of creatures bred expressly to service people is something I find too appalling to contemplate" (Rudloe, 1977).

And yet the marine environment and sea-creatures that Rudloe wishes to preserve function, like the shark, to remind us of our most fundamental instincts and needs. The horseshoe crabs he collects for his wife's research copulate constantly and alligators arise from the depths and drag off his favorite airedale (Rudloe, 1988). All around him he sees an enormous waste of life, making him wonder whether, finally, "all life has equal value" (Rudloe, 1977). "Life is cheap," he concludes, not meaning it is insignificant, only that it is abundant and easily replaced (Rudloe, 1977). Instead of lifting us towards Thoreauvian "Higher Laws," Rudloe faces the sea and its creatures for what they are, shearing them of the personifying tendencies one finds in a popular book about the coast such as Anne Morrow Lindbergh's, Gift From the Sea, and giving us a more naturalistic, less idealized view of the lessons nature teaches.

Rudloe's living dock is a symbol as powerful as Thoreau's pond, but its meaning is somewhat different. As a manmade projection into a foreign environment, it asserts human authority and power over the environment. Yet the amazing fecundity and resilience of sea life eventually overtakes the dock and makes it part of the coastal environment, covering it with sea organisms. At the end of the book, in fact, the coast even reclaims the dock. It is destroyed in a hurricane, swept away in a blast of violence unimaginable at Walden Pond. Nature, Rudloe realizes, is not so fragile as it might appear. It can, if you will, fight back, and remind human beings of their limited impact on the coast. Man's relationship with nature does seem to be one of eternal struggle, according to Rudloe, and any transcendence above the "larva state" is a fond hope at best. Perhaps our relationship is condemned to be more discordant than harmonic, to be full of the same ambivalences and conflicts that surface continually in Rudloe's personal reflections on his ambiguous trade. Is he a killer or a conserver? Or is our view of nature still in such infancy, so partial, that we cannot understand either its complexity or the full effects of our place in it? "Man likes to manage things," he realizes; "He likes to putter and play and see what he can do to reverse and manipulate nature." And "I," Rudloe concludes, "am no exception" (Rudloe, 1977). Because of his reluctance to spiritualize or idealize natural facts, even those that implicate him in nature's predatory food chain, Rudloe may have alienated the vast popular audience that wants reconciliation with nature on humanity's terms. But nature is too vast to comprehend. Like Walden, Panacea concludes on a note of final renewal when Rudloe rebuilds the dock and Dickerson Bay begins to recover from the hurricane. This "rebirth" shows that "the life-building process goes on and on, but nothing lasts forever, not even our pollution and our alteration of nature and her environment" (Rudloe, 1977). If human beings learn to take their place within the larger cycles of nature Rudloe has traced, instead of always trying to control them, perhaps an ecological balance can be maintained. And the living dock will take its place in the endless cycles of birth and death as a symbol of the fusion of the natural and the manmade, a relationship not of transcendence but of symbiosis.

References

Lindbergh, Anne Morrow. Gift From the Sea (1955). Rpt. New York: Random House, 1978.

Rudloe, Jack. 1968. The Sea Brings Forth. New York: Alfred A. Knopf, Inc. NY.

_____. 1971. The Erotic Ocean: A Handbook for Beachcombers. New York: World Publishing Co.

_____. 1977. The Living Dock at Panacea. New York: Alfred A. Knopf,Inc. NY.

_____. 1979. Time of the Turtle. New York: Alfred A. Knopf, Inc. NY.

_____. The Wilderness Coast: Adventures of a Gulf Coast Naturalist. New York: Truman Talley Books, 1988.

Thoreau, Henry David. (1854). Walden and Civil Disobedience Rpt. ed. Owen Thomas. New York: W. W. Norton & Company, Inc., 1966.

_____. (1864) Cape Cod. Rpt. ed. Paul Theroux. New York: Viking Penguin, Inc., 1987.

The Texas Gulf Coast in Fiction: An Uneasy Setting

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In 1957, Walter P. Webb wrote that the Texas coast has a problem finding a literary voice appropriate to its experience: "We have ignored the Gulf, the Golden Coast, and the strange life of those who live on the edge of the Texas sea. There is as yet no literature about it, and scarcely any history" (quoted in Graham, 1985, p. 105). Some thirty years later things remain pretty much unchanged. In his literary survey of East Texas, the Border, West Texas, urban Texas, and the Gulf coast, Don Graham says: "For whatever reasons, as a literary region the Gulf Coast is the least developed of the five" (Graham, 1985, p. 92).

Why is the Gulf coast relatively untouched by fiction? The wide-open spaces of East, West, and Borderland Texas continue to offer settings for rural or frontier fiction. Urban Texas--especially Houston, Dallas-Ft. Worth, and San Antonio--offers a modern setting for exploration of a new breed of city folks. But the Gulf coast has not defined itself as sharply, has not been accepted in fictional consciousness. Bryan Wooley (1985) says it is a matter of image. "The classical image of the 'typical Texan' isn't nautical. The stereotype wears a ten-gallon hat and cowboy boots and rides a horse in the cattle kingdom. He's never in sailor's garb, never working the deck of a seagoing vessel or hauling a shrimper's net from the deep or unloading freighters on the docks. Even the Texan's own image of the Texas is tied to the land--a huge land and a dry land, most of it--and the work we do on it. We don't see ourselves as a sea people, a coastal people."

Still, there are some remarkable literary treatments of the Texas coast. In this paper, I would like to look closely at three singled out for praise by Graham (1985): a novel by David Westheimer; a novel by Stephen Harrigan; and a short story by Donald Barthelme. The three illustrate a tendency to use the coast as an uneasy setting for the failed or failing relationships between man and man, man and beast, man and the environment.

David Westheimer (1948) begins his poignant novel, Summer on the Water, with a lyrically enervating description of Pine Creek, a fictional version of Houston's suburban Clear Creek, as "...an uncertain stream. It twists and crawls and inches its way toward the sea in wide loops and sudden bends and sprawls among the swamps, forests and flatland of South Texas like a flung chain" (p. 1). In this Jackson Pollock painting, the narrator splashes and drips words and phrases to convey a sense of the fortuitous, aimless way of nature in these parts. He shows us an environment of negatives: the stream is "...not straight and true and purposeful" (p. 1). And that negative quality--or lack of quality--seems to infect Pine Creek's inhabitants. "Along its widening bed are scattered the straggling dilapidated farmhouses of men as feeble and uncertain as its own sluggish waters" (p. 2). Are the men or their farmhouses "...feeble and uncertain"? Perhaps both. It is difficult to say because the language is as ambiguous as the stream.

The whole effect is Southern Gothic, full of mildew, mold, and Spanish moss choking, rotting, and ruining. And for what? "For nothing it struggles, winds, twists, cuts, digs, marches, retreats toward the sea through prairies, thickets, forests and marshes, but along its banks are the rough cabins of poor men, the houses of those who seek pleasure or peace, the mansions of the wealthy and brawling, fish-smelling honky-tonks, cafes and bait houses. Rowboats and yachts, speed boats and sailboats, shrimpers, trawlers and aquaplanes roam its dull, placid surface. Men fish, swim and boat in it, for food, for pleasure, for the satisfaction of incoherent hungers. Summer on Pine Creek, summer on the water, has something for all men, something to share, something to treasure, something to throw away when summer is gone" (p. 6).

Summertime and the living is too easy: "The creek made things easy for a man." For sixty-year-old Grover Johnson, one of the almost anonymous supporting characters along the creek's banks, it is an escape from his own unacknowledged but nagging human needs. Here, he reflects, you don't need any "fancy" tackle or gun, when a simple drop line can haul up "...something good to eat without so much as working up a sweat." With a beat-up old skiff, you don't need any fancy car. And you sure don't need any women: "Pine Creek didn't talk back like a woman, or paint its lips or snigger or marry a man and then run away from him." Johnson is so numbed that "...mosquitoes did not hurt his insensistive skin" (p. 7). Pine Creek is his River Lethe, a place away from life where he can forget the past, and almost forget the present. At least he doesn't have to make any effort to live.

Westheimer's novel is about failed relationships. Its plot revolves around an intelligent black woman whose free will has been squandered along the banks of this meandering creek. Preferring the easy, secure life of playing dumb maid to a fatuous white family, Mathilde is afraid to take a risk. She gives up her one chance to escape with a virile, politically active black college student. But, being a maid is not nearly so secure as she had thought. She is raped by her white employer, Uncle Talbot Carably, and has to hide the secret of her bastard son's father from Talbot's wife, Aunt M'Lou. Eight years later, when she is wrongfully suspected of having an affair with their white nephew, Mathilde is told she must either marry a dullard of a black yardman or be fired. She chooses a third alternative--suicide by drowning in Pine Creek. Thus, the curse on the House of Carably, inextricably linked to life along the steamy Texas Gulf coast, finally claims her life as it has already claimed her soul.

Westheimer's novel deals with gaps in the relationship between people. He suggests this symbolically in a localized image: "Across from the pier a man and a boy were fishing from an anchored rowboat which bobbed madly every time a speedboat raced by. The man looked up when the boats roared past and once he shook his fist at a cruiser which came too close" (p. 36). Coming too close makes waves--physical disturbances for a placidly anchored rowboat; coming too close in this tortured society seems fatal for blacks like Mathilde. Mathilde, who cannot swim, spends many an evening staring at the creek and humming "Danny Boy," whose lyrics speak of love, separation, death, and return: "This is a lovely song, she thought, an old song, a living thing which carries with it fragment of the weary past as Pine Creek carries driftwood to the bay" (p. 46).

Mathilde must adopt multiple personalities to survive. We are told that "Mathilde lived three lives in the Carably household and only one of them was a true expression of character. With Talbot Carably she was brazen, provocative, reckless; with his wife she was demure, efficient, sensible, a perfect servant; and with Randy [her black boyfriend], and later Bobby Lee [the Carably's nephew], she was herself--intelligent, honest, thoughful" (p. 51). She believes she can sustain her two false fronts easily because--with good reason--she feels superior to her employers. When a frustrated and stifled Randy offers to take her up North, she says there is no need to run away. "You can get along down here if you know how. Let them think we're dirt and sit back and laugh inside" (p. 52). But Uncle Talbot's physical strength and caste standing prove too much for her.

For Mathilde, the Gulf coast's promise of security is a heartbreaking illusion. In the lush nightime, she dreams of her sea-changed "...body like polished new ivory shining between the vivid green of the water and the vivid blue sky" (p. 61). Her daytime dream is similarly unrealistic: "It would be wonderful to get into the boat and float endlessly with the current, free from all fear and anxiety, away from the blanketing heat, the brooding moss-hung oaks and M'Lou's nagging. If only that dream of hers was true, if only she could float effortlessly and forever between the vivid green of the water, moving effortlessly toward some peaceful, vast and enchanted sea" (pp. 195-196).

If only. But, as summer's stultifying heat increases, images of death and decay are everywhere: "The Spanish moss changed from greenish gray to dull gray; the honeysuckle blossoms rotted on their vines, filling the air with a dense, cloying scent, and then disappeared; the mockingbirds sang only in the cool hours of morning and evening, and the rank grass lay brown and sere. Only Pine Creek remained unchanged, making its slow futile march toward the sea, sighing gently between its sunstricken banks. Sometimes a hot breeze limped in from the land side scarcely strong enough to flutter the shades but bringing discomfort and a horde of hungry mosquitos from the marshlands"

(p. 148).

And Mathilde is left alone, with no one to help. She turns to the sea. Pine Creek offers her the only way out, an escape from the "...evil, victorious, mocking" cottage, trees, land and people. It holds out the promise of "...an enchanted sea and a romantic island more clearly even than in her dreams" (p. 257). Ironically the enchanted sea is suicide; the romantic island, death.

Stephen Harrigan (1980), too, in his lighter novel, Aransas, finds community with people along the Gulf coast impossible. For that reason, his protagonist Jeff Dowling, a superannuated hippie, turns to dolphins. Harrigan, like Westheimer, sees the Gulf coast in negatives: the Texas coast is a "...featureless land--and seascape" (p. 5), and Aransas Bay "...is not a bay at all, simply a place where the gap between the mainland and the offshore islands is wide enough to warrant a name." This sense of vagueness and murkiness--an existence without clear definition--pervades the novel. When Dowling looks out upon the night, he sees only several spoilbanks in the "...milky darkness" and a couple of sailboats with running lights, "...but otherwise the bay was featureless, and the lights that fringed it seemed tentative and imperiled" (p. 44). In the palpably humid air, he finds himself "...moving with effort through the heavy, sluggish, barely breathable atmosphere" (p. 46). Yet, Dowling feels at home in this seemingly unhospitable place that had bred him and his friends "...like mosquitos" (p. 45).

Dowling recognizes the unsavory side of his "...painful stretch of coast" (p. 26). To be sure, it's nothing like the postcard pictures of translucent turquoise water on a bed of brilliant white sand: "...you could be certain of that by simply looking out over the muddy water, at the tar-stained beaches where the surfers rode paltry waves, waxing their boards and sprinkling meat tenderizer on their man-of-war wounds" (p. 24). Scarred by the unplanned and haphazard developments of condominiums, burger joints, and porpoise circuses, its shores are "...littered with milk cartons and bleach bottles and dead cabbageheads" (p. 46).

Dowling's mother finds it more menacing than seedy; she is frightened by the unknown it represents. She "...never liked the ocean--it was like a nightmare version of Kansas [her home state], a prairie that would not bear one's weight" (p. 21). She fears what lies beneath its murky surface, ready to obliterate her reality. A family anecdote, more legend than anecdote, has it that Dowling's father was saved by a guardian-angel dolphin after he was shot down over the ocean in the Second World War. She clung to this story because she "...wanted to believe that something existed beneath the surface of that water that was capable of treating her with kindness" (p. 21). In other words, she hopes for the best but fears the worst.

It's hard to tell heroes from villains on this mixed-up coast. Dowling's environmentalist girlfriend writes an impassioned letter to the editor attacking a local land developer for turning her coast into "...an extended shopping mall" (p. 106). Yet he turns out to be Dowling's surrogate grandfather, a well meaning old man who is "...as innocent a despoiler as the hurricane that could one day level all he had built" (p. 37). And even the girlfriend is forced to admit that beauty on the Texas coast is problematic. Before she had first seen it, she was enthralled by her mother's babble about how wonderful the ocean was. But "...by the time we got here and I actually saw it I was kind of disappointed. The Gulf of Mexico seemed like a bargain-basement ocean" (p. 140).

The story of Aransas is a story of ambivalence. While Dowling helps capture and train porpoises at the request of the developer, he both hates and is fascinated by it. For instance, in one of the speedboats that is closing the circle of a net around a dolphin, he "...marveled at how neat it was: the high-speed maneuvering, the completion of the prescribed pattern provided me with an aesthetic rush" (p. 14). This closing circle pattern is symbolic of the way things work out. Dolphins and people learn "behaviors" and "tricks" from each other. For instance, Dowling learns about free will from a dolphin he had captured; but by the time he frees it, the dolphin has become too tame to survive in the wild. The dolphin, echoing the pattern of Dowling's father's story, saves Dowling from drowning. But, in doing so, the dolphin puts itself at risk, is recaptured, and shipped off to a large dophin circus in Florida. Ironically, Dowling comes to prefer the murk and mystery of the Texas Gulf to the crisp, dry air of New Mexico or the crystal waters off Florida. Picture-postcard clarity, biologists tell us, is evidence of the absence of life--deserts and lifeless waters. On the other hand, murk and mystery teem with life, whether it be mosquitos and stingarees or dolphin and people. Surrounded by his humid air and muddy waters, Dowling remains ambivalent: "I could feel the ease and panic beneath the murky waters, the struggle for sensation among the creatures there" in "...water nearly as thick and abiding as the earth itself" (p. 260). He is ineluctably drawn to the mystery: "I knew I wanted this brooding seascape around me for the rest of my life" (p. 260).

Westheimer and Harrigan are earnest, almost solemn; Donald Barthelme is anything but. Yet, he too uses the Texas coast as an uneasy backdrop for failing relationships. Here the alienation of man from himself, others, and his environment. With wit and sinister charm, Barthelme (1981) tells us a fable in his short story "I Bought a Little City." The idea for the plot is simple. Land developers are often accused of playing God; what would happen if one were to assume that role, almost literally? The unnamed narrator in the story has somehow managed to purchase the entire island city of Galveston. With disarming candor, he tries to allay our fears: "I told everybody that nobody had to move, we were going to do it just gradually, very relaxed, no big changes overnight. They were pleased and suspicious" (p.

295). For good reason. Galveston, the narrator tells us almost immediately afterwards, "...suited me fine so I changed it" (p. 295).

The narrator just can't seem to take things as easy as he had planned. He moves people around as if they were so many game pieces. First he tries a little urban renewal by the sea. An entire block of people is moved into the Galvez Hotel and their old neighborhood houses are razed and made into a park. The narrator doesn't pause to deal much with the reactions of the island's citizens; that is not his main concern. Power is. Many projects later, he has rearranged things to his own liking so artfully that from the air the island looks like a jigsaw puzzle version of DaVinci's Mona Lisa.

On a whim, he suddenly decides that dogs are a nuisance and has 6,000 of them shot. When a dog owner complains, the narrator replies "I am the sole owner [of this city] and I make all the rules" (p. 298). The rules and his whims are the same. But when he shifts his interest from impersonal land development to very personal attempts at adultery, he loses interest in his own machinations. Thwarted in love and bored with power, he sells Galveston back at a loss. His reflections on the meaning of his experience seem as non-sequitur as his actions: "I learned something--don't play God. . . . Probably I went wrong by being too imaginative, although really I was guarding against that. I did little, I was fairly restrained. God does a lot worse things, every day, in one family, any family, than I did in that whole city" (p. 300). In other words, he excuses himself by shifting the blame elsewhere--God plays God too.

The island is an inconsequential playtoy for a developer to manipulate as far as his money and interest take him. In Shakespeare's King Lear, Gloucester says, "As flies to wanton boys, are we to the gods; they kill us for their sport." The Texas coast in Barthelme's short story bears a similar relationship to land developers. The narrator's riotous exercise of absolute interference in others' lives leaves him sadder and withdrawn. He moves fifty miles north to Galena Park, where he refuses to meddle in community life at all: he won't even run for the school board. The narrator shrinks in significance to a mindless accumulator, a maker of lists of things to do, another failed relator on the Texas Gulf coast.

Literature about the Texas coast tends to focus on the inhospitable. A dime novel, The Freebooters: A Story of the Texas War (Aimard, 1861) paints a nasty Galveston, full of "...bold gaps and sudden fissures in the tall cliffs that border" its "...dangerous and ragged coast" (quoted in Graham, 1985, p. 90). This early fiction got all the details wrong--Galveston is actually a flat sandbar whose highest natural elevation is twelve feet above sea level--but sounded an ominous chord that resonates in most literature about the Texas coast. In his official report to the king of Spain, Cabeza de Vaca (1542) described an island (likely Galveston) where natives died of dysentery and

Spaniards resorted to cannibalism in a vain attempt to avoid starvation; he named the place "Malhado" (literally, "island of doom"). In his novel, Anything for Billy, Larry McMurtry (1988) has his narrator, a dime-novel writer, come to Galveston prepared for romantic encounters with Apaches and bandidos, but unprepared for mundane reality: "...what I got in Galveston was bugs. . . . I had not been on the Texas shore twenty-four hours before I had to contend with lice, chiggers, mosquitos, nits, ticks, houseflies, horseflies, bedbugs, beetles, ants, spiders, roaches, centipedes, scorpions, and gnats" (p. 55). In his classic science fiction short story "Earth Eighteen," Frederik Pohl (1966) envisions the Texas coast as an appropriate stop on his imagined future tour of a United States laid waste by the effects of unchecked technology. Houston "...is not recommended for more than a short visit because of the unpleasant odor of a native hydrocarbon compound. Once used as fuel, 'oil,' as it is called, invades the drinking water, the air, and the conversations of the locals, who firmly believe it will once again have value, and who attempt to trade 'leases' to travelers in exchange for chocolate bars or bits of colored glass" (p. 419).

References

Barthelme, D. 1981. Sixty Stories. New York: Putnam.

de Vaca, C. 1542. La Relacion. Translated by Cyclone Covey. (1961). Cabeza de Vaca's Adventures in the Unknown Interior of America. Albuquerque: U of New Mexico P.

Graham, D. 1985. Texas: A Literary Portrait. San Antonio: Corona.

Harrigan, S. 1980. Aransas. New York: Knopf.

McMurtry, L. 1988. Anything for Billy. New York: Simon & Schuster.

Pohl, F. 1966. "Earth Eighteen." Digits and Dastards. Reprinted in Eric S. Rabkin (ed.), 1983. Science Fiction: A Historical Anthology. New York: Oxford UP. pp. 415-425.

Westheimer, D. 1948. Summer on the Water. New York: Macmillan.

Wooley, B. 1985. Where Texas Meets the Sea: A Coastal Portrait. Dallas: Passworks.

Winslow Homer: English Inspiration to American Realization

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Winslow Homer (1836-1910) has long been viewed as one of this country's most accomplished, distinctive artists, and much of his reputation rests on his paintings of the Maine coast. He has been called a most "American" artist, "the quintessential Yankee New Englander -- self-reliant, strong-willed, practical, terse" (Judge, 1986). Homer was born in Boston, and as a youth he trained there in a famous lithographer's shop. He recorded many typical scenes of 19th Century life, from corn-husking parties to busy city streets, in illustrations for Harper's Weekly. Later, he would provide somber illustrations of the Civil War. An outdoorsman, he often travelled to the White Mountains, the Adirondacks, and to the Bahamas. Homer spent the last decades of his life in independent seclusion in Maine, away from any artists' colonies, painting some of his most profound works. Homer is thus identified with the stoic people he depicted and, as he lived and painted within a stone's throw of the breakers of Casco Bay, he is also identified with the free, rough sea itself. In this, the man and his work exemplify one 19th Century ideal: the rugged man attuned to nature, moved by its grandeur yet commanding its wildness with his imagination.

However, the development of Homer's marine paintings is not without "un-American" influences. Though Homer sought to paint "...with as little interference from the outside world as possible" (Judge, 1986, p.5), two trips abroad did affect his technique and choice of subjects. A visit to Paris in 1866 exposed him to French nature painters, such as Millet and Corot; to the lighter palette and sophisticated composition of Boudin and Monet; and to the bold patterns of Japanese art. A much later trip in 1881-1882 to Cullercoats, an English fishing village on the North Sea, is my concern in this paper, because his stay there initiated his mature interest in the sea, and thereafter his paintings began to take on a more suggestive, heroic, and timeless quality. It is these paintings of the 1880s and 1890s that secure Homer's reputation as original and important. It seem this most "American" painter discovered a profound approach to his subject by observing the atmosphere and people of England.

Before the trip to Cullercoats near Tynemouth, Homer's early seaside pictures focused on fashionable resorts visited by fashionable ladies or on the childlike joys of boating. "The Beach at Long Branch" (1869) shows what one critic calls Homer's "confident absorption of the stylistic devices . . . found in Japanese prints and French painting" (Wilmerding, 1972, p.86). However, his colors remain richer than the light ones of many French contemporaries, his surface seems less flat, as he "retains" an American interest in "solidly modelled forms and deep spacial (sic) recession" (Wilmerding, 1972, p. 86).

The shore, sea, and horizon here become part of the composition that creates an illusion of depth, and a sunny bright setting for the ladies to enjoy, with their parasols and viewing glasses, and to be seen against in the well-pinned outdoor finery.

In contrast to this refinement, one of Homer's most popular pieces, "Breezing Up," (1876) conveys the freedom and pleasure of a boy's life. The treatment of the waves, sky, and boat suggest easy, liberating motion. The boys find nature their playground, an escape from school and responsibilities made safe by the weather and presence of one adult, probably very willing to join them on such a sea.

But with his observation of life on the English coast, Homer's work took on a more probing quality, dwelling on a threatening nature and the anxiety or stoicism of a figure in an ominous seascape ("Inside the Bar, Tynemouth" [1883]). Why Homer went to Cullercoats is a mystery, as much in his life is a mystery because of his extreme reticence.

> "But I think it would probably kill me to have such a thing [a biography] appear, and as the most interesting part of my life is of no concern to the public, I must decline to give you any particulars in regard to it." (to William Howe Downes, cited by Wilmerding, 1972, p. 18).

Whatever Homer's private thoughts might have been, critics agree that the stay at Cullercoats "proved to be a major turning point in his career" (Judge, 1986, p.48). We can only speculate that Homer wanted something other than pleasant scenes of everyday life and sentimental subjects for Victorian illustrations. Biographer Philip Beam believes that Homer's daily notice of a demanding life "jarred" him from the comfort of his "middle class background" (Beam, 1966, p.19). The artist's subject matter changed as he ignored stylish women at nearby English resorts to focus on the robust, hardworking, and often anxious wives and daughters of fishermen. Also, while Homer lived in a secluded cottage, his studio was near the Brigade Watch House, featured behind the vigilant waiting women of "Perils of the Sea" (1881). Danger and rescue at sea would become prominent in Homer's English works and those of the following decade in Maine. Witnessing the daily challenges facing the Cullercoats people, Homer took on his own new challenge in an ancient theme: the struggle for survival in a nature that could change suddenly from beneficent to malevolent.

The "diffused English light" (Judge, 1986, p.48) and new atmospheric conditions also influenced Homer's technique. His colors became muted; grey permeates his watercolor washes, complementing the sobriety of his new subject. He also worked more with charcoal and white chalk in preliminary sketches, the underlying technique of "Perils at Sea," to achieve subtle texture (Wilmerding, 1972, p. 135). Sparkling light will return in his later watercolors of the tropics, but, for now, a North Sea dampness and chill pervades. Homer's human figures also become statuesque, suggesting that he had absorbed not only English weather, but also some dominant trends in English art. Many see in his strong women the classical modeling and timeless air of Pre-Raphaelite art. I cannot now explain that distinctive movement in British culture, except to say that the Pre- Raphaelites sought a high-minded art of thematic and technical clarity and integrity. Often, such painters as Edward Burne-Jones sought artistic truth in very un-Homer-like subjects--the world of ancient myth or medieval romance ("Le Chant d'Amour" [1864]). The powerful forms of Homer's fisherwomen resemble the grandeur of Burne-Jones' "Le Chant d'Amour" and "Seated Woman." The almost expressionless faces, devoid of individual personality, are also in Homer. While the look may seem "vacuous" as one critic complains (Gardner, 1961, p. 78), it may suggest the ancient serenity of classical sculpture. Indeed, an influence on the Pre-Raphaelites and possibly on Homer was the 5th-Century B.C. Elgin Marbles housed in the British Museum. The nobility of the marbles, conveyed by the full idealized figures, is updated by Homer in his strong but less god-like presentation of youthful women facing the basic elements of nature and their existence ("A Voice from the Cliffs" 1883).

In 1882, Homer returned to the United States and soon moved to Prout's Neck, Maine. He had brought from England "watercolors, charcoal drawings, and some oils,"--sources for work to come (Wilmerding, 1972, p. 135). He continued to focus on one or a few individuals struggling against natural forces. "The Gale" (1893) is a reworking of an English subject. The first version featured the same background as "Perils of the Sea"--a boardwalk and dock. Homer simplified and strengthened the composition, replacing the boardwalk with a Maine ledge and using "brighter and stronger greens, blues, and whites" (Wilmerding, 1972, p. 140) to convey the different atmosphere of New England. I believe this painting and "Inside the Bar" are rare for the 19th-Century in depicting a woman in a determined, even defiant, stance against inhuman, hostile nature. Homer exhibited "The Gale" at the 1893 World's Columbian Exposition in Chicago; it was awarded a gold medal and, along with fifteen other works he showed, established his national reputation. A contemporary critic praises these paintings for "strong sincerity," "originality of mood," "vigor of conception," and a "stern poetry of feeling... [Homer] had never reached before" (Mrs. Van Rensselaer in Wilmerding, 1972, p. 135).

In subsequent years, Homer produced many works now considered masterpieces: "The Herring Net" (1885); "The Fog Warning" (1885); "The Life Line" (1884); "Eight Bells" (1886). Stern Yankee fishermen replace the sturdy English girls, but the timeless themes of anxious survival and quiet heroism remain. Carried too from the dangerous North Sea to Maine's icy waters was

Homer's interest in rescue at sea. One of Homer's most dramatic paintings, "Life Line," features a "breeches buoy" and a woman in distress. The Victorian melodrama of virile rescuer and helpless maiden is downplayed, though, by the woman's scarf blown haphazardly across the man's face and by the awkward vulnerability of both, nearly immersed in the jagged waves.

A more understated heroism appears in "Fog Warning" and "Eight Bells". In a series on fishermen, Homer illustrates a relationship between man and sea that may be life-sustaining but dangerous, detached but intimate. In "Fog Warning," the man's face is turned away -- as is often the case in Homer --- suggesting he is more type than personality, suggesting too a stoic reserve. Also common for Homer, the painter chooses a moment when a danger is revealed, or assessed, rather than a moment of resolution or certainty about fate. In "Fog Warning," we cannot tell if the fisherman will make it back to his ship. As one critic explains, the fisherman "pits his physical strength, his knowledge, his experience, and his courage against the sea with the calm heroism that is a component part of his daily existence" (Prown, 1980, p. 89). According to Philip Beam, great schools of herring came into Maine waters in the early 1880s, and a local boy, Roswell Googins, rowed Homer out to observe the fishing fleets, and "waited until nearly nightfall for [the artist] to make sketch after sketch of the men and the boats" (Beam 1966, p. 66). Googins, as a grown man, recalls for Beam that the fleet used an "old-time method": they "fished from dories with gill nets . . ., rather than the more modern pocket nets" (Beam, 1966, p. 68). Not only would this method disappear as fishermen would change to fishing gear allowing for "mass hauls," but the herring themselves would not come back, possibly fished out (Beam, 1966, p. 68). In these paintings, Homer captures a formidable way of life that is disappearing within his lifetime.

"Eight Bells" (1886), again portrays men in a pose realistic, but generalized into an understated model of control, competence, and stoicism before nature. To illustrate this moment, probably occurring after a storm when the men take their coordinates, Homer uses a "simplified design, concentration on major forms, and de-emphasis of subordinate details" (Wilmerding, 1972, p. 139). Thus, he applies the grandeur of Pre-Raphaelite paintings and classical sculpture to reveal the implicit dignity of these seafaring men. While modern navigation may be far more accurate and safe, it may lack the dignity, the intimate link between the human and inanimate nature (Wilmerding, 1972, p. 139) that must have fascinated Homer.

As the turn of the century -- and modernism -- approached, Homer became more intrigued by the sea itself as his subject, and began many studies of the sea without a human presence, eg., "High Cliff, Coast of Maine" (1894). These studies explore how painterly techniques can convey the realities of water's movement and atmospheric changes; they attempt to combine realism with an evocation of a more mysterious nature. Homer observed the sea continually, took photographs, and sometimes spent a harsh winter at his studio. But, along with his scientific habit of observation, Homer's interest in formalist issues -- in tone, light, juxtaposition of color -- becomes pronounced in his late paintings. He possessed a remarkable "ability to distill forms almost to the point of abstraction while still retaining their factual appearance" (Judge, 1986, p. 89). "High Cliff, Coast of Maine" illustrates this ability and reveals a shift in his treatment of human subjects. The commanding women and men of the 1880s are reduced to barely recognizable forms--their purpose, perhaps, to provide scale or to suggest their own insignificance. Natural forces dominate the painting: the massive rocks through their strong jagged diagonals suggest a defense against the sea; the sea is caught as it invades and retreats from the cliff, and the spume created by the timeless opposition of rock and water obscures the horizon. This power, an ancient and a present force, is exaggerated in "Northeaster" (1895). Such works move away from the theme developed in England, human survival, to create in paint the illusion of movement and stillness, weight and lightness. These works are far removed from other artists' benign, romantic depictions of sea and land in the early 19th-Century, but Homer's paintings are still a meditation on nature: is the dark background of "Northeaster" the presentation of a fact, the creation of an unnerving mood, the suggestion of timeless, ominous powers continually asserting themselves, or all of these?

Homer would not return to the heroic poses of his Tynemouth period, but the matter of survival stays with him. While some of his late paintings create harmonious moments, others push the threat of nature toward a dark conclusion. "The Gulf Stream" (1899), shows a black man abandoned in a disabled boat, as sharks circle about. That oil painting has its conclusion in the watercolor, "After the Hurricane, Bahamas" (1899). To my knowledge, this is the only time since a few routine Civil War sketches that Homer paints a human death. In 1909, the year before his own death, Homer painted "Right and Left," which he described to his brother as "'a most surprising picture'" (Judge, 1986, p. 86). This "surprising" oil is one of Homer's paintings embraced by modernists. A barely perceptible hunter has just shot two ducks with a double-barrelled shotgun. The unusual composition, with the undersides of the writhing ducks almost pushed into our faces, the confusion of water and sky, the hidden hunter, are akin to the cropping, displacement, and unexpected perspective of much modern art. It also makes us ask where we are in relation to the scene: what relationship do we have to the ducks with their pinpoint eyes -- a direct confrontation we did not have with Homer's fishermen -- what relationship with the obscured hunter, the rough waves and sky? Not a painting about the cruelty of hunting, "Right and Left" nonetheless raises unsettling ideas about the relationship between human beings and the natural world, and about the cold, abrupt death that occurs somewhere between sea and sky--long-time subjects of Homer's vision.

From the fresh air joy of "Breezing Up," to the basic dignity of the

Tynemouth women and Maine fishermen, and to his stern paintings of wave and rock, Homer's work evolves to focus on survival amidst powerful natural forces. Along with the pieces begun in England, Homer's late paintings illustrate his mature achievement in combining a sustained study of the kinetics of water and reflection of light with human issues: pleasure and survival; dignity and insignificance; solitude and mortality.

References

Beam, P. 1966. Winslow Homer at Prout's Neck. Little, Brown., Boston, MA.

Gardner, A.T.E. 1961. Winslow Homer -- American Artist: His World and His Work. Bramhall House, New York, NY.

Judge, M.A. 1986. Winslow Homer. Crown, New York, NY.

Prown, J. 1980. American Painting: From Its Beginnings to the Armory Show. Rizzoli, New York, NY.

Wilmerding, J. 1972. Winslow Homer. Praeger, New York, NY.

X. LIVING MARINE RESOURCES OF THE COAST

"Dermo" and the El Nino/Southern Oscillation. Are Yearly Changes in Perkinsus marinus Parasitism in Oysters (Crassostrea virginica) Controlled by Climatic Cycles in the Gulf of Mexico?

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Introduction: The Problem of Perkinsus

Parasitism is very common in the marine environment and when the host is a commercially important species, the impact of the parasite must be considered when developing management strategies for optimal yield of the resource. The protozoan endoparasite, Perkinsus (=Dermocystidium) marinus is the most important pathogen affecting the eastern oyster, Crassostrea virginica, in the Gulf of Mexico (Hofstetter, 1977). P. marinus detrimentally affects the health of its oyster host and has been implicated as a major source of mortality in natural populations (Hofstetter, 1977; Wilson et al., 1988). Prevalence and intensity of P. marinus infection has been related to temperature and salinity, with low temperatures and salinities usually limiting infection (Mackin, 1962; White et al., 1989). Recent studies have suggested that a variety of pollutants may also influence infection prevalence and intensity (Wilson et al., in press). Although local variations in infection prevalence and intensity have been well studied (Andrews and Hewatt, 1957; Mackin, 1962), regional variations are poorly understood, and multi-year changes in the regional distribution of prevalence and infection intensity have not been studied. Understanding the distribution of the parasite in space and time is important, but determining those environmental variables which affect that distribution is also important.

Long-term climatic cycles, as they influence temperature and salinity, probably affect most marine organisms (Cushing and Dickson, 1976) but long-term studies on host-parasite systems are rare. Any parasite such as P. marinus that can alter a host's population dynamics (Wilson et al., 1988) might be expected to have a significant impact on its host's response to climatic variation and, in the case of a commercially important species, on the success of the fishery. Natural oyster populations in the Gulf of Mexico now contribute over half of the United States' oyster harvest (Broutman and Leonard, 1988) and P. marinus prevalence and infection intensity are high in nearly every commercial population (Craig et al., 1989; Wilson et al., in press). We asked then, to what extent do climatic cycles affect the prevalence and infection intensity of this parasite in the Gulf of Mexico?

NOAA's National Status and Trends "Mussel Watch" environmental monitoring program was initiated in 1986. The goal of this program is to monitor changes in environmental quality by measuring levels of contaminants in bivalves and fish along the Atlantic, Pacific, and Gulf coasts of the United

States and to identify biological responses to these contaminants. The biological component of this program is concerned with describing the regional distribution and yearly trends in P. marinus prevalence and infection intensity in oyster populations. The results of this program represent the most comprehensive temporal and regional dataset on parasite incidence in natural oyster populations yet available. Here we consider the 4-year trends in distribution of P. marinus throughout the Gulf of Mexico and its possible relationship to trends in climatic changes occurring over the same period.

Methods and Statistical Analysis

Detailed methods employed in this study for sample collection and data interpretation may be found in Powell et al. (submitted) and will only be briefly summarized here. Oysters were collected between December and February of each year (1986-1989). Seventy-five sites, from Brownsville, Texas to the Florida Everglades, were sampled at least once and 43 sites were sampled in each of the 4 years (see Craig et al., 1989 and Wilson et al., in press, for site locations and information). Three stations were established at each site and 20 oysters were sampled at each station. Each oyster was assayed for the presence and intensity of infection by P. marinus using the thioglycollate culture method of Ray (1966). Infection intensity was ranked on Mackin's (1962) 0 (uninfected) to 5 (heavily infected) scale as modified by Craig et al. (1989).

Sampling sites were assigned to bay systems which were slightly modified from Broutman and Leonard (1988). Only those sites which were sampled in all 4 years of the study were considered in the statistical analyses. The scale of variability in the spatial distribution of P. marinus among bay systems for each year was examined using a spatial autocorrelation method described by Cliff and Ord (1973). The scale of variability in temporal changes in P. marinus prevalence between years and among bay systems was determined using the ranking method described in Powell et al. (1984).

Environmental parameters such as temperature and those which can affect salinity, such as precipitation and stream flow, were analyzed in relation to variation in P. marinus infection. Temperature and salinity data were collected at each site on the day of collection. Regional climatic data were obtained from various sources (for specific sources, see Powell et al., submitted). Mean monthly temperature and precipitation data were obtained from NOAA and values for several stations surrounding each bay system were averaged. Monthly streamflow data were obtained for most gauged streams from U.S. Geological Survey; for the Rio Grande River from IBWC; and for the Mississippi and Atchafalaya Rivers from the Army Corps of Engineers. From these data, an estimate of total freshwater input to each bay was obtained by summing the stream gauge data and estimating freshwater runoff from precipitation data and an estimate of watershed area from NOAA.

Spatial and Temporal Distribution of P. marinus Prevalence and Intensity

Results of these statistical analyses indicate that specific geographical, temporal, and regional shifts in prevalence and infection intensity occurred over the 4-year period of the study. Geographically, centers of infection tended to remain constant in three areas of the Gulf. Galveston Bay, Texas, Barataria Bay, Louisiana, and Tampa Bay, Florida had consistently higher infection intensities and prevalences over the course of the study. The spatial scale of these loci of infection are greater than 300 km, which is much greater than the scale of the bay systems. This spatial scale is much larger than can be explained by water transmission of the parasite and has been related to environmental and geographic variables, particularly latitude, location of industrial centers, and the body burden of certain contaminants (Craig et al., 1989; Wilson et al., in press). This pattern is stable over the 4 years of the study despite substantial changes in prevalence from year to year within sites, bays, and the Gulf as a whole. A distinct break in distribution pattern occurs on the short (<300 km) and long (>1800 km) spatial scales between 1987 and 1988, resulting in the first two years of the study being very different from the final two years. This suggests that an event occurred between 1987 and 1988 which altered the distribution of P. marinus prevalence and infection intensity.

Yearly changes in prevalence were similar over very broad regional areas, typically greater than 1200 km, which are much larger than the regional scale of infection centers for any one year. Regional shifts occurred throughout the 1986-1989 study period. Prevalence and infection intensity dropped in the southeast and southwest Gulf (infection intensity most strongly). Both prevalence and infection intensity rose in the Florida panhandle (prevalence most strongly). Infection intensity fell but prevalence rose on both sides of the Mississippi delta and values in central and north Texas remained essentially unchanged.

The most dramatic trends over the four years of the study were the decline in P. Marinus prevalence and infection intensity from Corpus Christi Bay south in Texas and Tampa Bay south in Florida, the prominent rise in prevalence and infection intensity over the entire Florida panhandle, and the distinct shift in distribution which occurred over short and long spatial scales between 1987 and 1988.

Causes of the Observed Spatio-temporal Trends

The regional and temporal distribution of P. marinus in the Gulf of Mexico can be considered to be a product of two spatio-temporal phenomena. A relatively stable spatial pattern exists with centers of infection on the order of 300 km. This distance is much larger than a bay system and suggests (l) that site pairs within bays are much more similar to one another than site pairs much further apart and (2) that the determinant of this scale has little to do with transmissibility but rather originates in the distribution of anthropogenic and natural parameters (Craig et al., 1989; Wilson et al., in press). Only freshwater inflow, not temperature or precipitation, demonstrated the same distribution pattern as P. marinus. The moderation in the significance of the 300 km scale in 1988/1989 is in concordance with the observed shift in the distribution of P. marinus prevalence and intensity around the Gulf. This trend suggests that anthropogenic and natural parameters, probably salinity, acted together to result in higher values in 1986/1987 and interfered with one another to produce lower values in 1988/1989.

The second pattern is a concordance in yearly and regional shifts in prevalence and infection intensity among sites relative to the Gulf-wide mean. The scale of these phenomena is much larger than the scale of centers of infection and probably originates in broad shifts in weather patterns as they affect temperature and salinity (via rainfall and river runoff). Only broad climatic factors have scales of this order in the Gulf region. Infection intensity responds to salinity, temperature, and other environmental parameters, while prevalence depends upon transmissibility as well as these environmental parameters to some degree. Accordingly, changes in prevalence, particularly increases, probably require longer time scales and more intense and continuous environmental shifts.

The Role of the El Nino/Southern Oscillation Phenomenon

The El Nino/Southern Oscillation (ENSO) phenomenon affects weather patterns in the Gulf of Mexico by varying both temperature and rainfall (Ropelewski and Halpert, 1986). Several aspects of the data presented here suggest that the spatio-temporal shifts in P. marinus prevalence and infection intensity can be related to the ENSO. The identically-occurring events in southern Texas and southern Florida require a major subtropical/tropical climatic shift such as ENSO. A strong El Nino/La Nina cycle occurred between 1986 and 1989 (Philander, 1989). The major shift between El Nino and La Nina which occurred between 1987 and 1988 corresponds to the largest shift in P. marinus prevalence and infection intensity, which occurred in the same two years. The ENSO cycle primarily affects southern Texas and the eastern Gulf, particularly the Florida panhandle and southern Florida (Ropelewski and Halpert, 1986). The spatio-temporal variations we observed were primarily associated with these regions. Consequently, the spatio-temporal shifts in P. marinus prevalence and infection intensity between 1986 and 1989 may well be associated with ENSO activity.

Since El Nino events affect weather patterns by altering temperature regimes and rainfall, salinity would ultimately be affected as well. Whether temperature or salinity, or both, were important factors in determining the distribution of P. marinus was considered using data on temperature and precipitation. Mean monthly temperature was never significantly related to P. marinus distribution. Yearly rankings for the bays based on precipitation were significantly similar to those obtained using P. marinus prevalence for each of the 3 months prior to sampling. This O to 3-month response time is similar to bay flushing rates for many Gulf estuaries (Armstrong, 1982) and the yearly range in rainfall typically varied by a factor of 2 to 4 in most bays and for most months of the year. The change in salinity can be expected to be of the same order as observed in rainfall in most Gulf estuaries and this range is physiologically significant for P. marinus. Accordingly, yearly shifts in P. marinus prevalence probably respond to climatic cycles as mediated by salinity. However, the spatial distribution of P. marinus in any one year could not be completely ascribed to changes in salinity (Craig et al., 1989). Therefore, salinity as it is controlled by freshwater runoff and precipitation is implicated as the primary mediating factor for variations in P. marinus prevalence and infection intensity.

Implications for Management of the Oyster Fishery in the Gulf of Mexico

Perkinsus marinus infects 60-80% of marketable oysters in most commercially important oyster populations in the Gulf of Mexico. Summer mortality (during periods of elevated temperature and increased salinity) resulting from these infections is typically high (Hofstetter, 1977; Craig et al., 1989; Wilson et al., in press). This suggests that oyster populations are significantly impacted by this parasite. P. marinus responds to climatic variations, particularly in temperature and salinity (as controlled by rainfall). Researchers have noted changes in productivity of oyster populations related to change in climatic variables, particularly salinity (Ulanowicz et al., 1980; Allen and Turner, 1989). Our data demonstrate the importance of multi-year cycles, not just seasonal cycles and occasional heavy rains, in determining P. marinus prevalence and also implicate salinity as the primary mediating factor. Long-term changes in climate exert a significant impact on P. marinus prevalence and infection intensity through salinity, which in turn affects oyster population dynamics and eventually fishing success in the Gulf of Mexico. These long-term climatic cycles are naturally occurring events that, with further study, can be predicted and combined into existing optimal yield models. By understanding the effects of these cycles on other environmental parameters that directly affect productivity, harvests and season length can be controlled to further protect the resource. Resource managers concerned with optimal yield of Gulf oyster populations need to be aware of these long-term climatic cycles and their effect on the success of the fishery.

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References

Allen, R.L. and R.E. Turner. 1989. Environmental influences on the oyster industry along the west coast of Florida. J. Shellfish Res. 8:95-104.

Andrews, J.D. and W.G. Hewatt. 1957. Oyster mortality studies in Virginia. II. The fungus disease caused by Dermocystidium marinum in oysters of Chesapeake Bay. Ecol. Monogr. 27:1-25.

Armstrong, N.E. 1982. Responses of Texas estuaries to freshwater inflows. Pages 103-120 In: V.F. Kennedy, (ed.) Estuarine Comparisons, Academic Press, New York.

Broutman, M.A. and D.L. Leonard. 1988. The quality of shellfish growing waters in the Gulf of Mexico. NOAA Office of Oceanography and Marine Assessment, National Ocean Service, 43 pp.

Cliff, A.D. and J.K. Ord. 1973. Spatial Autocorrelation. Pion Limited, London, 178 pp.

Craig, M.A., E.N. Powell; R.R. Fay, and J.M. Brooks. 1989. Distribution of Perkinsus marinus in Gulf Coast oyster populations. Estuaries. 12:82-91.

Cushing, D.H. and R.R. Dickson. 1976. The biological response in the sea to climatic changes. Adv. Mar. Biol. 14:1-122.

Hofstetter, R.P. 1977. Trends in population levels of the American oyster Crassostrea virginica Gmelin on public reefs in Galveston Bay, Texas. Tex. Parks Wildl. Dep. Tech. Ser. 24:1-90.

Mackin, J.G. 1962. Oyster disease caused by Dermocystidium marinum and other microorganisms in Louisiana. Publ. Inst. Mar. Sci. Univ. Tex. 7:132-229.

Philander, G. 1989. El Nino and La Nina. Am. Sci. 77:451-459.

Powell, E.N., H. Cummins, R.J. Stanton, Jr. and G. Staff. 1984. Estimation of the size of molluscan larval settlement using the death assemblage. Estuarine, Coastal Shelf Sci., 18:367-384.

_______, J.D. Gauthier, E.A. Wilson, A. Nelson, R.R. Fay and J.M. Brooks, submitted. "Dermo" and the El Nino/Southern Oscillation. Are yearly changes in Perkinsus marinus parasitism in oysters (Crassostrea virginica) controlled by climatic cycles in the Gulf of Mexico? Mar. Ecol. Prog..

Ray, S .M. 1966. A review of the culture method for detecting Dermocystidium marinum, with suggested modifications and precautions. Proc.

Natl. Shellfish Assoc. 54:55-69.

Ropelewski, C.F. and M.S. Halpert. 1986. North American precipitation and temperature patterns associated with the El Nino/Southern Oscillation (ENSO). Mon. Wea. Rev. 114:2352-2362.

Ulanowicz, R.E., W.C. Caplins, and E.A. Dunnington. 1980. The forecasting of oyster harvest in central Chesapeake Bay. Estuarine Coastal Mar. Sci. 11:101-106.

White, M.E., E.N. Powell, E.A. Wilson, and S.M. Ray. 1989. The spatial distribution of Perkinsus marinus, a protozoan parasite, in relation to its oyster host (Crassostrea virginica) and an ectoparasitic gastropod (Boonea impressa). J. Mar. Biol. Assoc. U.K. 69:703-717.

Wilson, E.A., E.N. Powell, and S.M. Ray. 1988. The effect of the ectoparasitic pyramidellid snail, Boonea impressa, on the growth and health of oysters (Crassostrea virginica) under field conditions. U.S. Fish Wildl. Serv. Fish. Bull. 86:553-556.

______, ________, M.A. Craig, T.L. Wade, J.M. Brooks, in press. The distribution of Perkinsus marinus in Gulf coast oysters: its relationship with temperature, reproduction, and pollutant body burdens. Int. Rev. gesamten Hydrobiol.

Life History and Growth Requirements of the Domoic Acid Producer Nitzschia pungens f. multiseries from Galveston Bay

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Introduction

The increasing number and diversity of reported shellfish poisoning syndromes relate to the ability of mussels, clams, oysters, and other molluscs to concentrate pathogenic agents from seawater and to pass these pathogens on to human consumers. Among the phytoplankton, dinoflagellates have been most readily identified as agents of shellfish toxins; however, in 1987, for the first time a diatom, Nitzschia pungens Grunow f. multiseries Hasle, was found to be the source of a human intoxication, Amnesic Shellfish Poisoning (ASP), in Canada. In 1989, Fryxell discovered this same diatom resident in Galveston, Texas waters. Clonal cultures of N. pungens f. multiseries and the species' other form, N. pungens f. pungens, were isolated from Galveston and have been maintained at Texas A&M, Department of Oceanography, since May, 1989. Tests have proven that the Texas clones are capable of producing the ASP toxin, domoic acid.

Amnesic Shellfish Poisoning

Only Paralytic Shellfish Poisoning (PSP) has occurred regularly in North America, along the Pacific coast from the Aleutian Islands to northern California and at two locations in Mexico, and along the Atlantic coast from New England to the Maritime Provinces of Canada and the Gulf of St. Lawrence (Shumway, 1990). Outbreaks of PSP are generally associated with blooms of saxitoxin-producing dinoflagellates in coastal waters during summer. Late in 1987, a new syndrome was reported from Canada. Amnesic Shellfish Poisoning (ASP) resulted from consumption of blue mussels (Mytilus edulis Linnaeus) found to be tainted with the glutamate agonist domoic acid (DA). From the 145 probable cases reported at the time, four deaths were attributed to ASP; after three years, two dozen victims still suffer loss of short-term memory, hence the name (Perl et al., 1990).

The mussels, commercially farmed in estuaries of Prince Edward Island, Canada, had been harvested after an anomalous bloom of the diatom Nitzschia pungens f. multiseries, which Fryxell, at TAMU, was asked by Canada's Atlantic Research Laboratory (ARL), Halifax, to help identify in December, 1987. Canadian workers quickly established N. pungens f. multiseries as the domoic acid producer. The diatom has since bloomed annually in and around the same estuaries, although possibly in somewhat lesser concentrations each year (L. Hanic, personal communication to Fryxell, 1990). Due to effective phytoplankton monitoring and "mussel watch" programs instituted in response to the 1987 outbreak, there have been no further reports of ASP in Canada.

In its more extreme symptoms and long-term effects, ASP is clearly distinct from other mollusc-associated intoxications (Table I). Perl et al. (1990) reported that within 24 hours of consuming the domoic acid-tainted mussels, victims reported rapid onset of confusion, disorientation, and memory loss. Other symptoms peculiar to ASP include anorexia, incapacitating headache, unusual eye movements, involuntary grimacing, and decreased reaction to deep pain (Perl, 1989). While these symptoms distinguish ASP among shellfish poisonings, they and the syndrome's more ordinary symptoms -- nausea, vomiting, diarrhea, abdominal cramps -- parallel common emergency room complaints, and thus, many cases of ASP may well have gone, and may continue to go, unrecognized and unreported.

The Neurotoxin Domoic Acid

Domoic acid (DA) is a water soluble, heat stable, excitatory glutamic acid analog originally isolated 35 years ago in Japan by workers studying the macroalgal family Rhodomelaceae. At that time, it was extracted from the red alga Chondria armata (Kützing) Okamura, known as "domoi" in Japan. The compound has since been discovered in other species of the Rhodomelaceae, namely Alsidium corallinum C. Agardh and C. baileyana (Montagne) Harvey (Bates et al., 1988; Bird et al., 1988). It has been reported that Japanese folk medicine practitioners have prescribed a weak tea of domoi as an intestinal vermifuge; it is known to have insecticidal effects as well (Takemoto & Daigo, 1958; Maeda et al., 1984; Quilliam & Wright, 1989).

The effects of DA resemble those of the well-studied kainic acid, another neurotransmitting glutamate analog. Domoic acid, however, is two to three times more potent than kainic acid, and 30 to 100 times stronger than glutamic acid (Perl et al., 1990). DA binds to kainic receptor sites in the nervous system, but unlike kainic acid the domoic binding is likely to be permanent. Nervous tissue thus sustains constant bombardment as receptors continuously transmit impulses while DA is bound. Soon receptors burn out from the incessant transmission, resulting in lesions and the memory loss characteristic of ASP (Addison and Stewart, 1989).

The Toxic Diatom Nitzschia pungens forma multiseries

Taxonomically, the pennate diatom genus Nitzschia has been subdivided into several groups, one of which is Pseudonitzschia. The pointed, spindle-shaped diatoms of this group are noted for their distinctive pattern of chain formation by overlapping tips. Hasle (1965) differentiated two forms of the species N. pungens Grunow: the nominate f. pungens, characterized by two rows of pores between costae, or ribs, and f. multiseries Hasle, with three or four rows of pores. As Hasle did 25 years ago, we have found significant overlap in other measurements of the two forms (Table II). Although the nominate form can be positively identified under 100 power and oil immersion, light microscopy is not sufficient to positively establish the identity of N. pungens f. multiseries; the electron microscope is needed to resolve its several rows of pores.

N. pungens' resemblance to other Pseudonitzschias has led to misidentifications in the past. N. seriata, for one example, has been mistaken for N. pungens and vice versa. Hasle (1965) authoritatively reported N. pungens f. multiseries present in coastal waters of the North Atlantic (Oslofjord, Drobak, Norway, and Chesapeake Bay); in coastal South Atlantic waters off Atlantida, Uruguay, and Quequen, Argentina; and from the northeast Pacific coast of Oregon. The form's presence has since been confirmed in estuaries of Prince Edward Island, Canada; Vancouver, British Columbia, Canada; Jinhae Bay, Korea; Tokyo Bay, Japan; and Galveston Bay, Texas, USA (Fryxell et al., 1990).

The discovery of N. pungens f. multiseries in Galveston waters came about through the conjunction of university teaching and basic research. In February, 1989, Fryxell guided members of her graduate oceanography course to sites on Galveston Island that she had been sampling routinely for a number of years. The students gathered and preserved samples and returned to the laboratory in College Station to prepare them for light and electron microscopy. A month later, when examining student-prepared stubs under the electron beam, Fryxell was disturbed to recognize the domoic acid producing diatom among the phytoplankton from Galveston.

Methods

A 15-month long, Nitzschia pungens-centered sampling program was begun in May, 1989. Six stations (five locales) on Galveston Island and neighboring Pelican Island were designated for monthly water and net samples to be taken at or about the time of the full moon: the TAMUG oyster hatchery on Offatt's Bayou; a city "pocket park" on 61st St., also on Offatt's Bayou; Galveston Channel at the TAMUG campus; the 89th St. Fishing Pier; and East Lagoon at incoming tide and again at outgoing tide (Fig. 1). Net hauls and water samples were taken at each station; temperature, salinity, weather conditions, and tidal information were also noted.

Isolations of short chains were placed in 24-well plastic test plates, each 3.5 ml well containing f/2 enriched seawater medium (Guillard, 1975) at 25 or 28 ppt salinity. Later, Pyrex and plastic petri dishes were used. The clones were positively identified via electron microscopy performed at the Texas A&M EM Center. Clonal cultures are maintained at windows in a north-facing room kept at 20°C. Daily observations of life stages and growth habits were made using dissecting and compound light microscopes.

Several experiments were conducted to establish growth rates for correlation to life stages, salinity and temperature preferences, and production of domoic acid (Reap, 1990). Samples of the Galveston clones were deep-frozen at predetermined intervals during the growth experiments and were later shipped to the ARL in Halifax, Nova Scotia, for analysis of domoic acid productivity. The Canadian lab is standardizing testing procedures for DA, using HPLC and UV fluorescence methods.

Results and Discussion

A total of 51 clones of both forms of N. pungens were isolated from Galveston, 30 of the nominate f. pungens and 21 of the toxic f. multiseries. Enriched seawater medium (f/2) was found to support the growth of N. pungens f. multiseries very well. Month by month, field samples were dominated by only one form, although both forms were often present in the same sample. N. pungens f. multiseries was most abundant in winter and spring samples, while the non-toxic form was more prevalent during summer and fall. The diatom was seen in Galveston the first time (February, 1989) in surface water of 13.4° C; the first isolates of N. pungens f. multiseries were taken from May and July, 1989 samples of Galveston water of temperatures ranging from 19-30° C. All isolates of N. pungens f. multiseries have been taken from samples of above 27° C water.

Phytoplankton of more southerly distribution is temporarily introduced into Oslofjord every autumn, and Hasle (1965) speculated that N. pungens f. multiseries might be such an alga even though it apparently thrived in the cold Norwegian coastal waters. Around Prince Edward Island, the toxic form is first noticed among the phytoplankton in August, with, since 1987, peak concentrations expected in October and November and disappears in January after severe weather sets in (Smith et al., 1990).

Results from ARL establish that Texas clones of N. pungens f. multiseries can produce domoic acid in per cell volumes comparable to those of Canadian clones when cell numbers are brought to bloom concentrations ($>10^6$ cells per liter) during stationary growth phase. Subba Rao et al. (1990) report maximum production of DA by cultures of Canadian clones at 0.3 to 2.0 pg per cell.

Daily observation of both forms of N. pungens revealed that, in culture, the diatoms follow a benthic-planktonic-benthic pattern in their life cycle. After a fresh isolation, or recent transfer of an established culture, single cells or doublet chains are distributed about the floor of the test plate well or petri dish. A newly isolated clone sometimes requires as long as 10 days before chain formation can be observed, although most often significant growth is seen in 3-6 days. Established clones transferred to fresh medium can fill the bottom of a well in less than 48 hours. Under the 40X magnification of a dissecting microscope, individual chains are observed moving against the substrate and/or against other chains. A chain moves as a coordinated whole, not as individual cells acting independently. When chains achieve lengths of 4 or more cells, they become planktonic and distributed throughout all levels of the well. As the member cells continue to reproduce, the chains continue to lengthen, sometimes measuring as long as a centimeter, or more than 100 cells. As they lengthen, the chains become sinuously spiralled, leading to the formation of "rafts" of chains circulating as clumps. As log phase growth (.48-.7 divisions per cell per day) slows to stationary phase rates (8-13 days from commencement of log phase), the well becomes clogged and matted with chains. Then, suddenly, the planktonic chains disassemble and short chains (4 or fewer cells in length), doublets, and single cells again litter the bottom of the well.

We have found that planktonic chains periodically (10-14 day intervals) transferred into new medium can be maintained in the planktonic state and in log phase almost indefinitely under the light and temperature regime of our laboratory (natural northern light and 20° C). Moreover, even after the senescent phase has been reached, single cells and doublets remaining planktonic can be pipetted into fresh medium and can then initiate a new "bloom." Smith et al. (1990) have shown the autumn 1989 bloom of the diatom to be bimodal in nature, having a first peak in mid- October and a second in mid-November. In particular, the Cardigan River estuary in eastern Prince Edward Island is surrounded by agricultural land, and Canadian workers postulate that runoff from unusually heavy autumn rains, especially in 1988 and 1989, pumped nitrates into the estuarine system at coincidently critical points of the diatom's growth cycle, thus sustaining and prolonging the bloom periods.

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References

Addison, R.F. and J.E. Stewart. 1989. Domoic acid and the eastern Canadian mulluscan shellfish industry. Aquaculture 77:263-269.

Bates, S.S., C.J. Bird, R.K. Boyd, et al. 1988. Investigations on the source of domoic acid responsible for the outbreak of amnesic shellfish poisoning (ASP) in eastern Prince Edward Island. Atlantic Research Laboratory Technical Report 57.

Bird, C.J., R.K. Boyd, D. Brewer, et al. 1988. Identification of domoic acid as the toxic agent responsible for the P.E.I. contaminated mussel incident. Atlantic Research Laboratory Technical Report 56.

Fryxell, G.A., M.E. Reap, and D.L. Valencic. 1990. Nitzschia pungens f. multiseries Hasle: observations of a known neurotoxic diatom. Nova Hedwigia. In press.

Guillard, R.R.L. 1975. Culture of phytoplankton for feeding marine invertebrates. Pages 29-30 IN : Smith, W.L. & M.H. Chanly (eds.), Culture of Marine Invertebrate Animals. Plenum Press: New York.

Hasle, G.R. 1965. Nitzschia and Fragilariopsis species studied in the light and electron microscopes. II. The group Pseudonitzschia. Skrifter Utgitt av Det Norske Videnskaps- Akademi I Oslo, Mat.-Naturv. Klasse Ny Series 18.

Perl, T.M. 1989. Human health aspects. Proc. First Canadian Workshop on Harmful Marine Algae, Moncton N.B., Sept. 27-28, 1989:22.

_____, L. Bedard, T. Kosatsky, et al. 1990. An outbreak of toxic encephalopathy caused by eating mussels contaminated with domoic acid. N. Engl. J. Med. 322:1775-1780.

Maeda, M., T. Kodama, T. Tanaka, et al. 1984. Insecticidal and neuromuscular activities of domoic acid and its related compounds. J. Pesticide Sci. 9:27-32.

Quilliam, M.A. and J.L.C. Wright. 1989. The amnesic shellfish poisoning mystery. Anal. Chem. 61:1052-1060.

Reap, M.E. 1990. Observations of Nitzschia pungens Grunow f. multiseries Hasle, the domoic acid producing diatom. MS thesis, Texas A&M University. In preparation.

Shumway, S.E. 1990. A review of the effects of algal blooms on shellfish and aquaculture. J. World Aquaculture Soc. 21(2):65- 104.

Smith, J., P. Odense, R. Angus, et al. 1990. Domoic acid levels in field and laboratory populations of Nitzschia pungens forma multiseries and Nitzschia pungens forma pungens. Bull. Canadian Aquaculture Assn. 90(4): in press.

Subba Rao, D.V., A.S.W. deFreitas, M.A. Quilliam, R. Pocklington, & S.S. Bates. 1990. Rates of production of domoic acid, a neurotoxic amino acid, in the pennate marine diatom Nitzschia pungens. Pages 413-417 IN: Graneli, E. et al. (Eds.), Toxic Marine Phytoplankton. Elsevier: New York.

Takemoto, T. and K. Daigo. 1958. Constituents of Chondria armata. Chemical Pharmacology Bull., Tokyo 6:578-580.

Table I. Epidemiology and symptomology of Paralytic Shellfish Poisoning and Amnesic Shellfish Poisoning, two intoxications found in North American coastal waters (after Perl, 1989).

	PSP	ASP
organism	*Alexandrium tamarense* & other dinoflagellates	*Nitzschia pungens* f. *multiseries*
toxin	saxitoxin & its derivatives	domoic acid
season	May - November	November - January
vehicle	clams, mussels, etc.	mussels
location	Pacific & Atlantic coasts of United States & Canada	Prince Edward Island, Canada
incubation	within 30 min.	15 min. to 24 hours
duration	6 hours to 7 days	hours to years (permanent)
symptoms	nausea, vomiting, abdominal pain; diarrhea less common	gagging, nausea, vomiting, diarrhea, abdominal pain, anorexia
neurologic	paresthesia, floating feeling	decreased reaction to deep pain; long-term neuropathy
motor	weakness, motor & respiratory paralysis	none
cranial nerves	dysarthria, dysphonia, dysphagia	dysarthria, paresis, unusual ocular movements
cerebellum	vertigo, ataxia, nystagmus	dizzyness, loss of balance, ataxia
cardiovascular	tachycardia, EKG changes	blood pressure fluctuations, arrhythmias
other	aphasia; headache, dysuria	headache; disorientation, confusion, memory loss, hallucinations, seizures
fatalities	2.6 - 23.2%	3% - ?
treatment	life support	symptoms treated

Table II. Morphological measurements of the two forms of *Nitzschia pungens* (after Hasle, 1965).

	length x width in µm	fibulae in 10µm	costae in 10µm	rows of pores between costae
N. pungens f. *pungens*	74-142 x 3-4.5	9-15	9-15	2
N. pungens f. *multiseries*	68-140 x 4-5	10-18	10-18	3 or 4

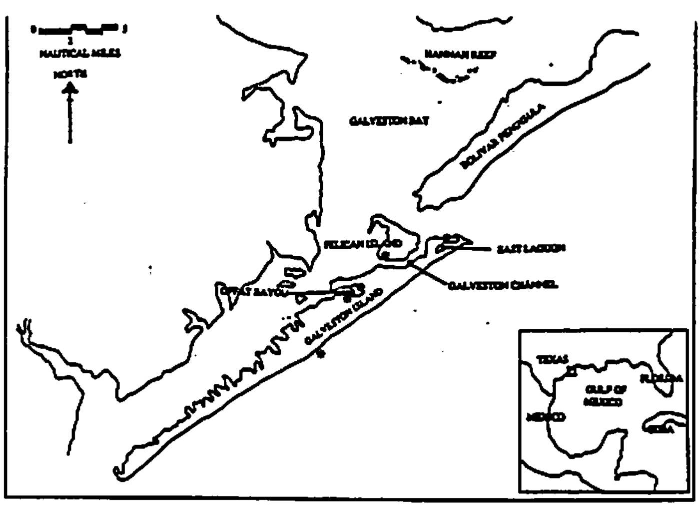

Fig. 1. Map of Galveston Island, Texas, U.S.A., on the Gulf of Mexico.

Salt Marsh Creation in the Nueces River Delta, Texas: Establishment of Estuarine Faunal Use.

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Abstract

To mitigate wetland losses associated with the deepening of the Corpus Christi Ship Channel in Texas, the Port of Corpus Christi was required to create an 80 ha. (200 acre) marsh comprised of deep, shallow, and emergent estuarine habitat. High marsh in the Nueces River delta was excavated to provide 36 ha. (90 acres) to be planted with Spartina alterniflora, with the remainder forming a complex of channels and ponds. Although marsh creation techniques have provided areas that come to look like natural marshes, the extent of use of artificially created marsh habitat by estuarine species is not well known. Stations in the mitigation site and an adjacent natural marsh were sampled monthly from June, 1989 through June, 1990 for benthic infauna, epifaunal invertebrates, and fish and were also observed for bird activity. This study examined the establishment of faunal use of the excavated site and compared its faunal assemblages with those of a nearby natural Spartina alterniflora marsh as the first part of an ongoing project to determine the success of the mitigation area. Opportunistic benthic invertebrates, such as capitellid and spionid polychaetes, and juvenile fish and shellfish are using the area. Shorebirds and some migrating ducks use the creation site for feeding and resting. The mitigation site exhibited high but uneven faunal use, while the natural marsh showed more predictable seasonal cycles.

Introduction

The many values of wetlands have been well established over the last two decades (Greeson et al., 1979; Rabalais, 1980). Correspondingly, there has been increasing pressure to balance environmental protection and economic development (Fehring et al., 1979). Mitigation of unavoidable adverse environmental impacts of permitted projects is implemented under Section 404 of the Clean Water Act and includes avoiding, minimizing, repairing, restoring, or compensating for wetland losses. Of these methods, compensation by creation of new marsh has become a mitigation tool for those who must balance the demands for coastal development against the needs for wetland preservation (Race and Christi, 1982).

Although marsh creation techniques have provided areas that come to look like natural marshes, the question of whether created wetlands can replace the functional value of destroyed areas has not been answered to the satisfaction of many researchers. Race and Christi (1982) questioned whether there is sufficient evidence to indicate that created wetlands can provide the biological and hydrological functions of natural marshes. Quammen (1986) found that most studies of mitigation projects have judged success on the basis of permit compliance or implementation of restoration effort. Colonization by compatible communities of benthic invertebrates and utilization by fish and wildlife appears to accompany vegetative establishment (Garbisch, 1977). However, density and survival of fauna in artificially created marsh habitats is not well documented (Rader, 1984).

Marsh creation in Texas has typically involved planting on dredged material deposited in shallow water (Chabreck, 1989). Such mitigation projects along the south Texas coast have met with only limited success. The critical factors that have influenced success or failure of marsh projects include site selection incorporating low energy levels, proper intertidal slope, suitable elevation, proper substrate, and conditioning time (Cobb, 1987). Judgements of success have primarily been based on vegetative growth; none of the local studies have evaluated the faunal use of created habitats.

The deepening of the Corpus Christi Ship Channel caused wetland losses that required mitigation by the creation of a substitute environment. An 80 ha. (200 acre) salt marsh site was designed and excavated to consist of deep (to 1 m), shallow, and emergent estuarine habitat, with 36 ha. (90 acres) supporting emergent vegetation (U.S. Army COE, 1982). The site has been connected to the Nueces Bay estuary since June, 1988 to saturate the substrate prior to planting and allow channel margins to reach a stable angle of repose. Initial planting of 12 ha. (30 acres) with Spartina alterniflora occurred in February, 1990. The marsh creation goal is a minimum of 70% vegetative coverage of mean sea level (MSL)-designated areas within three to four years (U.S. Department of the Interior, 1984).

The objectives of this study were to follow the natural succession of flora, examine the establishment of faunal use of the excavated site, compare faunal assemblages with those of a nearby Spartina alterniflora marsh and associated channels, and determine if the hydrologic parameters of the mitigation site fit the requirements for marsh creation.

Study area

The 80 ha. salt marsh creation site is located on the southeastern coast of Texas in the river-influenced western edge of the Nueces-Corpus Christi Bay estuary (27°52'N, 92°32'30"W). Salt marsh on the Nueces delta covers about 5850 ha. and is primarily a high marsh and sacahuista, Spartina spartinae, community with 35 ha. supporting Spartina alterniflora (Espey, Huston and Assoc., 1981). Thirty-six ha. were excavated to MSL and are designated to support emergent vegetation, with the remainder forming a complex of ponds and channels with elevqtions ranging from -0.3 m to -0.6 m MSL and an island with elevations of +0.3 m to +1.2 m MSL (Fig. 1). The site is located approximately 120 m north of the Nueces River and just south of a channel that connects it to Nueces Bay and the adjacent natural marsh system of Rincon Bayou.

The climate of the region is subtropical and semiarid with hot summers and, generally, mild winters, although freezes can occur. Seasonal distribution of rainfall is bimodal, peaking in the spring and fall. The combined effects of warm temperatures and moderate rainfall result in an annual net moisture deficit. Prevailing winds are southeasterly for most of the year, with strong northerly winds during winter frontal passages. Wind movements are calm less than 5% of the time. Tides are primarily diurnal with an average amplitude of 10 cm, while seasonal water levels create a tidal range of about 1 m. Tidal range and duration are primarily controlled by wind. Tidal exchange with the Gulf of Mexico is through the Aransas Pass inlet. Freshwater inflows are from precipitation runoff and input from the Nueces River (Brown et al., 1976).

Methods and Materials

Three locations within the mitigation site and one in the adjacent natural marsh were sampled monthly from June, 1989 through June, 1990. Permanent transects included three strata of the marsh system: 1) elevation designed to support *Spartina alterniflora* (designated as "MSL" in the project plans); 2) adjacent channel edge; and 3) tidal pond. Salinity, temperature, pH, and dissolved oxygen were measured monthly in the channel with a Hydrolab Surveyor II. Natural plant succession was documented through seasonal photographs.

Three replicate, 10 cm-deep substrate cores were taken with a 10.16 cm-diameter PVC sampler from each location and strata, put in 0.5 mm saran mesh "biobags," and placed in 10% formalin/seawater with rose bengal. Nektonic and epibenthic fish and invertebrates were sampled with a benthic marsh net (Pullen et al., 1968). The 1 m-wide net was pulled by rope along a 25 m length at right angles to the transects in each of the strata. Organisms were removed from the net by hand and placed in 10% formalin with rose bengal. In the laboratory, samples were washed through a 0.5 mm sieve. Organisms were sorted, counted, and identified to the lowest feasible taxa. Infaunal density was determined by multiplying the number of organisms by 41.1 (the number derived from dividing the volume of the core sample into a 10 cm-deep meter square area). Epifaunal density was determined by dividing the number of organisms by 25. Bird counts were taken within a 50 m^2 area around each permanent transect. Two half-hour period counts were taken at each location approximately twice a month.

Hydrologic parameters were compared between the mitigation site and the natural marsh using student t-tests. Species composition and seasonal trends of faunal utilization of both areas were also analyzed. Faunal density was compared between the mitigation site and the natural marsh using the student t-test. The Shannon-Wiener diversity index (H') (Smith, 1980) was computed to measure species diversity.

Results and Discussion

Hydrologic parameters

MSL areas in the mitigation site were partially to totally submerged on 92% of the sampling days, while the Spartina alterniflora in the natural marsh was partially to totally submerged on 77% of the sampling days. Mitigation site channels excavated to 0.3-0.6 m below MSL were over a meter deep during seasonal high water periods. The channel in the natural marsh had a maximum depth of 0.5 m, while during December and January it held only a few centimeters of water. Salinities ranged from a low of 16.3 ppt to 50.0 ppt, with an average of 36.5 ppt. Salinity trends within the natural marsh system paralleled those of the mitigation site but salinity in the natural marsh system was higher in all months except February and March (Fig. 2). Water temperatures ranged from 6.3°C to 33.4°C, with an average of 22.8°C. The natural marsh had a greater temperature range than the mitigation site. Dissolved oxygen ranged from 4.71-14.40 mg/l, with the natural marsh having a slightly higher average value (7.72 mg/l) than the mitigation site (7.07 mg/l). The range of pH values was 6.98-8.59; both locations had similar averages. Natural plant succession has not occurred in the mitigation site except for some slight (less than one ha.) Batis maritima, Salicornia virginica, and Distichlis spicata growth along the higher elevation northern edge adjacent to the natural marsh. Field observations indicate that 12 ha. of Spartina alterniflora planted in February failed to take hold and survive.

A two-year precipitation deficit of 56.5 cm (NOAA, 1990) created drought conditions during the first half of the study. This is reflected in the salinity levels reaching 50.0 ppt in a salt marsh area that would typically be expected to have salinities averaging below the seawater value of 35 ppt. A mandated water release of 10,000 acre-feet from Lake Corpus Christi (Texas Water Commission, 1990) contributed to the drop in salinity observed in May, 1990. Lower average salinity and temperature in the mitigation site probably reflect a more direct association with Nueces Bay through the artificial channel that leads directly to the bay and deeper channels, resulting in less evaporation. Higher average dissolved oxygen in the natural marsh may reflect the presence of vegetation, but since phytoplankton was not measured the amount attributed to presence of vegetation cannot be analyzed. Student t-tests comparing means of mitigation site and natural marsh hydrologic parameters showed no significant differences between the two areas at $P<0.05$. The effect of wind on the mitigation site was not analyzed in this study, but field observations indicate that high energy will be a problematical factor in the success of vegetation establishment at this site.

Benthic Infauna

Twenty-four benthic infaunal species representing 3 phyla were identified from the two sites. Polychaetes were represented by 11 species, crustaceans by 10, and molluscs by 3. The mitigation site contained 22 infaunal species, 7 of which did not occur in the natural marsh. Benthic composition at the mitigation site was 42.5% polychaete, 57.0% crustacea, and 0.5% mollusc (Fig. 3A). The natural marsh had 16 species including 2 that did not occur in the mitigation site, and benthic composition was 92.8% polychaete and 7.2% crustacea (Fig. 3B). The number of species was lower in the natural marsh in every month except October. At a dredge spoil mitigation site in Bolivar, Texas, Newling and Landin (1985) found benthic invertebrates colonized the site in abundance within 7 months. More species, particularly less common ones, were found in the created area, with abundance equal to or lower than an adjacent marsh, depending on season.

Abundances were somewhat parallel at the two locations through the summer and fall (Fig 4A). The natural marsh showed slight peaks in abundance in October, 1989 and June, 1990 but otherwise maintained a fairly steady level. Abundance of benthic organisms at the mitigation site showed extreme variations in winter and spring months with great peaks alternating with significant declines. The benthic community here was dominated by the amphipod, Corophium louisianum, (54%) and the polychaete, Streblospio benedicti, (31%), with the polychaetes, Mediomastus californiensis, and, Laeonereis culveri, also present. Mulinia lateralis was the dominant mollusc, but accounted for less than 1% of total benthic abundance. Dominant benthic infauna in the natural marsh were the polychaetes, S. benedicti, (41%), M. californiensis, (19%), and Capitella capitata, (14%). Amphipods were present in small numbers, with C. louisianum just slightly more abundant than three other amphipod species. No molluscs were found in the natural marsh. Numerical dominance by C. louisianum at the mitigation site resulted from extremely high numbers occurring in samples from one mitigation station (densities up to $35{,}000/m^2$). Its overwhelming dominance masks a lower density at other stations, but a varying seasonal abundance pattern still emerges. The high presence in one area indicates a microhabitat favoring this amphipod. However, factors that influence distribution and abundance of benthic infauna are poorly understood (Rader, 1984).

Benthic infauna density in the mitigation site was $3014.3/m^2$, with species diversity index $H'=1.82$. Density in the natural marsh was $796.2/m^2$

and species diversity index H'=2.57. Both the mitigation site and the natural marsh show low densities compared to salt marshes in other regions. Benthic infaunal densities in a North Carolina marsh averaged $7600/m^2$ and seasonal patterns varied by species, with abundances greatest in winter and spring (Cammen, 1979). Student t-tests showed differences at $P<0.01$ between the mitigation site and the natural marsh, with differences also between mitigation site and natural marsh MSL/Spartina and tidal pond strata, but not between channel strata at $P<0.05$. Cammen et al. (1976) compared two mitigation areas in North Carolina with adjacent natural areas and concluded that where the elevational difference between plots was slight, infaunal communities were quantitatively and qualitatively similar, but where the difference in elevation was large, communities were dissimilar.

Epifaunal Invertebrates and Nekton

A total of 37 species of epifauna or nekton representing 5 phyla were collected from the two sites. Invertebrate species included 7 crustacea, 4 molluscs, 2 bryozoans, and 1 hydroid; vertebrates included 23 fish species. The mitigation site, containing 69.2% crustacea, 23.5% fish, 7.8% molluscs, and 0.5% bryozoan and hydroid (Fig. 3C), had 34 total species, 14 of which did not occur in the natural marsh. Crustacea made up 72.9% of the total abundance in the natural marsh, while fish accounted for 26.4% and molluscs for 0.7% (Fig. 3D). Twenty-three species occurred in the natural marsh, including 3 not found in the mitigation site.

Both the natural marsh and the mitigation site had moderately high abundances in June, 1989, with lower numbers in the remaining summer months (Fig. 4B). The natural marsh had higher abundances than the mitigation site in July with a slight peak in August, but winter numbers dropped below those in the mitigation site, which showed a slight peak in November. The mitigation site showed a large peak in February, while the natural marsh exhibited a smaller one. At both locations, abundance fell somewhat in March. Abundances at the two sites diverged dramatically in the remaining three months of the study. Abundance continued to climb in the natural marsh, while remaining low in the mitigation site until a slight rise in June, 1990. Penaeus aztecus, P. setiferus, and Palaeomonetes pugio were somewhat more abundant in the natural marsh than the mitigation site, while fish abundance varied according to species. Leiostomus xanthurus and Gobiosoma bosci were much more abundant at the mitigation site, while Brevoortia patronus and Menidia beryllina dominated the marsh abundance. Callinectes sapidus, Anchoa mitchilli, Lagodon rhomboides, and Paralichthys lethostigma were present in about the same numbers at both locations. Zimmerman and Minello (1984) found that P. pugio, P. caztecus, and B. patronus selected vegetative habitat, while L. xanthurus and P. setiferus preferred unvegetated bottom. Since the mitigation site has virtually no vegetation and the marsh has a combination of Spartina alterniflora, shallow creeks, and ponds, vegetation preference may not be the only factor influencing species habitat use. Utilization by estuarine fauna depends on factors other than just presence of vegetation. Tidal flooding patterns and marsh geomorphology control access, while low diel tides and high seasonal amplitude extend access during periods of relatively high water levels (Minello et al., 1987). Espey, Huston and Associates (1981) concluded that large portions of Rincon Bayou are rarely flooded, so much is not utilized by estuarine organisms. The deeper channels and more frequent submergence of the mitigation site allows more access by estuarine species than similar areas in the natural marsh.

Mitigation site average density of epifauna and nekton was 11.1 individuals/m^2 and species diversity (H') was 2.48, while in the natural marsh density was 11.4 individuals/m^2 and H' was 1.94. Evaluations of transplanted dredge disposal sites in Texas and North Carolina showed that transplanted marshes had lower abundances of macrofauna, with the exception of C. sapidus, when compared to adjacent natural sites (Minello et al., 1987). Several studies emphasize that quantification of use by motile estuarine species is hampered by high weekly variability and sampling difficulties (Boesch and Turner, 1984; Livingston, 1987).

Birds

Wading shorebirds, aquatic shorebirds, herons, egrets, white pelicans, and cormorants were using the mitigation site. Aquatic shorebirds were present 36% of the time, mostly when the mitigation site was partially or totally submerged. Gulls and terns in large numbers occasionally used emergent areas to rest. Wading shorebirds, such as black-neck stilts, sandpipers, willets, yellow legs, plovers, and avocets fed on emergent and partially submerged MSL areas and were present 19% of the time. Shorebird predation has been shown to reduce macrobenthic densities on mud flats at low tide (Quammen, 1984), and along with other natant component predation (Knieb, 1984) may be partially responsible for lower summer infaunal abundances. Herons and egrets used the mitigation site 14% of the time at various submergence levels, but not during high water periods when MSL areas were often up to 0.5 m submerged. White pelicans and cormorants occurred frequently throughout the mitigation site, but only occasionally (20%) in the areas being counted. The natural marsh was used more frequently by herons and egrets (33%), particularly along channel edges, and had some wintering waterfowl (8%), such as scaup and bufflehead, in the channels. White pelicans, wading and aquatic shorebirds used the natural marsh, but with lesser frequencies than the mitigation site (10%, 6%, and 18%, respectively). Newling and Landin (1985) found that more shorebirds used the marsh creation site at Bolivar Peninsula, Texas, during the early stages of development. Reimold et al. (1978) reported that bird species associated with open spaces began to disappear as vegetation became established and were replaced by marsh species such as egrets and northern harriers.

Conclusions

Benthic infauna, epibenthic invertebrates, and fish are present in the 86 ha. salt marsh creation site in the Nueces Delta. Species composition, abundance, and diversity vary between the mitigation site and the adjacent natural marsh, especially in terms of benthic infauna. Faunal components reflect the influence of Nueces Bay as well as the adjacent natural marsh. Mitigation site infauna showed widely fluctuating abundances, possibly due to uneven habitat development in the absence of vegetation. Patterns in this study indicate that the mitigation site has a less stable infaunal community than the adjacent natural marsh, with opportunistic and rapidly colonizing species dominant. Local drought conditions may have contributed both to low densities observed and species and numbers available for colonization of the mitigation site. Patchy distribution may also be a contributing factor to the observed variations. Motile estuarine faunal use showed less difference between the mitigation site and the natural marsh. Hydrographic parameters are similar in both areas, but geomorphology differs considerably.

Acknowledgements

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References

Boesch, D.F. and R.E. Turner. 1984. Dependence of fishery species on salt marshes: the role of food and refuge. Estuaries 7l(4A):460-468.

Brown, L.F., J.L. Brewton, J.H. McGowen, T.J. Evans, E.L. Fisher, and C.G. Groat. 1976. Environmental Geologic Atlas of the Texas Coastal Zone. Corpus Christi area. Univ. Tex., Bur. Econ. Geol., Austin. 123 pp. plus maps.

Cammen, L.M. 1979. The macro-infauna of a North Carolina salt marsh. Am. Mid. Natur. 102(2):244-253.

__________, E.D. Seneca, and B.J. Copeland. 1976. Animal colonization of man-initiated salt marshes on dredge spoil. North Carolina State University. Tech. Paper UNC-SG-74-15. 58 pp.

Chabreck, R.H. 1989. Creation, restoration and enhancement of marshes of the north central Gulf Coast. In: J.A. Kusler and M.E. Kentula (eds). Wetland creation and restoration: the status of the science, Vol. 1: Region reviews. U.S. EPA, Envir. Res. Lab., Corvalis, OR. EPA/600/3-89/038.

Cobb, R.A. 1987. Mitigation evaluation study for the south Texas coast, 1975-1986. U.S. Fish and Wildlife Service. Corpus Christi State University Coop. Agree. 14-16-0002-86-919. 88 pp.

Espey, Huston and Associates. 1981. Nueces marsh enhancement: a feasibility study of the introduction of river flows. Section 6, Marsh biology, pp. 6-1 to 6-60. Contract DAC W-4-81-6-0018. Doc. #81328.

Fehring, W.K., C. Giovenco, and W.Hoffman. 1979. An analysis of three marsh-creation projects in Tampa Bay resulting from regulatory requirements for mitigation. In: D.P. Cole (ed.). Proc. 6th Annual Conference on Wetlands Restoration and Creation. Hillsborough Community Coll. pp.191-206.

Garbisch, E.W. 1977. Recent and planned marsh establishment work throughout the contiguous United States: a survey and basic guidelines. U.S. Army Corp Eng., Envir. Effects Lab. Contr. Rept. D-77-3. 41 pp.

Greeson, P.E., J.R. Clark, and J.E. Clark. 1979. Wetland functions and values: the state of our understanding. American Water Resour. Assoc., Minneapolis, MN. 324 pp.

Livingston, R.J. 1987. Field sampling in estuaries: the relationship of scale to variability. Estuaries 10(3):194-207.

Minello, T.J., R.J. Zimmermann, and E.F. Klima. 1987. Creation of fishery habitat in estuaries. Tech. Rept. D-87-01, Environmental Effects Lab., U.S.Army Corp Eng. 0-87-01, 120 pp.

Newling, C.J. and M.C. Landin. 1985. Long-term monitoring of habitat development at upland and wetland dredged material disposal sites, 1974-1982. Tech. Rept. D-85-5. Environmental Lab., U.S.Army Corp Eng. 191 pp.

NOAA. 1990. Local climatological data at Corpus Christi International Airport, 1989-1990. U.S.Dept. Comm., Ashville, NC.

Pullen, E.J., C.R. Mock, and R.D. Ringo. 1968. A net for sampling the intertidal zone of an estuary. Limnol. and Ocean. 13(1):200- 202.

Quammen, M.L. 1984. Predation by shorebirds, fish and crabs on invertebrates in intertidal mudflats; an experimental test. Ecology 65:529-537.

__________. 1986. Measuring the success of wetlands mitigation. Nat. Wetlds. Newsletter 8(5):6-8.

Rabalais, N.N. 1980. Ecological values of selected coastal habitats. In: P.L. Fore and R.D. Peterson (eds). Proc. Gulf of Mexico Coastal Ecosystems Workshop. USFWS Biol. Serv. Prog., Albuquerque, NM. pp. 191-199.

Race, M.S. and D.R. Christie. 1982. Coastal zone development: mitigation, marsh creation, and decision-making. Envir. Manag. 6(4):317-328.

Rader, D.N. 1984. Salt marsh benthic invertebrates: small scale patterns of distribution and abundance. Estuaries 7(4S):413-420.

Reimold, R.J., M.A. Hardisky, and P,C. Adams. 1978. Habitat development field investigations, Buttermilk Sound marsh development site, Atlantic Intracoastal Waterway, Georgia, Appendix A: Propagation of marsh plants and post propagation monitoring. U.S. Army Corps Eng. Dredged Material Res. Prog. Tech. Rept. D-78-26. 223 pp.

Smith, R.L. 1980. Ecology and Field Biology. 3rd Ed. Harper and Row. NY. 835 pp.

Texas Water Commission. 1990. Open computer files on Texas river flow and rainfall data. 1990.

U.S. Army Corp of Engineers. 1982. Supplemental information report to the final supplement to the final environmental statement, Corpus Christi Ship Channel, Texas, 45-foot project, Inner Harbor Reach. U.S.Army Engineer District. Galveston, TX. 315 pp.

U.S. Dept. of Int., Fish & Wildlife Service, Ecological Services. 1984. Supplemental Report, Fish and Wildlife Coordination Act Report for Corpus Christi Ship Channel, Texas, 45-foot project. Inner Harbor Reach. Ltr. to U.S.Army COE dated April 4, 1984.

Zimmerman, R.J. and T.J. Minello. 1984. Densities of Penaeus aztecus, Penaeus setiferus, and other natant macrofauna in a Texas salt marsh. Estuaries 7(4A):421-443.

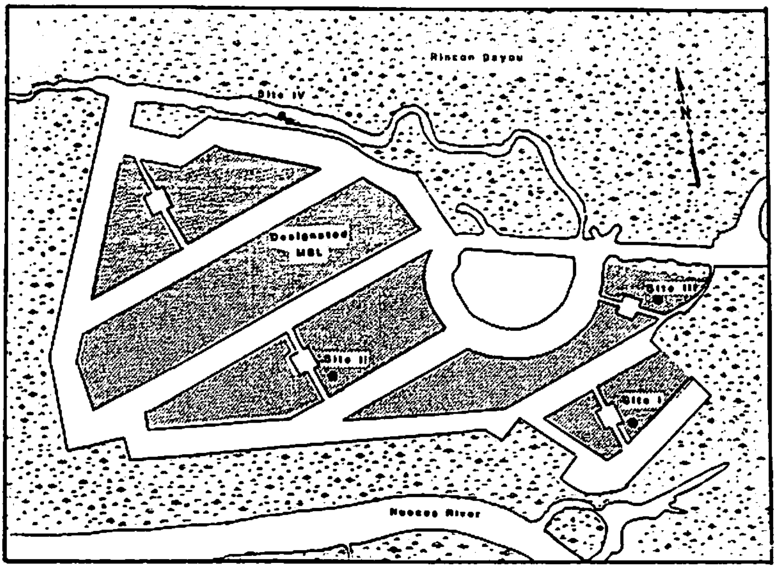


Figure 1. Salt marsh creation site on the Nueces River Delta, Texas.

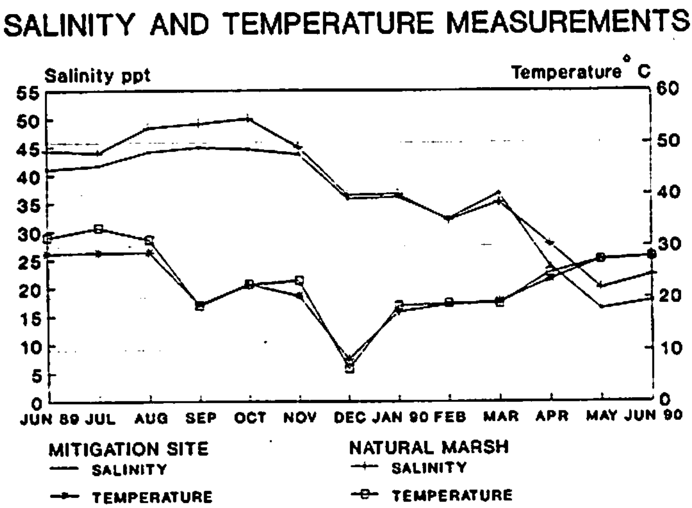


Figure 2. Salinity and temperature measurements at mitigation site and natural marsh, June 1989 through June, 1990.

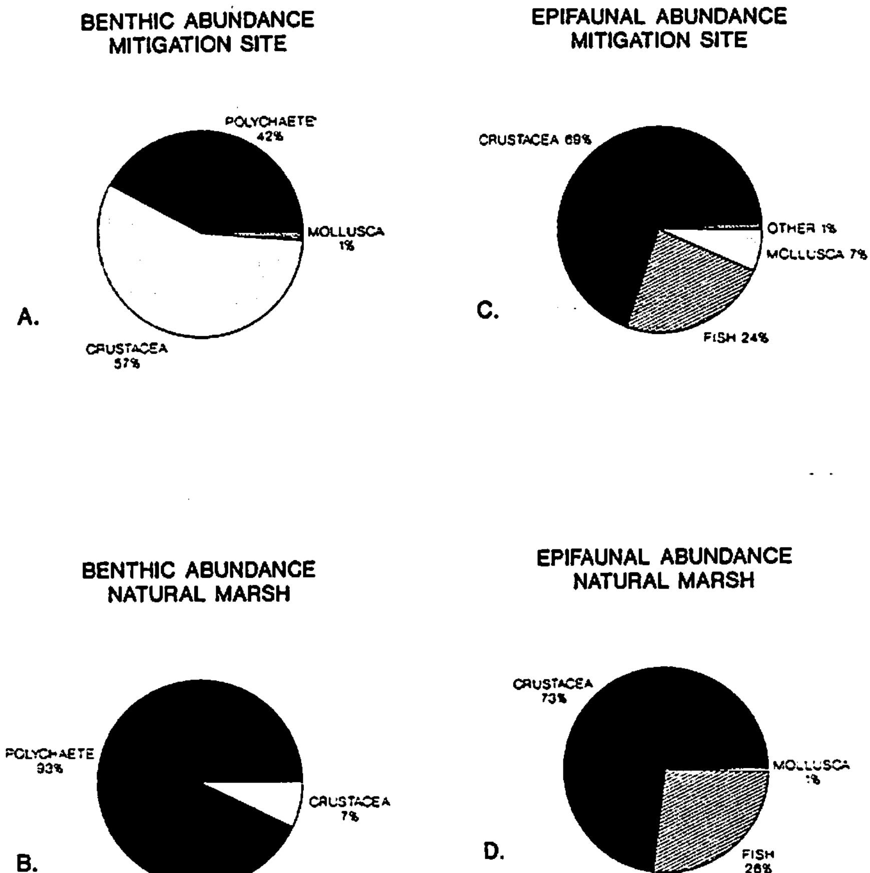
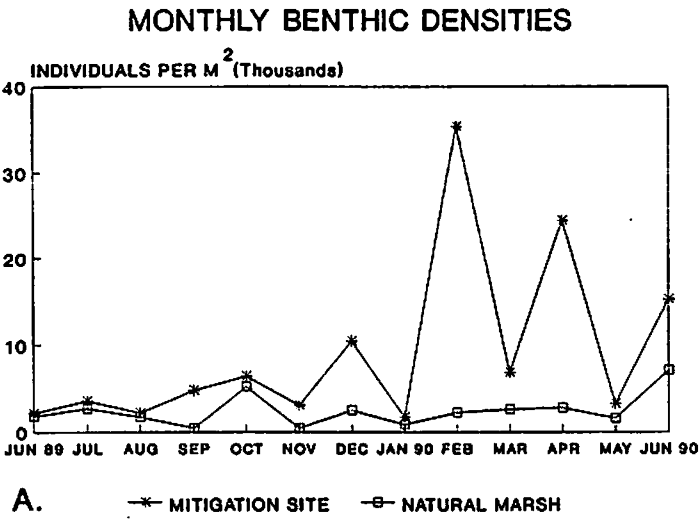


Figure 3. Abundances in per cent taxa at Nueces Delta marsh for June, 1989 through June, 1990: A. Benthic infauna, mitigation site; B. Benthic infauna, natural marsh; C. Epifauna and nekton, mitigation site; D. Epifauna and nekton, natural marsh.



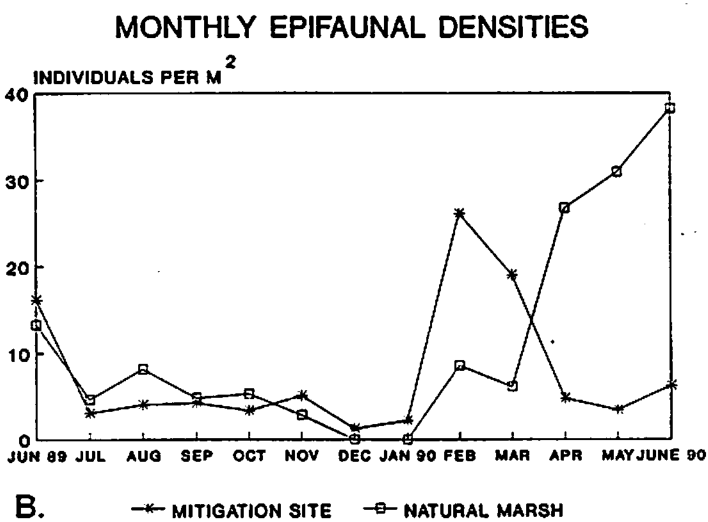


Figure 4 Monthly faunal densities at the Nueces Delta marsh for June, 1989 through June 1990: A. Benthic infauna; B. Epifauna and nekton.

Life History and Population Dynamics of Spotted Seatrout (Cynoscion nebulosus) in Louisiana

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Introduction

The spotted seatrout (Cynoscion nebulosus) is an important commercial and recreational species throughout the northern Gulf of Mexico and particularly in Louisiana. Because of the value of spotted seatrout to recreational and commercial fisheries, concern over the continued abundance of this species has become an important and controversial issue. Currently, the Louisiana recreational possession and catch limit for spotted seatrout is 25 per day with a minimum total length of 12". The commercial fishery is regulated by an annual quota of 1.25 million pounds and a size limit of 14" minimum total length (J. Shepard, pers. comm.). Debate continues between user groups with regard to the allocation of the resource and fishing quotas, and there is continuing interest in closing the commercial fishery by legislating gamefish status for spotted seatrout in Louisiana.

No comprehensive studies of the population dynamics of spotted seatrout in Louisiana have been undertaken, although numerous investigators have studied aspects of the species' life history in various locations in the northern Gulf of Mexico (eg. Arnoldi, 1982, 1984, 1985; Fontenot and Rogillio, 1970; Hein and Shepard, 1979). However, information derived from these studies may not be generally applicable throughout the range of spotted seatrout in the region (Overstreet, 1983; Iversen and Tabb, 1962; Perret, 1971; Weinstein and Yerger, 1976). Effective management of spotted seatrout and other fishery resources depends, in part, on yield-per-recruit estimates from accurate life history information (Merriner, 1980; Perret et al., 1980). Using sagittal otoliths for ageing, we described population dynamics of spotted seatrout in Louisiana waters, with particular emphasis on mortality and yield-per-recruit analysis.

Materials and Methods

Spotted seatrout (N = 2,146) were collected monthly between April, 1986 and June, 1988 from three sources: Louisiana Department of Wildlife and Fisheries' (LDWF) Finfish Sampling Program (N=1,451); the commercial gill net fishery (N=434); and the recreational hook-and-line fishery (N=261) (Wieting, 1989).

Fish were aged by viewing thin sections of sagittae otoliths using the methods of Beckman et al. (1988). We validated annulus formation by the marginal increment method (Beamish and McFarlane, 1983). Otolith measurements (N = 1,319) were used to back-calculate length at annulus formation using the method of Whitney and Carlander (1956). Mean back-calculated lengths at age for males and females were then fit by the Beverton and Holt method (Ricker, 1975) to a von Bertalanffy growth equation (Ricker, 1975). These parameters were fit by a nonlinear version of the von Bertalanffy growth equation to obtain final growth parameter estimates of L_{inf}, K, and t_0. The relationship between whole weight and total length was calculated and possible differences between sexes were tested by analysis of covariance (ANCOVA) (SAS Institute, 1985). Differences in the relationship of body length to otolith radius between sexes were also tested by ANCOVA (SAS Institute, 1985). Mortality and yield-per-recruit analysis were estimated from fishery-independent age-frequency data (N=1,110). Mortality rates were estimated from catch curve analysis and the Robson and Chapman combined estimates of survival method (Robson and Chapman, 1961). A Beverton and Holt yield-per-recruit equation (Ricker, 1975) was computed separately by sex, with sex-specific growth parameter estimates from the von Bertalanffy growth equations.

Estimated natural mortality was obtained from Pauly's equation (1979) and subtracted from the instantaneous rate of mortality to calculate fishing mortality rates. We varied values for rate of fishing (F) and age at recruitment (R) separately to determine consequent changes in yield-per-recruit for each sex.

Results

Marginal increment analysis indicated that fast growth occurred from June-November with an opaque zone or annulus forming at the margin of the otolith from December through April (Wieting, 1989). There was a significant difference in the weight-length equations of male and female spotted seatrout ($P<0.0001$), females being significantly larger than males ($P<0.0001$). Body length was positively correlated with otolith radius for both sexes (females: $R^2=0.74$, males: $R^2=0.55$, $P<0.0001$). There was a significant difference in body length- otolith radius equations between males and females ($P<0.0001$).

Because of sex-specific age and otolith growth differences, von Bertalanffy growth equations were fit separately for each sex:

Males: $Lt = 527\ (1-e^{-.339(t+.53)})$

Females: $Lt = 605\ (1-e^{-.465(t-.03)})$.

Annual survival (S) and total instantaneous rate of mortality (Z) were estimated for each sex:

males $S=0.15$, $Z=1.9$;

females $S=0.12$, $Z=2.12$.

Subtracting estimated natural mortality (0.22) from sex-specific mortality, Z, we estimated spotted seatrout fishing mortality rates of 1.90 for females and 1.67 for males. Under these fishing mortality rates, the maximum yield-per-recruit for males was at age 4.5 (431 mm TL) and a fishing rate of 1.0. For females, the corresponding maximum yield-per-recruit was at age 4.0 (509 mm TL) and a fishing rate of 1.2.

Discussion

Louisiana spotted seatrout exhibit significant sex-specific differences in growth and mortality rates which result in differences in yield-per-recruit. This poses great difficulty when the objective of fishery managers is to optimize fishery biomass. Selecting an optimum fishing rate or size restriction for combined genders does not address the existence of sex-specific growth and mortality rates.

What are the reasons for sex-specific differences in spotted seatrout life histories? Part of the answer may be that males reach maturity earlier in life, size, and season than do females. During the spawning season, male sciaenids aggregate in suitable spawning habitat (Mok and Gilmore, 1983) to attract females in spawning condition by making drumming sounds, a regular evening activity which requires substantial amounts of time and energy, reducing the amount of time males can spend on foraging. In contrast, females probably only spend time on the spawning grounds when they are ready to spawn, an average of once every 21 days (Tucker and Faulkner, 1987; Brown-Petersen et al., 1988). This difference in reproductive strategies may remove the males from the best feeding grounds, may result in slower growth throughout their reproductive lives, and may account for their smaller size at age.

Combined gender equations, often used in the literature to describe spotted seatrout weight-length relationships, may not be accurate because of gender-specific growth rates. The back- calculated lengths at age and growth rates in this study were greater than those found in most other studies of spotted seatrout in the Gulf of Mexico (Wieting, 1989). This may be the result of a number of factors: 1) most previous studies used scales for age analysis, leading to inaccurate age and growth estimates (Chilton and Beamish, 1982); 2) sampling in this study may not have accurately reflected growth of older, rarer age classes (i.e., ages > 3 for males and 4 for females); and 3) spotted seatrout may exhibit different growth rates at different life stages and a single equation for all age classes may be biased.

Studies of mortality and growth are essential to the assessment of the effects of fishing effort on yield-per-recruit. For fisheries managers, the yield-per-recruit curve is useful in estimating the limits of allowable fishing pressure to identify maximum biomass and production (Ricker, 1975; Condrey et al., 1985). Sex-specific yield-per-recruit estimates from this study indicate that maximum yield-per-recruit would be achieved by reducing the fishing mortality rate toward 1.0 for male and 1.2 for female Louisiana spotted seatrout. Maximum yield-per-recruit at current fishing mortality rates for males is at 4.5 years (431 mm, 17 inches TL) and for females is at 4.0 years (509 mm, 20 inches TL).

If minimum size limit restrictions are not sensitive to population sex ratios and age-class reproductive potential, and if the population is also subject to recruitment over-fishing, the population age structure could be altered, with long-term effects on the population. Spotted seatrout are highly fecund and their fecundity increases significantly with length and age, with maximum oocyte production at ages 3 and 4 (Wieting, 1989). Other studies from the Gulf of Mexico also suggest greatest potential fecundity at age 3, followed by ages 2 and 4 (Pearson, 1929; Tabb, 1961; Sundararaj and Suttkus, 1962; Arnoldi, 1982; Overstreet, 1983). Under the current recreational and commercial minimum size restrictions of 12 inches (305 mm) and 14 inches (356 mm), females enter the fisheries at 1.5 years and two years, respectively, and may not reach their reproductive potential, which does not occur before age 3 (18 inches, 453 mm) TL. Fisheries managers seeking to increase the yield-per-recruit of the fishery for females, could increase the minimum size limit toward 20 inches (509 mm) TL. This would allow more females to reach reproductive potential and maximize the yield-per-recruit of females at the current rate of fishing (1.67); however, it would also virtually eliminate the harvest of males.

Sex-specific differences in age and growth may have a profound effect on mortality rates and yield-per-recruit. Mortality estimates were determined from experimental gill nets composed of five panels, with bar meshes ranging from 2-6 inches in 1" increments. If growth is rapid early in life, mortality estimates of ages 2 and 3 may be biased when sampling with panels of 1" increments. Since 1988, the LDWF has been conducting experimental gillnet surveys with additional 0.5" mesh sizes added to the gillnet panels. Ongoing studies of mortality rates from these age composition data (Thomas Helser, Louisiana State University, personal comm.) may give better mortality estimates.

In 1986 and 1987, the Louisiana Legislature enacted fishing regulations which changed the commercial minimum size limit for spotted seatrout from 12 " (305 mm TL) to 14 " (356 mm TL) and set the recreational minimum size limit at 12 " (305 mm TL). In this study, it was not possible to examine fishery-independent mortality estimates for 1986 and 1987 separately, due to insufficient sample sizes for older age classes. The changes in minimum size restrictions for the recreational and commercial fisheries from 1986 and 1987 may have affected the fishery-independent mortality rates estimated from those years combined. These uncertainties must be taken into consideration when evaluating fishery-independent mortality rates and subsequent yield-per-recruit equations for male and female spotted seatrout in Louisiana waters.

Although sex-specific management of the spotted seatrout fishery is ideal, in practice it is difficult to achieve because of the inability to distinguish males and females in the field and because the necessary data needed to detect real differences in natural and fishing mortality between males and females are not available. The most conservative approach would be to manage the spotted seatrout fishery for maximum yield-per-recruit of females. From this analysis, this approach would effectively eliminate male spotted seatrout from the fishery, but would provide for maximum reproductive output and yield-per-recruit of females. Such a minimum size restrictive management scheme may maximize yield-per-recruit and maintain favorable fish population dynamics and production, but would most likely not maintain the level of benefits, such as quality of fishing, in proportion to the productivity of the system (Brousseau and Armstrong, 1987). However, anglers can still enjoy the quality of fishing, including catching more than the current limit of 25 fish, by releasing most of their fish, including all undersize individuals.

References

Arnoldi, D. C. 1982. Certain Aspects of the Life History and Habits of the Spotted Seatrout in Calcasieu Lake, Louisiana. La. Wildl. Fish. Comm., D-J Completion Report Proj., F-32. 97p.

_____. 1984. Age and Growth, Spawning Success and Movement and Migration of Spotted Seatrout in Calcasieu Lake, Louisiana. La. Wildl. Fish. Comm. D-J Completion Report Proj. F-42. 41 p.

_____. 1985. Aspects of the biology of spotted seatrout (Cynoscion nebulosus) in Calcasieu Lake, Louisiana, with management implications. Proc. 38 Ann. Conf. S.E. Assoc. Game and Fish Comm. 18 p.

Beamish, R.J. and G.A. McFarlane. 1983. The forgotten requirement for age validation in fisheries biology. Trans. Am. Fish. Soc. 112:735-743.

Beckman, D.W., C.A. Wilson, and L. Stanley. (in press). Age and growth of red drum (Sciaenops ocellatus) from offshore waters of the Northern Gulf of Mexico. Fish. Biol.

Brousseau, C.S. and E.R. Armstrong. 1987. The role of size limits in walleye management. Fisheries 12(1):2)5.

Brown-Peterson, N.J., P. Thomas, and C. Arnold. 1988. Reproductive biology of the spotted seatrout, (Cynoscion nebulosus) in south Texas. Fishery Bull. 86(2).

Chilton, D.E. and R.J. Beamish. 1982. Age determination methods for fishes studied by the groundfish program at the Pacific Biological Station. Canadian Spec. Publ. Fish. and Aquatic Sci., No.60, 102 p.

Condrey, R.E., G. Adkins, and M.W. Wascom. 1985. Yield-per- recruit of spotted seatrout. Gulf Res. Rep., Vol. 8(1):63-67.

Fontenot, B.J., Jr. and H.E. Rogillio. 1970. A study of estuarine sportfishes in the Biloxi Marsh Complex, Louisiana. La. Wildl. Fish. Comm. Fish Bull. No. 8, 172 p.

Hein, S.H. and J.A. Shepard. 1979. Size Disparity Between "Inside" and "Outside" Spotted Seatrout (Cynoscion nebulosus) During a Three-month Study in South-central Louisiana. LDWF., Contrib. Mar. Res. Lab., Tech. Bull. No. 2816-28.

Iversen, E.S. and D.C. Tabb. 1962. Subpopulations based on growth and tagging studies of spotted seatrout, (Cynoscion nebulosus), in Florida. Copeia

(1962):544-548.

Merriner, J.V. 1980. History and management of the spotted seatrout fishery. Proc. Colloq. on the Biology and Management of Red drum and Seatrout. Gulf States Mar. Fish. Comm. Spec. Rep. No. 5:55-61.

Mok, H. and R.G. Gilmore. 1983. Analysis of sound production in estuarine aggregations of Pogonias cromis, Bairdiella chrysura and Cynoscion nebulosus (Sciaenidae). Bull. Inst. Zool., Academia Sinica 22(2):157)186.

Moreau, J. 1987. Mathematical and biological expression of growth in fishes: recent trends and further developments. In: R. Sommerfeldt (ed.), Age and Growth of Fish. Iowa State Univ. Press, Ames IA.

Overstreet, R.M. 1983. Aspects of the biology of the spotted seatrout, Cynoscion nebulosus, in Mississippi. Gulf Res. Rep., Supp. 1:1-43.

Pauly, D. 1979. On the interrelationships between natural mortality, growth parameters and mean environmental temperatures in 175 fish stocks. Journal du Conseil: 39(2):175-192.

Pearson, J.C. 1929. Natural history and conservation of redfish and other commercial sciaenids on the Texas coast. Bull. of the U.S. Bureau of Fisheries, 44:129)214.

Perret, W.S. 1971. Phase IV, Biology. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. La. Wildl. Fish. Comm. Proj. 2-22R:41)105.

______, J.E. Weaver, R.O. Williams, P.L. Johansen, T.D. McIlwain, R.C. Raulerson, and W.M. Tatum. 1980. Fishery Profiles of Red Drum and Spotted Seatrout. Gulf States Mar. Fish. Comm. Rep. 6.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Fish. Res. Board Can. Bull. 191. Ottawa. 382 p.

Robson, D.S. and D.G. Chapman. 1961. Catch curves and mortality rates. Trans. Am. Fish. Soc., 90:181-189.

SAS Institute, Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. Cary, NC: SAS Institute Inc.

Sundararaj, B.I. and R.D. Suttkus. 1962. Fecundity of the spotted seatrout, Cynoscion nebulosus (Cuvier), from Lake Borgne area, Louisiana. Trans. Am. Fish. Soc. 9:84.

Tabb, D.C. 1961. A Contribution to the biology of the spotted seatrout, Cynoscion nebulosus (Cuvier), of east-central Florida. Fla. Board Conserv. Mar. Res. Lab. Tech. Ser. 35, 24 p.

Tucker, J.W., Jr. and B.E. Faulkner. 1987. Voluntary spawning patterns of captive spotted seatrout. Northeast Gulf Science 9(1):59-63.

Weinstein, M.P. and R.W. Yerger. 1976. Electrophoretic investigation of subpopulations of the spotted seatrout, Cynoscion nebulosus (Cuvier), in the Gulf of Mexico and Atlantic coast of Florida. Comp. Biochem. Physiol. 54B:97-102.

Whitney, R.R. and K.D. Carlander. 1956. Interpretation of body- scale regression for computing body length of fish. J. Wildl. Manage. 20(1):21)27.

Wieting, D.S. 1989. Age, growth, and fecundity of spotted seatrout Cynoscion nebulosus in Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge, LA.

Can Shrimp Release Programs be an Effective Fishery Management Tool?

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Abstract

Most shrimp populations are being exploited at or near maximum capacity. Because there are no new shrimp populations to exploit, current management objectives focus on methods by which declining stocks can be conserved or restored. One approach, modeled on trout and salmon hatchery programs, is to propagate shrimp for release. This approach has been recently attempted in the marine environment with scallops, abalone, redfish, and shrimp. A review of shrimp propagation and release programs in Kuwait, Italy, the U.S., and two separate programs in Japan suggest that certain factors must be present before such programs can be successful. Successful restocking programs share the following characteristics: enclosed waters; low predator abundance; small and discrete shrimp populations; established hatchery prccedures and facilities; adequate fishery and ecological data; clearly defined ownership of fishery stocks; and favorable economics. The latter is a product of high market price for the shrimp, low fishing costs, and publicly subsidized hatchery production of seed. These conditions do not exist for the northern Gulf of Mexico shrimp fishery. Shrimp propagation and release programs do not appear to be an economically feasible management option for this fishery. Emphasis and resources would be better directed towards preservation and creation of critical wetland nursery habitat.

Introduction

Most shrimp populations are exploited at or near maximum capacity. Because there are no new populations to exploit, current management objectives focus on methods by which declining fisheries stocks can be conserved or restored (U.S. Department of Commerce, 1988). There are two approaches to this objective. The first is the propagation and release program modeled on trout and salmon hatchery programs. This approach has been recently attempted in the marine environment with molluscs (Tong et al., 1987; Malouf, 1989), redfish (Gulf of Mexico Fishery Management Council, 1984), and in various areas of the world with shrimp (Farmer, 1981). The second approach involves the preservation and expansion of inshore nursery habitats. These habitats are critical to the development and growth of shrimp during their complex life cycle. Without such habitats, the exploited populations cannot be sustained (Turner, 1977; Bielsa et al., 1983; Lassuy, 1983; Muncy, 1984).

Both approaches depend on recent advances in technology. Because of developments in maturation, spawning, and hatchery techniques, it is possible to consider and implement hatchery-based release programs for shrimp. Hatcheries can theoretically produce tens to hundreds of millions of shrimp post-larvae per year (Lawrence and Huner, 1987) at costs of $10.00 per thousand or less in the U.S. (Johns et al., 1981), Latin America (Griffin et al., 1985), Japan (Kurata, 1981), and Asia (Hirasawa, 1985).

Knowledge of the structure and function of estuarine and coastal wetlands as shrimp nursery areas has also advanced rapidly in recent years (e.g. Turner, 1977; Weinstein, 1979; Minello et al., 1989). New techniques for the creation and restoration of wetlands (e.g. Zedler, 1984) and submerged aquatic vegetated habitats (e.g. Fredette et al., 1985), have also been developed. These findings have led to better management of these critical areas to the benefit of shrimp and other fisheries. Both approaches have the same objective, to maintain or increase the stock of sub-adult shrimp and, therefore, the catch of adult shrimp in a commercial fishery.

There have been efforts to implement propagation and release programs for shrimp in various areas. However, information on the success of these programs has not been readily available. Because of recurring interest in developing a shrimp propagation and stocking program for the northern Gulf of Mexico, this paper will review past stocking programs and discuss how such propagation programs would apply as management options in the northern Gulf of Mexico. Emphasis will be on identifying the factors essential for the development of successful stocking programs.

The Japanese Experience: The Seto Inland Sea Program

The Seto Inland Sea shrimp release program is the oldest and largest program of its kind in the world. Doi (1981) and Kurata (1981) review the program in considerable detail. While critics of the program question its effectiveness and cost-benefit calculations, the program illustrates the components essential to the development of a successful stocking program.

The Seto Sea is a semi-enclosed body of water that supports a fishery for *Penaeus japonicus* (Kuruma shrimp). A large proportion of the shrimp population is resident in the Seto Sea. Market demand for fresh, live Kuruma shrimp is strong and the species commands high prices. Because of the importance of this fishery, data on *Penaeus japonicus* stocks, including complete information on life cycle, growth, population size, movement, ecological requirements of all life stages, and other factors was available. Because this species is also produced through aquaculture, hatchery technology for *P. japonicus* was fully developed. Perhaps most important, research had identified that the greatest mortality occurred in the period between hatching and the twentieth day of post-larval development. The minimum size for release necessary to avoid the peak mortality period was determined to be about 3 cm. This suggested a nursery program where shrimp could be reared to the appropriate size prior to release.

Based on this information, fisheries managers initiated a propagation and release program that would duplicate the natural life cycle of the shrimp but would limit the mortality of the larval shrimp traveling between the spawning grounds and their estuarine habitat. Optimal habitat requirements for the released juvenile shrimp were determined and survival was found to be best on the upper parts of coarse-grained beaches.

Field surveys determined that good natural sites for shrimp nurseries were very limited in the Seto Sea. The solution was to create artificial habitats of two main types (Kurata, 1981). The first uses nets to exclude predator fish from release areas and to contain the juvenile shrimp. However, damage to nets, fouling, and other problems limit their use. The preferred approach is to use artificial tidelands (Kurata, 1981). Artificial tidelands are designed to closely control elevation, water depths, waves, currents, sediment type, and other physical factors. The tidelands mimic the different natural micro-habitats required by the shrimp as they grow from post larvae through their juvenile stages, utilizing differences in habitat requirements between shrimp size classes to allow increased stocking densities and between the shrimp and their predators to control predation. When correctly designed, post- larval shrimp stocked into the tidelands at ten mm grow to 3 cm. in about 2-3 weeks and successfully migrate to the open sea. Approximately 150 million hatchery produced post-larval shrimp are stocked into these tidelands annually (Kurata, 1981).

It has been difficult to determine the effectiveness of this program. Tagging of juvenile shrimp is ineffective. An indirect method is to trace a released cohort in the wild population as a distinct bulge in the population size-frequency distribution. Recovery rates of 3.5% to over 8% of the released larvae have been reported based on this method (Kurata, 1981) and proponents of the program point to a turnaround in the declining shrimp fishery in the Seto Sea (Kurata, 1981). Based on these observations, Kurata (1981) claims a benefit over cost of 2.75 yen per shrimp caught in the Seto Inland Sea fishery.

Critics of the program counter that there are no conclusive data on the effect of this program on the fishery (Doi, 1981; Uno, 1985). Critics also claim that even if the program were successful, the fishery is profitable only because it sells live shrimp at greatly inflated prices. The cost-benefit estimates of the program have also been questioned because the program must apparently operate at 100% efficiency to meet the suggested cost- benefit ratios.

<u>Kuwait</u>

In the 1970's, Kuwait experienced a declining catch of shrimp in the Persian Gulf (Farmer, 1981). A shrimp propagation and release program, based on the Japanese Seto Inland Sea model, was put into place in an attempt to reverse the trend. Despite a significant multiple effort, the program was discontinued after over 120 million post-larval shrimp were released. There were several reasons for this decision (Farmer, 1981).Perhaps the most important was that the release program did not identify and address the underlying causes of the decline in the shrimp fishery. The causes remain unknown and the decline continues. The program was also hampered by the lack of basic fishery statistics and insufficient understanding of the population biology of the target species. The program may also have been ineffective because of the relatively large size and mobility of the shrimp stocks. The propagation program appeared to produce too few shrimp in relation to stock size to be effective.

Marifarms

Marifarms of Florida attempted to farm shrimp through stocking and management of shrimp in natural waters. Kittaka (1981) describes Marifarms' operations in detail. Briefly, hatchery-produced post-larvae of all three commercial Gulf shrimp species were released at appropriate times into netted-off portions of a coastal bay in northwestern Florida. Shrimp were also released into the open bay itself as part of the lease agreement.

Post-larval brown and white shrimp (Penaeus aztecus and P. setiferus) were stocked in spring and early summer for fall harvest. Pink shrimp (P. duorarum) post-larvae were released in late summer to over-winter for a spring crop. While survival in the initial stocking pens and in the nursery areas was good, recovery of harvestable shrimp was very poor: 2-13% for whites and 0-10% for browns. Few pink shrimp were harvested. Problems with fouling of the nets, escape of shrimp, weather damage, and inability to control predator populations contributed to the failure of the operation, even after three full years of effort.

The catch of white shrimp in the vicinity of Marifarms operations reportedly increased during the life of the project. Up to 100,000 pounds of white shrimp were landed in the bay after Marifarms started operations, up from negligible harvests in prior years (Kittaka, 1981). This suggested that both escaping shrimp and intentional releases of shrimp post-larvae augmented natural stocks. However, any relationship between increased harvests and shrimp releases has not been substantiated.

Italy

In contrast with the unsuccessful restocking efforts attempted in Kuwait or the questionable results obtained at Marifarms and in the Seto Sea program, Italy provides a success story. The local Mediterranean shrimp species caught off the coast of Italy (P. kerathurus) had been in decline for many years. Since the opening of the Suez Canal, an exotic shrimp species (P. japonicus) had become established in the eastern Mediterranean. Following initial trials in the north in 1982 (see Lumare, 1984 and 1986; Lumare et al., 1986), researchers in southern Italy stocked a 12,000-acre lagoon in 1983 with this exotic species. Three years of releases in this lagoon have resulted in a recovery of 24-33% of the stocked numbers. Stocked shrimp exhibited excellent growth in all years. Researchers calculated benefits exceeding costs by over 6:1.

Because of this success, the effort has been expanded to other lagoons along the Italian coast. Recovery rates of 20-46% have been reported but wide variations in lagoon configuration, salinity, temperature, and especially in fish biomass have produced variable results. The most successful programs are in lagoons that have restricted access to the sea and are fished by fishermen's cooperatives who exclusively own the shrimp. The most important factor, however, appears to be the absence of fish in the stocked lagoons. Because the cost to benefit ratios in the new areas have been good (from 1:2.2 to 1:9) and the returns of stocked shrimp are high (up to 46%), the program continues to expand to new areas.

There were several critical factors contributing to the success of the Italian stocking program. The stocked lagoons had limited access to the sea and low fish densities. Resident shrimp populations in these lagoons were small or non-existent; the release shrimp contributed significant numbers of recruits to the total population. The biology of the shrimp species was relatively well known and data necessary for effective stock management, including identification of suitable stocking areas, were available. A critical component of the program was an efficient hatchery system for producing inexpensive post-larval shrimp for the program.

Controlled production, synchronized with stocking needs, good larval survival, and low unit costs for the hatchery contributed significantly to the success of the stocking program. The cooperative approach used by the fishermen to fish the stocked shrimp resolved a potentially thorny problem of ownership. Clear ownership of the stock is required in order to have returns defray the cost of stocking and to direct the benefits to the target social group. Finally, the costs to benefits ratio was positive because of the very high price received for the shrimp in the local Italian markets.

Japan Revisited

In contrast with the high cost and controversial Seto Inland Sea stocking program (Kurata, 1981), a successful program in a coastal lagoon in eastern Japan deserves examination (see Uno, 1985). The lagoon is small and is cooperatively fished by the resident villagers. The shrimp fishery was small, landing only about 40 metric tons per year. The biology and ecology of the shrimp species (P. japonicus) are very well known. The lagoon population is particularly amenable to management by a restocking program because a large part of the population does not migrate away from the lagoon or the immediate offshore waters. Over 17 million post-larval shrimp have been released by the prefectural government between 1978 and 1983.

Analysis of fishery data indicate that most of the released shrimp overwinter within the lagoon and contribute to the next year's fishery. Yields from the shrimp fishery after the start of the stocking program improved by a factor of over 2.4. Landings rose from about 40 metric tons to over 100 metric tons per year. The limited area to be fished, small shrimp population, and good fisheries data contributed significantly to the success of the program. With state funding of hatcheries, inexpensive post-larvae, clear ownership of the stock by the villagers, and good market prices for the product, the success of the program was assured.

Factors for Successful Stocking Programs

Any shrimp stocking program depends on a number of important considerations (Doi, 1981; Kurata, 1981; Sander, 1981). The technology for hatchery production of post-larval shrimp must be well established. The knowledge of the life cycle of the shrimp in relation to the fishery for the animal must be complete. To be successful, artificial propagation programs must have access to usable estimates of length, weight, and growth relationships. Further, estimates of population parameters including mortality, reproduction, dispersion of the stocks, and other factors must be available. The relation of mortality to physical, chemical, and biological conditions must also be known. Finally, the habitat requirements or ecology of each life stage must also be fairly well understood. This demand for information is not excessive. Indeed, any meaningful fisheries management effort requires this information (Doi, 1981; Sander, 1981).

Any stock enhancement program must also have a measure by which the success of such a program can be determined. A propagation and release program can be considered successful if the number released form a significant proportion of the adult fishery (Doi, 1981). As a result, release programs work best with small populations, where a contribution of several percent to the existing stock from a propagation and release program can be both economical and biologically effective. Because of their effectiveness with small populations, propagation and release programs are particularly useful in lagoon or enclosed sea fisheries. To increase effectiveness, predation on newly released shrimp must be minimized by using nursery areas and stocking into netted-off areas from which predators have been removed or into areas with low predator abundance.

Social and economic considerations are at least as important as biological and physical factors to the success of stocking programs. Cost of production of stocking material must be reasonable, in keeping with the market value of shrimp captured in the fishery. Hatchery production must also be timely and consistent.

Decisions regarding program funding and program goals (who the beneficiaries of such a program will be and how the flow of benefits is guaranteed) are essential for program success. Costly hatchery programs require continued government support. Benefits to local economies must be great enough to justify continued government funding to benefit the private sector. Exclusive access to or ownership of the stock must be clearly identified to prevent legal conflicts and to ensure the economic and social success of the progam. Controls should be in place to restrict additional fishermen from entering the fishery and diluting the economic benefits of the stocking effort to the target fishing community.

It is interesting to note that shrimp stocking programs for fishery enhancement have been tried in a kingdom (Kuwait) and in countries (Italy, Japan) where local authorities are powerful and capable of acting autonomously.

Application to the Northern Gulf of Mexico Fishery

Based on the experiences and results of stocking programs worldwide, a shrimp stocking program in the northern Gulf of Mexico does not appear to be feasible. A number of basic elements are lacking. Shrimp populations in the Gulf of Mexico are large, relatively mobile, and do not generally overwinter in embayments or coastal sounds (Bielsa et al., 1983; Lassuy, 1983; Muncy, 1984; Gitschlag 1986). There does not appear to be any close association between specific shrimp populations and water bodies. While hatchery technology for all Gulf shrimp species has been developed (Primavera, 1985), hatchery production of shrimp post-larvae in the U.S. remains inconsistent and uneconomical (Chamberlain, 1990). The economics of stocking programs are also unfavorable because the value of Gulf shrimp is relatively low (Roberts, 1989) while the cost of producing post-larvae remains high (Griffin et al., 1985).

Social conditions appear unfavorable as well. There is little local or federal government support available for costly hatchery operations, particularly to support private fishermen. Entry to the shrimp fishery is unlimited and the industry is heavily over-capitalized (Roberts, 1989). Any significant increase in stocks would attract more fishermen and would not improve the financial condition of existing fishermen.

The key to maintaining and increasing stocks of shrimp is habitat preservation. Evidence suggests that this is a less costly and more effective approach than a propagation and release program. The importance of marshes and submerged aquatic vegetation to the shrimp fishery are well established (e.g. Turner, 1977; Weinstein, 1979; Laussey, 1983; Muncy, 1984; Minello et al., 1989). These areas serve as nurseries, providing shelter from predators and important sources of food for juvenile shrimp. The Japanese found losses of nursery areas closely related to the decline of the shrimp fishery (Doi, 1981; Uno, 1984). Similarly, there are significant negative correlations between landfilling of wetlands and declining shrimp yields. In the U.S., Turner (1977) found total shrimp yields in Louisiana to be proportional to total marsh acreage in the state. On a larger scale, shrimp yields in the northern Gulf of Mexico were proportional to the combined area of submerged aquatic vegetation and marshlands. Finally, decreases in intertidal habitat flooded in spring tides correlated closely with declines in the size and total abundance of shrimp (Turner, 1977).

It is more effective and less costly to preserve wetlands and submerged vegetated nursery habitats than to implement a hatchery and stock enhancement program (Uno, 1985). Avoiding indiscriminate development to protect nursery areas is of greater overall benefit to enhancing shrimp populations than any hatchery and release program. Experience has shown that stocking programs are expensive to start up, prone to technical problems, costly to operate, and require extensive data bases and monitoring efforts to ensure success. Protecting, restoring, or even creating needed submerged aquatic vegetation and marsh habitat is the most promising approach to stock augmentation of shrimp in the Gulf of Mexico.

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References

Bielsa, L.M., W.H. Murdich and R.F. Labisky. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Florida)--pink shrimp. U.S. Fish and Wildlife Service Publication FWS/OBS-82/11.17. 21 p.

Chamberlain, G.W. (editor) 1990. Texas Aquaculture. State of the industry. Proceedings of the 1990 Texas Aquaculture Conference, Corpus Christi, TX, January 30-February 1, 1990. Texas Water Commission, Austin, TX. 133 p.

Doi, T. 1981. Population dynamics and management of the shrimp fishery in the Seto Inland Sea. Pages 289-306 In: A.S. D. Farmer, (ed). Proceedings of the International Shrimp Releasing, Marking and Recruitment Workshop, 25-29 November 1978, Salmiya, Kuwait. Kuwait Bulletin of Marine Science No. 2. Kuwait Institute for Scientific Research, Salmiya, Kuwait.

Farmer, A.S.D. (ed). 1981. Proceedings of the International Shrimp Releasing, Marking and Recruitment Wworkshop, 25-29 November 1978, Salmiya, Kuwait. Kuwait Bulletin of Marine Science No. 2. Kuwait Institute of Scientific Research, Salmiya, Kuwait. 415 pp.

Fredette, T.J., M.S. Fonseca, W.J. Kenworthy, and G.W. Thayer. 1985. Seagrass transplanting: 10 years of Army Corps of Engineers research. Pages 121-134 in F.J. Webb, (editor). Proceedings of the 12th Annual Conference on Wetlands Restoration and Creation. Hillsborough Community College, Tampa, FL.

Gitschlag, R. 1986. Movement of pink shrimp in relation to the Tortugas Sanctuary. North American Journal of Fisheries Management 6: 328-338.

Griffin, W., A. Lawrence, and M. Johns. 1985. Economics of penaeid culture in the Americas. Pages 151-160 In: Y. Taki, J.H. Primavera, and J.A. Llobrera, (eds). Proceedings of the First International Conference on the Culture of Penaeid prawns/shrimps, Iloilo City, Philippines, 4-7 December, 1984. Southeast Asian Fisheries Development Center, Iloilo City, Philippines.

Gulf of Mexico Fisheries Management Council. 1984. Artificial propagation and stocking. Page 5.29 In: Fishery Profile of the Red Drum. Gulf States Marine Fisheries Commission, Ocean Springs, MS.

Hirasawa, Y. 1985. Economics of shrimp culture in Asia. Pages 131-150 In: Y. Taki, J.H. Primavera and J.A. Llobrera, (eds). Proceedings of the First International Conference on the Culture of Ppenaeid prawns/shrimps, Iloilo City, 4-7 December 1984, Philippines, Southeast Asian Fisheries Development Center, Iloilo, Philippines.

Johns, M., W. Griffin, and A. Lawrence. 1981. Budget analysis of penaeid shrimp hatchery facilities. Journal of the World Mariculture Society 12(2): 305-321.

Kittaka, J. 1981. Large scale production of shrimp for releasing in Japan and the United States and the results of the releasing program at Panama City, Florida. Pages 149-166 In: A.S.D. Farmer, (ed). Proceedings of the International Shrimp Releasing, Marking and Recruitment Workshop, 25-29 November 1987. Salmiya, Kuwait. Kuwait Bulletin of Marine Science No. 2. Kuwait Institute for Scientific Research, Salmiya, Kuwait.

Kurata, H. 1981. Shrimp fry releasing techniques in Japan, with special reference to artificial tidelands. Pages 117-148 In: A.S.D. Farmer, (ed). Proceedings of the International Shrimp Releasing, Marking and Recruitment Workshop, 25-29 November 1978, Salmiya, Kuwait. Kuwait Bulletin of Marine Science No. 2. Kuwait Institute for Scientific Research, Salmiya, Kuwait.

Lassuy, D.R. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico)--Brown Shrimp. U.S. Fish and Wildlife Service Publication FWS/OBS-82/11.1. 15 p.

Lawrence, A.L. and J.V. Huner. 1987. Penaeid shrimp culture in the United States: a brief overview stressing species, seed production and growout. Pages 31-41 In: C.J. Sindermann, (ed). Reproduction, Maturation and Seed Production of Cultured Species. Proceedings of the twelfth U.S. Japan meeting on aquaculture, Baton Rouge, LA, 25-29 October 1983. NOAA Technical Report NMFS 47, Washington, D.C.

Lumare, F. 1984. Stocking trials of Penaeus japonicus Bate (Decapoda, Natantia) post-larvae in Lesina Lagoon (southeast coast of Italy). Pages 593-606 In: Management of Coastal Fisheries, Studies and Reviews, Volume 2, No. 61. General Fisheries Counsel of the Mediterranean, FAO Rome, Italy.

_____. 1986. Marine shrimp culture in the world and present state and trends of Kuruma prawn culture in Italy. Informes Technicos del Instituto de Investigaciones Pesqueras No. 136. Consejo Superior de Investigaciones Cientificos, Barcelona, Spain. 23 pp.

_____, C. Andreoli, G. Belmonte, G. Casolino, M. Cottiglia, L. Da Ros, G. Piscitelli and L. Tancioni. 1986. Growing studies on Penaeus japonicus (Decapoda, Natantia) in management and environmental diversified conditions. Estratto dalla Rivista Italiana di Piscicoltura e Ittiopatologia 21(2): 42-58.

Malouf, R.E. 1989. Clam culture as a resource management tool. Pages 427-447 In: J.J. Manzi and M. Castagna, (eds). Clam Culture in North

America. Elsevier, Amsterdam, The Netherlands.

Minello, T.J., R.J. Zimmerman and E.X. Martinez. 1989. Mortality of young brown shrimp Penaeus aztecus in estuarine nurseries. Transactions of the American Fisheries Society 118: 693-708.

Muncy, R.J. 1984. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico) -- White Shrimp. U.S. Fish and Wildlife Service Publication FWS/OBS-82/11.20. Washington, D.C. 19 p.

Primavera, J.H. 1985. A review of maturation and reproduction in closed thylecum penaeids. Pages 47-64 In: Y. Taki, J.H. Primavera and J.A. Llobrera, (eds). Proceedings of the First International Conference on the Culture of Penaeid prawns/shrimps, Iloilo City, Philipines, 4-7 December 1984. Southeast Asian Fisheries Development Center, Iloilo City, Philipines.

Roberts, K. 1989. An economic analysis of the U.S. shrimp industry. Pages 4-9 In: D. Burrage, (ed). The Mississippi shrimp industry: a management perspective. Proceedings of a workshop, Biloxi, MS, 12 April, 1990. Mississippi-Alabama Sea Grant Program Publication No. MASGP-89-029. Ocean Springs, MS.

Sander, F. 1981. Factors affecting shrimp recruitment. Pages 311- 351 In: A.S.D. Farmer, (ed). Proceedings of the International Shrimp Releasing, Marking and Recruitment Workshop. 25-29 November 1978, Salmiya, Kuwait. Kuwait Bulletin of Marine Science No. 2. Kuwait Institute for Scientific Research, Salmiya, Kuwait.

Tong, L.J., G.A. Moss and J. Illingworth. 1987. Enhancement of a natural population of the abalone, Halotis iris, using cultured larvae. Aquaculture 62: 67-72.

Turner, R.E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Transactions of the American Fisheries Society 106: 411-416.

Uno, Y. 1985. An ecological approach to mariculture of shrimp: shrimp ranching fisheries. Pages 37-46 In: Y. Taki, J.H. Primavera and J.A. Llobrera, (eds). Proceedings of the First International Conference on the Culture of Penaeid prawns/shrimps, Iloilo City, Philippines, 4-7 December 1984. Southeast Asian Fisheries Development Center, Iloilo City, Philippines.

U.S. Department of Commerce. 1988. Aquaculture and Capture Fisheries: Impacts on U.S. Seafood Markets. Special Report pursuant to the National Aquaculture Improvement Act of 1985 (P.L. 99 - 198). U.S. Department of Commerce, National Marine Fisheries Service. Washington, DC.

Weinstein, M.P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, North Carolina. Fishery Bulletin 77: 339-357.

Zedler, J.B. 1984. Salt marsh restoration: a guidebook for southern California. California Sea Grant College Program Report T-CSGCP-OO9. La Jolla, CA.

The Texas Coastal Aquaculture Facility

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Introduction

The Texas General Land Office (GLO), in conjunction with Texas A&M University, the Texas A&M Sea Grant College Program, and Matagorda County Navigation District #1, is planning the Texas Coastal Aquaculture Facility (TCAF). At this facility, production technology for a variety of aquatic species will be developed, refined, and transferred to the aquaculture industry. TCAF will be managed by the Texas A&M University System with guidance from a program committee. This committee will include representatives of the Aquaculture Executive Committee (chairman, Texas Parks and Wildlife Department; commissioner, Texas General Land Office; commissioner, Texas Department of Agriculture), the Matagorda County Navigation District #1, and the TCAF's proposed Industrial Advisory Committee. A primary objective of the TCAF is to initiate more research and development on practical aquaculture production techniques. As the industry matures, TCAF intends to effectively meet the industry needs. A secondary purpose of the TCAF will be to evaluate environmental consequences of aquacultural production. This is especially important for any aquaculture development in sensitive coastal areas. Topics of particular concern are: development of screening systems to reduce impact of intake/pumping operations on planktonic estuarine organisms; water quality of aquaculture effluents; evaluation of exotic species; and development of water conservation practices for aquaculture facilities.

Background

Several economic, health, and natural resource issues are driving the Texas aquaculture industry. The world's rising demand for fishery products is rapidly exceeding the supply. U.S. consumption of seafood and seafood products rose in 1988 to 19.8 pounds per capita. Only 1.5 pounds, or 7.6 percent, of this demand was met bydomestic aquaculture. In 1988, the U.S. imported $8.9 billion of edible and inedible fishery products. This approaches a 4:1 negative national trade deficit for fishery products, making the U.S. second only to Japan as fishery products importer. Fishery products are second only to petrochemicals as non-manufacturing contributors to the U.S.

foreign trade deficit. Aquaculture is the fastest growing agricultural industry in the U.S., with production increasing more than 20% annually in this decade. Only 1% of the U.S. fishery supply was produced by aquaculture in 1970, increasing to 7% by 1987. The total value of U.S. edible and inedible aquaculture products was $750 million in 1988. Key U.S. aquaculture species include catfish, crawfish, salmon, trout, tilapia, shrimp, baitfish, tropical fish, mussels, oysters, and clams. Other species showing potential are alligator, hybrid striped bass, carp, eel, red drum, northern pike, and sturgeon. Texas' natural resources, including soils, water, available land, and climate, all indicate strong potential for a viable aquaculture industry. The TCAF's mission of balancing production technology development with strong environmental concern should assist responsible industry growth.

Current Situation

Aquaculture is playing a steadily increasing role in world seafood production due to increasing demand for fishery products, limited capacity of traditional capture fisheries, and advancement in aquaculture technology. Currently, Texas has a limited role in the aquaculture industry. Estimated 1989 farm gate value of the Texas aquaculture industry was approximately $12.2 million. However, the Texas aquaculture industry is still small compared to other southern states. Mississippi's farm gate value exceeds $300 million annually, and Louisiana and Arkansas are approaching $100 million each. This disparity exists in spite of the fact that the growing season in Texas is approximately 60 days longer than in Mississippi. Texas aquaculture is characterized by small, family-oriented farms which distribute through local markets. Constraints on industry growth and development include: restrictive regulatory climate; lack of commercial infrastructure; and lack of research, technology, and technology transfer facilities.

Today, Texas aquaculture is at a critical crossroad. Although the industry is in a rudimentary stage of development, circumstances are now right for the emergence of aquaculture as a major component of Texas agriculture. The proposed Texas Coastal Aquaculture Facility could help trigger this metamorphosis. The TCAF will address the third major hindrance to Texas aquaculture development--a lack of facilities for applied research, demonstration, and technology transfer. Lack of these facilities deprives Texas producers of access to advancements in technology, putting them at a competitive disadvantage. At present, they are forced to travel to other southern states to view production techniques. Lack of Texas facilities also prohibits the pilot-scale testing link between Texas laboratory research and commercial application. Consequently, promising new diets, disease treatments, management methods, and equipment are slow to be adopted by Texas producers. The major mission of the TCAF is to improve the status of aquaculture in Texas. This facility will supply the essential missing link in the continuum from basic research to commercial production. That missing link is the translation of laboratory science into reliable, technology that is economically and environmentally sound.

Purpose and Program

The primary purpose of the TCAF is to develop, refine, and transfer aquacultural production technology for a variety of aquatic species. Targeted, practical research and demonstrations are planned for the following areas:

Pond management - of particular interest is the determination of appropriate mixing, aeration, and water exchange requirements for intensive culture systems. Practical trials will be available for topics such as water and sediment chemistry, ecological dynamics of bacteria, meiobenthos, macrobenthos, and phytoplankton, and economic feasibility.

Nutrition - the facility will be used to field test a variety of feeds developed in the laboratory. Various feeding strategies will also be tested and evaluated.

Health and Environmental Management - management tactics and treatment methods will be designed and tested.

Species Evaluations - production technology will be refined on a species)specific basis. Trials will be conducted on catfish, red drum, shrimp, and other species.

Aquaculture Engineering - technological advancements in environmental monitoring will be evaluated for use in management of water quality and waste treatments.

Indoor Culture Systems - various water recirculation methods and filtering systems will be tested for intensive culture practices.

Offshore Grow-Out Technology - net-pen systems will be designed, tested, and evaluated for Gulf of Mexico conditions. Various long-line culture techniques will be tested for shellfish culture.

A major theme in all TCAF trials will be to convert or translate research information into practical technology. Appropriate technology will be transferred to the commercial sector through hands-on training, field demonstrations, workshops, seminars, publications, and satellite-linked educational programs.

Facility

The proposed location for the Texas Coastal Aquaculture Facility is on Matagorda Bay near Palacios, Texas. The site has access to ample, high-quality saltwater and freshwater, as well as appropriate soils, elevation, and topography. The facility will be fully capable of raising estuarine, marine, and freshwater species. Saltwater will come from Matagorda Bay. This bay is one of the most stable on the Gulf of Mexico and usually has water of desirable salinities for ten to eleven months of the year. In addition, freshwater wells can be developed from the shallow Gulf Coast Aquifer. Initial construction will include 5,000 ft^2 of office and laboratories for emphasis on water quality and production studies. Expansion facilities will include provision for processing, storage, packaging, and feed manufacturing studies.

A 10,000 ft^2 culture building will be constructed to house a series of raceways and production tanks. These systems will be designed for both flow-through and recirculating operations. A series of replicated ponds from which reliable data can be obtained will be included in the facility layout. These ponds will allow trials to test proposed management practices. The pond complex will include twenty-four 0.25-acre rectangular ponds, six 1-acre rectangular ponds, two 5-acre rectangular ponds, and two 0.25-acre round ponds.

By the year 2000, at least five units of the Texas Coastal Aquaculture Facility should be constructed. These variants of the prototype facility will accommodate the regional diversity of appropriate crops, technologies, and environments for Texas aquaculture.

Aquaculture in Dredged Material Containment Areas: Multiple Uses, Multiple Benefits

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Abstract

Multiple use of Dredged Material Containment Areas (DMCA) for material disposal and aquaculture can significantly benefit dredging project sponsors, owners of disposal area real estate, the Corps of Engineers (CE), the aquaculture industry, and local economies. Dredging interests may benefit from increased availability of needed real estate for DMCA. The aquaculture industry benefits from increased availability of suitable sites for pond culture, reduction of certain construction costs, and a reduced regulatory burden. Land owners benefit from site improvements and from a greater financial return from their land in the form of operational profits or lease fees.

A CE-funded project to demonstrate the commercial feasibility of DMCA aquaculture began cultivating penaeid shrimp in active DMCA sites (42 and 47 ha) near Brownsville, Texas, in 1987. Six crops of shrimp were harvested during the 3-year production trials, yielding over 118 metric tons of high quality shrimp. Shrimp production was successfully integrated with material disposal operations. A variety of commercial production techniques were successfully evaluated. The results of these trials refute the view that active disposal areas are economically or biologically unproductive. With proper planning and management, aquaculture and material disposal are compatible activities.

Transfer of the technology developed during these trials is underway. A series of technical and extension documents to guide port managers, aquaculturists, and other interested parties is in preparation. These documents cover site selection, containment evaluation, engineering, construction and production economics and marketing, production technology, and legal and institutional constraints to such activities.

This concept has wide application. It is a valuable tool for the acquisition of real estate for dredged material disposal, relieving some of the

economic pressure on port and waterway development. Because it is expensive and difficult to acquire coastal real estate for aquaculture ventures, it also serves to promote the development of aquaculture in coastal areas. Moreover, it may improve benefits in cost:benefit calculations for dredging projects.

Introduction

A large portion of the approximately $230x10^6$ m^3 of sediment dredged annually by the U.S. Army Corps of Engineers (CE) is disposed in dredged material containment areas (DMCAs). Most DMCAs are located on private land and acquisition of easements for disposal is the responsibility of the dredging project sponsors. Although DMCAs often have a usable life span of up to 50 years, an estimated 2800 ha of new DMCAs are needed annually. Acquisition is difficult because of high real estate values, the long-term nature of the easements, and the perception by land owners that dredged material is not esthetic.

To overcome these difficulties, the CE has worked to develop beneficial use concepts which identify ways in which the landowner can use the acreage for activities that are financially attractive but do not interfere with periodic disposal of dredged material. One of these beneficial use concepts with a high potential for obtaining new sites is aquaculture (Homziak and Lunz, 1983).

Aquaculture is promising as a compatible activity with disposal because aquaculture ponds and DMCAs share many design characteristics. Common features include perimeter levees to retain water, construction on relatively impervious soils, and control structures for water discharge and drainage. Both facilities have similar regulatory and permitting requirements for construction and operation, and both types of facilities include locations adjacent to waterways in coastal areas, often on large tracts of land and near transportation routes and/or major markets.

In the United States, important aquaculture industries exist for oysters, clams, crayfish, catfish, trout, baitfishes, and ornamental fishes (Kensler, 1989; USDA, 1990). Shrimp farming, which is rapidly expanding in the international aquaculture scene, has lagged in domestic development, partly due to high costs of construction and a lack of suitable and permittable sites (Aquaculture Digest, 1990). The US imports over 90% of its edible seafood and about 45% of imported shrimp are farm-produced (USDA, 1990).

Preliminary work done in the early 1970's (Quick et al., 1978) indicated that shrimp grew well in ponds containing dredged material. Furthermore, the potential contaminants most likely to be found in dredged material were tightly bound to the sediments and were not accumulated by the shrimp (Quick et al., 1978; Tatem, 1983). Technical improvements in shrimp hatchery operations in the early 1980's reduced the cost of post-larval shrimp needed to stock ponds from over $40/thousand to about $12/thousand. This resulted in a rapid expansion of shrimp farming in many countries (Lawrence et al., 1985; Chamberlain et al., 1985).

Potential Benefits of Aquaculture in DMCAs

Lunz and Konikoff (1980) and Homziak et al. (1987) review the benefits of aquaculture in DMCAs. For the CE, the primary benefit of aquaculture in DMCAs is to facilitate acquisition of new disposal sites. Significant benefits can also be realized from DMCA aquaculture by the aquaculture industry, port and waterway interests, and land owners. High land and construction costs and restrictive legal and regulatory requirements have hindered the development of pond-based coastal aquaculture in the United States. Thus, prospective aquaculturists will benefit from increased availability of suitable sites for pond culture, reduction of certain construction costs, and a reduced regulatory burden. The waterway interests and dredging industry will benefit from increased availability of needed real estate for DMCAs. The economic benefit of aquaculture in DMCAs may also have an influence on cost:benefit ratios of dredging projects. Land owners will benefit from site improvements and from a greater return from their land as operational income or lease fees. The local economy will be enhanced by the introduction of a new industry, and the national economy by replacement of imported seafood with a local product.

Containment Area Aquaculture Program (CAAP)

To demonstrate the feasibility of DMCA aquaculture, the U.S. Army Corps of Engineers conducted a three-year project to grow penaeid (marine) shrimp in two active DMCAs near Brownsville, Texas (Homziak et al., 1987). The purpose of the demonstration project was to establish, for both the CE and the aquaculture industry, the economic and technical feasibility of containment area aquaculture. From the CE perspective, feasibility requires the demonstrated ability of aquaculture operations to coexist with dredged material disposal--the primary function of DMCAs. It is important to recognize that the application of the concept is mainly to acquire new DMCA sites and not to retrofit existing sites to aquaculture use.

Specific objectives of the demonstration project included: 1) determination of design specifications and construction methods that would allow use of DMCAs for both aquaculture and dredged material disposal; 2) development of management strategies that allow aquaculture operations and material disposals to coexist; 3) documentation of construction and operation costs to allow an objective evaluation of economic success; and 4) compilation of the economic and technical information generated by the project into a series of information transfer documents outlining the general guidelines and specific procedures for the construction and operation of a containment area aquaculture facility.

Demonstration site facilities

The facility is located adjacent to the Brownsville Ship Channel and consists of a 1.6 ha. nursery pond and two grow-out ponds of about 42 ha. (pond A) and 47 ha. (pond B). Modification of existing works at the site included raising and widening the perimeter levees to a minimum of 1.8 meters above pond bottom with a crown width of 3.5 to 4.5 meters, construction of a 1 ha. raised operations area, leveling and construction of interior drainage ways, construction of a water intake canal and water distribution channels, and construction of an in-levee water control/harvest structure.

Water was pumped from the intake canal by two 630 liter/second and one 1260 liter/second diesel pumps located in the pumping station. The water passed through a predator filter (0.25 mm screen) into the water distribution canal, which supplied the nursery pond and/or the production ponds as needed. Water levels were controlled by a water control/harvest structure located in each production pond. A harvest basin or sump located outside the weir in each harvest structure was designed to accommodate the cod end of a net used in harvest operations.

Support facilities included a boat landing, fuel storage, two 20-kw diesel generators in the pump house, a laboratory/residence trailer, feed storage building with a feed boat dock, workshop/storage barn, and a desalination system for water supply to the trailer.

Production operations

The main production scheme was to produce edible-sized shrimp using a two-stage, semi-intensive growout system (Chamberlain et al., 1985). Post-larval shrimp, approximately 1 mm in size, were purchased from a shrimp hatchery and stocked in the 1 ha. nursery where they were fed a high protein feed for about 1 month. Use of the small nursery pond allowed close monitoring of water quality, feeding, health, and growth rates. In addition, water exchange, mechanical aeration, and complete exclusion of predators is more manageable in a small pond. After the juvenile shrimp reached about 25 mm, they were transferred to the larger growout pond.

Chamberlain et al. (1985) review shrimp production systems. Briefly, in semi-intensive culture systems the stocking rate of the growout pond is about 10 shrimp per m^2 (100,000/ha.). The shrimp are fed a pelleted feed at a rate of about 3% of body weight per day for about 12-16 weeks, at which time they should be ready to harvest. Pond water exchange is usually about 10% per week. In the alternative extensive culture method, the shrimp are stocked at a rate of about 2-5 per m^2 (20,000-50,000/ha.) and are not fed, although the pond is periodically fertilized to enhance the growth of naturally occurring food organisms. In intensive culture, stocking rates may be as high as 50-100 shrimp per m^2 (500,000-1 million/ha.). Intensive culture requires continuous mechanical aeration and massive water exchanges of 100% weekly or more. In some cases, water in the intensive systems may be filtered or otherwise purified and then reused.

Harvesting of shrimp ponds can be accomplished by trawling, seining, or draining. While we attempted a partial harvest with seines, the most effective method of harvesting large ponds, such as those used in the demonstration project, is by draining. To harvest the demonstration ponds, dam boards and screens were gradually removed from the center sections of the drain/harvest structure. The shrimp moved out with the discharged water, which passed through a framed trawl-like net that had the cod end in a harvest sump. A fish pump attached to the cod end pumped water and shrimp into an elevated dewatering tower. Shrimp then moved down a pipe from the tower into 450 kg-capacity fish totes. These were frequently iced while filling and then loaded onto an adjacent trailer truck for hauling to a processing plant. Using this method, ponds over 40 ha. in size were harvested in 35-40 hours and produced a top quality, fresh, ultra-premium product.

Results

1987

Only pond A was used for production operations in 1987 (Homziak et al., 1987). Two crops of the white shrimp, Penaeus vannamei, (cycles: March-September and July-December) were harvested. Yields attained in the first crop were 48,098 kg. of heads-on shrimp (1143 kg./ha.) and in the second crop 21,784 kg. (522 kg./ha.). Reduced production in the second crop was attributed to early cold weather in October which reduced growth and survival. While the 42 ha. pond was in production during the spring and early summer of 1987, the adjacent 47 ha. pond was used for disposal of dredged material.

1988

In 1988, a semi-intensive crop of 31,960 kg. (676 kg./ha.) of heads-on shrimp was produced in the 47 ha. pond. Production, survival, growth, and feed conversion efficiencies were not as good as those recorded in the previous summer. The causes of this reduced performance were not clear, but prolonged high salinities (130 days above 36 ppt) and possible poor quality of post-larval seed stock were suspected. No adverse affects from the dredged material were evident.

The two-year, per-crop average production from semi-intensive (stocking about 10 juvenile shrimp/m^2) shrimp culture exceeded 34,000 kg. (over 780 kg./ha.) at favorable feed conversion ratios and with good survival (averaging 61%). This was within the target production range for the demonstration.

Two alternative production scenarios were attempted without success. In the first, an extensive (unfed) crop in the 42 ha. pond was lost due to contamination by predator fish which entered the growout pond when the predator filter became clogged and then overflowed. About 700 kg. of 0.5 kg. spotted seatrout were present at harvest and shrimp survival was only 3.4%. An electronic system to prevent future overflow was developed and installed to prevent reoccurrence. The second alternative was an attempt to grow a winter crop using a reportedly cool water-tolerant species, P. penicillatus (Main and Fulks, 1990), during the winter of 1988-89. These shrimp were killed by unusually low temperatures during February, 1989.

1989

A semi-intensive crop in 1989 suffered from an international shortage of seed stock which prevented timely stocking. Post-larvae were stocked in small amounts as they became available over several months. These undesirable circumstances resulted in poor survival and growth, with final production of only 14,155 kg. (337 kg./ha.) of heads-on shrimp, with over 60% being small (over 50 tails/lb.).

Summary of Demonstration Facility Shrimp Production

A total of six crops were attempted during the 3-year operation of the demonstration facility. Of these, two crops failed (due to cold temperatures in winter 1989 and fish contamination in summer 1988), and four successful crops were harvested (Fig 5). Production rates for the four crops averaged 669 kg./ha. of whole shrimp (range: 333-1143 kg./ha.) with 51% survival (range: 23% to 74%). Total production of 114,491 kg. of whole shrimp (70,761 kg. tails) was sold for over $475,000, which was deposited in the U.S. Treasury.

Demonstration Facility Disposition

At the conclusion of the demonstration project, the shrimp farm facility was transferred to the Brownsville Navigation District (BND), an independent political entity of the State of Texas, and the local dredging sponsor. The BND received over 25 inquiries from the private investors and leased the facility to a commercial shrimp farming enterprise in mid-1990.

Information Transfer Documents

Information obtained by the CAAP will be published in six technical reports to be published by the Corps of Engineers. Topics include site selection and acquisitions, legal and regulatory requirements for DMCA aquaculture, chemical suitability of DMCA for aquaculture, economic and marketing analysis of the demonstration, engineering design and construction, and description of project production methods. In addition, a guidance manual for use by CE field offices will be produced.

A third group of publications covering the same topics will be produced by the National Sea Grant College Program, and will be oriented toward prospective aquaculturists, investors, and financial institutions. These extension publications will be available at Sea Grant offices throughout the nation by late 1991.

DMCA Aquaculture - Future Prospects

In the demonstration facility, the main species of shrimp produced was the South American white shrimp, _Penaeus vannanei_. This species is produced by most of the commercial aquaculturists in Texas and the western hemisphere (Chamberlain et al., 1985). It tolerates crowding, is relatively hardy, has a good growth rate, and is available as post-larvae from commercial hatcheries. It is, however, a tropical species that requires temperatures above 22° C for acceptable growth. In the semi-tropical climate of South Texas it has a 6-8 month growing season. In more temperate climates, a more cold-tolerant species such as _P. chinensis_ or _P. penicillatus_ will be required (Main and Fulks, 1990).

Although the CAAP demonstration project was a penaeid mariculture facility, aquaculture in DMCAs is by no means limited to shrimp or even to marine species. There are over 100,000 ha. of aquaculture facilities for channel catfish, baitfish, and freshwater crayfish in the southeastern United States (Kensler, 1989; USDA, 1990). These industries are profitable and expanding. In areas where DMCAs may be located near temperate freshwater, there is a potential for containment area aquaculture of these species.

In cold water areas, commercial aquaculture facilities for rainbow trout and salmon are expanding in many countries, including the U.S. Various species of salmonids can be produced in either fresh or salt waters. Under current production practices, these are usually grown in raceways or cages rather than ponds, and therefore salmonids have less potential for DMCA aquaculture than warmwater species. However, production practices for these salmonids are evolving and pond culture remains a possibility.

Both oysters and hard clams grow well in the shrimp ponds, suggesting there is good potential for shellfish culture in DMCAs. Recent successful trials growing oysters, (R.Wallace, Auburn University Marine Center, Mobile, AL, personal communication) and hard clams (R. York, University of Hawaii, Kaneohe, HI, personal communication)) in ponds support the technical feasibility of pond-based mollusc culture. Mollusc culture in DMCAs may also be particularly attractive because of the freedom to use mechanical harvesters, outlawed or severely restricted for use in leased grounds in many states. Small DMCAs may be suitable for bag culture of shellfish (Vaughan et al., 1990). Other species such as mussels and scallops may also be suitable for DMCA culture.

A coastal fish species with significant aquaculture potential is the striped bass, especially the striped x white striped bass hybrid (Helfrich, 1989). These fish have good market acceptance, rapid growth rates, and are amenable to pond culture. A small (3-4 ha.) containment area on the Chesapeake Bay is currently being used for hybrid striped bass production (G. Earhart, US Army Corps of Engineers, Baltimore, MD personal communication).

Conclusion

The multiple use of DMCAs, primarily for periodic disposal of dredged material but with culture operations interspersed among disposal events, has many attractive features. Benefits to an aquaculture enterprise from multiple use of DMCA are numerous. Costs associated with land acquisition, levee and water control structure construction, and related items such as road access to sites could be fully or partially subsidized by either the federal government or by the local sponsor of the dredging project. Greatly improved access to suitable lands and use of areas already designated as DMCAs should aid in overcoming two major impediments to aquaculture development in the U.S., restrictive regulatory requirements controlling development of coastal property and lack of access to suitable coastal sites. Land owners would benefit by realizing greater revenues from their property, either through increased value from improvements or in the form of user lease fees. Real estate for DMCAs may be difficult for a project sponsor to locate because land owners are often reluctant to commit to the long-term leases involved or to cooperate with what they perceive to be a waste disposal activity. With the inducement of increased revenue, the CE and the local dredging sponsors of dredging projects may have less difficulty in finding affordable land to lease for containment areas.

Interest in the results of this demonstration within the CE, by local agencies, and by the industry has been high. The successful demonstration of aquaculture in DMCAs on a commercial scale allows the industry, land owners, dredging sponsors, and the CE to realize the benefits of this multiple use of DMCA.

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References

Aquaculture Digest. 1990. Shrimp farming in Texas, Hawaii and South Carolina, USA. Aquaculture Digest 15(3):6-16.

Chamberlain, G.W., M.G. Halsy, and R.J. Miget. 1985. Texas Shrimp Farming Manual. Texas Agricultural Extension Service, Texas A&M University Research and Extension Center, Corpus Christi, TX.

Helfrich, L.A. 1989. Hybrid striped bass species production plan. Pages 11-33 In: North Carolina Aquaculture Development Report. North Carolina Biotechnology Center, Research Triangle Park, NC.

Homziak, J., and J.D. Lunz. 1983. Aquaculture in dredged material containment areas. Proceedings. Miscellaneous Paper D-83-2 U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

_______, _______, and D.M. Dugger. 1987. Aquaculture in dredged material containment areas: a commercial scale demonstration of the concept. Pages A-1 to A-25 In: N.V. Brodtmann, Jr. (ed.) Proceedings of the Fourth Water Quality and Wetlands Management Conference, 24-25 September 1987, New Orleans, LA. Synopsis in Aquaculture Digest 12(11):2-5.

Kensler, C.B. 1989. A Regional Survey of the Aquaculture Sector in North America. FAO Aquaculture Development and Coordination Programme Report ADCP/REP/89/37. FAO/UNDP, Rome, Italy.

Lawrence, A.L., J.P. McVey, and J.V. Huner. 1985. Penaeid shrimp culture. Pages 127-157 In: J.V. Huner and E.E. Brown, (eds.), Crustacean and Mollusc Culture in the United States. Avi Co., Westport, CT.

Lunz, J.D., and M. Konikoff. 1986. Use of dredged material containment areas for aquaculture. Pages 292-302 In: D.D. Hook, (ed.), The Ecology and Management of Wetlands, Volume 2: Management Use and Value of Wetlands. Timber Press, Portland, OR.

Main, K.L. and W. Fulks. 1990. The culture of cold-tolerant shrimp: Proceedings of an Asian-U.S. workshop on shrimp culture. The Oceanic Institute, Honolulu, HI.

Quick, J.A., Jr., D.J. Milligan, S.E. Hill, R.J.. Hover, and W.F. McIlhenney. 1978. Field Demonstration of Shrimp Mariculture Feasibility in Dredged Material Containment areas. Technical Report S-78-53. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Tatem, H.E. 1983. Aquaculture and dredged material containment sites:

significance of contaminated ediments. Pages 169-190 in: J. Homziak and J.D. Lunz, (eds.) Aquaculture in dredged material containment areas. Proceedings. Miscellaneous Paper D-83-2. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

U.S. Department of Agriculture. 1990. Aquaculture Situation and Outlook Report. USDA Economic Research Service Report AQUA-4. U.S. Department of Agriculture, Washington, DC.

Vaughan, D.E., L. Creswell, and M. Pardee. 1990. A manual for farming the hard shell clam in Florida. Aquaculture Report Series, Florida Department of Agriculture and Consumer Services, Tallahassee, FL.

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I. STATE OCEAN ROLES

Hawaii and the Ocean

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Introduction

Once again, Hawaii is searching for an ocean policy. Despite two decades of attempts to develop an ocean management agenda and design the mechanisms to implement that agenda, Hawaii has no comprehensive ocean policy. Lack of focus, poor leadership, and a sole reliance on sector-based management have hampered past efforts. As a result, jurisdictional gaps and overlaps, combined with ineffective coordination efforts among the federal, state, and county agencies concerned with the ocean, have led to the state's failure to adequately deal with ocean and coastal resource degradation, increasing user conflicts, and resource depletion. With no comprehensive ocean policy to guide them, underfunded agencies set their own agendas and priorities with little public input or interagency communication, driven instead by outside political forces and financial realities.

Notwithstanding such constraints, Hawaii has had its successes in the ocean arena. For example, the State has successfully promoted its ocean recreational opportunities, contributing to the overall increase of tourism. Tourism in 1989, the most recent year for which data are available, represents almost 40% of the state's gross product (DBEDT, 1990). In addition, Hawaii's ocean industries grew at an average annual rate of 11% from 1981-1986, 4.4% above the state-wide average.

But such successes are small in comparison to what could be. For two decades, Hawaii has been struggling to find the key to taking better advantage of the surrounding ocean and its resources. Hawaii's ocean management efforts have waxed and waned since Governor John A. Burns formed the state's first Task Force on Oceanography in January, 1969 (see Lowry et al., 1990, for a history of Hawaii ocean policy in the past three decades). The latest attempt comes from the 1988 Legislature's directive to the newly-formed Ocean and Marine Resources Council to create an Ocean Resources Management Plan. The Council is now completing a draft Plan to be presented to the Legislature in January, 1991.

This process has brought to light strengths and weaknesses in Hawaii's competence in managing the area offshore of the Hawaiian Islands out to the seaward edge of the Exclusive Economic Zone (EEZ). This paper reports on Hawaii's regulatory system, the current ocean management planning process, and possibilities for the future strengthening of Hawaii's capacity for effective, sound ocean management.

Current Structure

Seven state agencies exercise authority over the use of Hawaii's ocean: Department of Business, Economic Development, and Tourism (DBEDT); Department of Land and Natural Resources (DLNR); Department of Transportation (DOT); Office of State Planning (OSP); Department of Agriculture (DOA); Department of Education (DOE); and Department of Health (DOH).

DBEDT's role is marketing Hawaii's ocean industries in order to generate jobs and revenue within the state. Its tasks range from administering the fishing vessel loan programs and seafood promotion campaign to acting as liaison with the federal government in developing an offshore mineral mining industry. The DLNR has primary resource development and regulatory authority over fisheries, marine ecosystem protection, and aquaculture and mariculture activities. DOT's role is primarily that of regulator, managing ocean recreation activities and the state's harbors. Its recently promulgated Ocean Recreation Management Plan and implementing regulations have been the subject of a lawsuit and remain embroiled in controversy. The OSP, the state's major planning agency, oversees, inter alia, implementation of the state's coastal zone management program.

DOA's role is limited to marine plant and animal inspections and aquaculture industry promotion. DOE's Office of Instructional Services develops marine education programs throughout the state, primarily in public schools. DOH, another key regulatory agency, has responsibility for all of the state's pollution control laws, including those impacting the ocean. It also runs an aquatic safety intervention program and inspects aquaculture facilities and seafood.

The Hawaii Ocean and Marine Resources Program

In 1988, the Hawaii Legislature created an Hawaii Ocean Resources Management Program consisting of two elements: an Ocean and Marine Resources Council and the Hawaii Ocean Resources Management Plan. The purpose of the Program is to make policy recommendations on how ocean resources should be managed. These policies are to focus on an overall conservation ethic while encouraging ocean resources development that is environmentally sound and economically beneficial. This tall order has been assigned to the Council, whose eleven voting members include six from state government and five gubernatorial appointees representing commercial, recreational, environmental, and research interests. The Council's two main responsibilities in this enterprise are (1) to serve as a forum for comprehensive policy formulation, public and private sector coordination and information and (2) to develop an Hawaii Ocean Resources Management Plan.

The Council started its work in 1989, setting for itself an ambitious schedule in order to meet the statutory deadline. Their first task was formation of a planning team drawing from the Council staff, the private sector, and the University of Hawaii. The group began the planning process by identifying a series of ocean and coastal resource management problems. This process occurred simultaneously with the compilation of an inventory of existing ocean and coastal programs, activities, staff and funding resources, and related laws, rules, and regulations in the state. The second step was the writing of nine sector papers (focusing on fisheries, ocean recreation, coastal erosion, energy, harbors, marine ecosystems, waste management, aquaculture, and marine mining) which were reviewed and amended following a series of public workshops. The Council is now considering two draft plans, one by the planning committee and another by a sub-committee of the Council. The Council will have its own draft plan ready for presentation at public workshops in early November. The final plan is scheduled to be published in January, 1991.

The Draft Plans

In drafting a plan, the planning team recognized that Hawaii, like many other states, manages ocean resources, not the ocean. This strategy has led to single-sector marine resource management and its concomitant shortcomings. For example, a single-sector approach often unwittingly creates conflicts when two or more uses compete for the same ocean space. A decision that make sense when considering only one group of ocean users often is unreasonable when other interests are at stake. Single-sector management makes it difficult for agencies to ferret out those other legitimate interests. In some cases, an agency's implementing legislation and own rules can make the other interests irrelevant in the decision-making process.

The two drafts currently before the Council change the focus of the planning effort to one of integrated management of the ocean. Such an approach is recommended by nationally-recognized ocean policy scholars (Cicin-Sain and Knecht; Miles; etc.). This idea is not new in Hawaii. The Task Groups from Hawaii's first ocean management initiative in 1969 recommended a long-term coordinative and integrative system (Lowry et al., 1990).

That such an approach has not yet been adopted is not surprising. Accomplishing such a task can mean major reorganization of the current agency framework, a step that entails significant political risk with no guarantee of success. It requires strong leadership and commitment to a different process of decision-making. For example, methods such as periodic coordination meetings, cross-training and rotation of personnel, and recruitment of "generalists" as well as "specialists" must accompany a reorganization plan (Cicin-Sain and Knecht, 1990). Such a major change of focus does not come easily to any bureaucracy.

In recognition of these problems, the planning team and staff for the Council have proposed a range of options from minimal "tinkering," to creation of an Office of Marine and Coastal Affairs in the Governor's Office, to establishing a Department of Marine and Coastal Affairs that would consolidate all ocean-related activities under one umbrella agency (Hawaii Ocean Resources Management Plan, Draft, 21 September 1990). In addition, they have identified a series of ten implementing actions to help accomplish the goal of integrated management. Included among these actions are development of methods to compute carrying capacities of areas, improved interagency coordination mechanisms such as Memoranda of Understanding, expansion of the State Geographic Information System database, a comprehensive water quality and marine life monitoring program, and improved public education. Because even integrated management does not obviate the need for some sectoral planning, the draft plan poses a series of implementing actions for each resource area (e.g. fisheries, marine ecosystem protection, etc.) that are designed to achieve a goal of sustainable development.

A sub-committee of the Council has developed its own proposal for integrated management (Sub-Committee Draft, 12 October 1990). Grounding its approach in a conservation ethic, the sub-committee recommends five major initiatives: (1) regional planning and management; (2) development of specific conflict resolution procedures; (3) improved enforcement; (4) active encouragement of public participation in policy-making; and (5) improved capability to foresee emerging issues. The sub-committee draft also advocates designating two areas as pilot projects to test the efficacy of their regional planning approach. A regional task force composed of representatives from government, community, and private industry would be created for each area. Each project would include components from the five initiatives. After a 2-5 year trial period, the projects would be evaluated. If they were judged successful, the approach could then be implemented state-wide.

The Future

Whether any of the far-reaching policy initiatives being proposed will be adopted by the Council or the Hawaii Legislature is problematic. Without strong leadership on the Council, through the Governor's office or within the Legislature, such an outcome is unlikely. This poses the question of whether Hawaii truly has the capacity to manage its offshore resources? King and Olson (1989) suggest the answer to that question lies in a five-part evaluation: (1) historical efforts by the state; (2) the institutional framework for dealing with ocean policy issues; (3) attitudes of political decision-makers towards ocean issues; (4) official commitment to problem-solving based on a rationality model; and (5) role of political leadership.

Hawaii would fare well under an historical effort analysis. As stated earlier, Hawaii has been working on an ocean management agenda for the past two decades. Throughout this process, the state has gone through two major stages: research and development, and promotion (Lowry et al., 1990). In both stages, important strides were made. One example was the institution in 1970 of a Marine Affairs Coordinator in the Office of the Governor. Although no longer in existence, the Coordinator position was largely responsible for the success of the R&D phase of ocean policy planning. But the state's public trust and regulatory functions made little progress during this period (Lowry et al., 1990; Cicin-Sain and Knecht, 1990). Recommendations that would have improved this area went unheeded. In fact, some marine resource development promotional activities have led to conflicts (particularly in the marine recreation and tourism arena) which the regulatory system has not been able to handle effectively. If the latest ocean management planning process directly addresses the state's regulatory short-comings ignored by previous efforts, Hawaii's capacity for ocean management will be significantly enhanced.

The institutional framework and attitudes of political elites may be Hawaii's weakest link. With few exceptions, interagency and intergovernmental coordination is inadequate. For example, despite a clear need to work closely on many issues, DOH, DOT, and DLNR continue to have difficulty working together. OSP has been unsuccessful in getting administrative support to oversee in a meaningful way the actions of county governments under the Coastal Zone Management Act. The Legislature abrogates its ocean policy-setting responsibilities by failing to follow-through on critical recommendations of studies it commissions. (see Lowry et al., 1990, for a history of recommendations from various ocean planning study efforts and their record of implementation).

The state seems to have fared somewhat better in working with federal agencies. A federal-state interagency task force, led by DBEDT and the federal Minerals Management Service, forged a meaningful partnership to explore the potential for offshore mineral mining in Hawaii's EEZ (Wiltshire, 1984; Lowry et al., 1990). Further, the consistency process under the federal Coastal Zone Management Act generally functions well in Hawaii.

Without further research, we are unable to adequately address the extent to which agencies have made in-house efforts to promote a rational scientific approach to policy-making. Areas of inquiry suggested by King and Olson (1990) include increased levels of professional training among staff members, working relationships with University marine researchers, and better relationships between professional staff and agency decision-makers. However, we do know that lack of financial support from the Legislature and creative data gathering systems by state agencies have caused serious gaps in Hawaii's ocean resource database. Without enlargement and adaptation of the State Geographic Information System (GIS) to existing marine and coastal resource and use databases, the state will have difficulty making rational decisions based upon accurate scientific data. Weaknesses in the state's environmental impact statement law exacerbate the problem.

Political leadership remains an open question. Fragmentation of ocean-related responsibilities among a number of agencies with differing agendas makes it difficult to carry out a coherent ocean policy agenda or to hold anyone accountable for failed ocean policy. For example, the 1985 Hawaii State Ocean Management Plan called for shared management of ocean resources among the agencies, with the Department of Planning and Economic Development as the overall lead agency. DPED was charged with preparing a biennial work program for the Governor and Legislature. Once this program was approved, DPED would oversee the implementation of the various work tasks, acting as coordinator of the activities of other affected agencies and organizations. In addition, it would periodically review and update the plan. But the Legislature failed to give the DPED sufficient legal authority to induce the inter-agency cooperation needed to effectively carry out the plan. Agency administrators failed to place sufficient priority on ocean issues to make the system work. Reorganization of DPED in 1987 dispelled whatever was left of the myth of integrated ocean management and planning. Furthermore, the Governor's one-year delay in making appointments to the current Council calls into question his commitment to the latest ocean planning effort.

Conclusion

Despite past failures to grapple with the hard issues in forging a comprehensive ocean policy, the current planning process in Hawaii offers hope for change. Proposals are now on the table that would give the legislature a selection of alternatives to pick from that are grounded in a conservation ethic and that incorporate an integrated management framework. These implementing actions include regional planning pilot projects, carrying capacity studies, improved data gathering and compilation, and conflict resolution procedures. The Council's recommended plan will be out by the end of 1990, whereupon the 1991 legislature will have an opportunity to make the necessary political changes to keep Hawaii in the forefront of ocean planning and management. If the legislature does this, and leadership emerges from the executive branch to carry out the new agenda, Hawaii will, for the first time, have a comprehensive ocean strategy.

Ocean Management Capacity in the State of Alaska: Bridging Resources in State and Federal Waters

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Introduction

Like other coastal states in the United States, Alaska is facing the issue of state participation in the management of ocean resources. Alaska has experienced the economic and environmental effects of activities and management programs in federal waters. Of particular importance are the management and utilization of oil and gas resources on the outer continental shelf and commercial fisheries stocks within the Exclusive Economic Zone (EEZ). As is only natural, the state desires to maximize the benefits and minimize the adverse impacts of activities that take place within the EEZ. However, Alaskans have used the limited opportunities for participation in EEZ management decisions with mixed success. The ruling by the U.S. Supreme Court to exclude oil and gas lease sales in the OCS from consistency requirements with state and local coastal management programs removed the most meaningful tool for influencing the location and conditions of offshore oil and gas development. Alaska is in a better position with regard to commercial fisheries, where the state holds a majority of seats on the council which manages commercial fishing harvests in the EEZ off of Alaska. In this arena, the state finds itself in increasing conflict over a limited resource with commercial fishing interests from other west coast states which currently use the fisheries.

Alaska is interested in either obtaining a greater level of participation in federal management of ocean resources or receiving expanded state jurisdiction to manage those resources. Alaska's capacity to manage resources in the EEZ should be viewed in the context of the resources present in coastal and marine waters, its relationship with the federal government, and the technical and policy skills present in state government. This paper addresses the historical aspects of state utilization of ocean resources and its relationship with the federal government; existing state capacity to manage ocean resources; and the outlook for increased participation in ocean resource management.

Historical Use of Ocean Resources and Relationship with the Federal Government

Resources in Marine and Coastal Waters

Alaska has the longest coastline of any state in the nation, 6,640 miles, which represents approximately 54% of the nation's coastline. Resources in the coastal and marine waters off the state are both extensive and diverse; they include valuable commercial fisheries, oil and gas reserves, mineral deposits, and fish and wildlife. Among the west coast states, the Alaskan economy is particularly reliant on its marine resources. Alaska has a historic orientation towards utilization of coastal and marine resources. Commercial fisheries provide employment in harvesting and processing, and generate tax revenues for state and local government. Petroleum production in coastal waters also creates direct employment and tax revenues, and through refining and support services, indirect employment and tax revenues. Offshore mining is again generating employment and state revenue in Northwest Alaska, after several decades of dormancy. Public opinion supports resource utilization, but requires that environmental quality be maintained.

Commercial Fisheries

Commercial fishery resources in coastal and marine waters off Alaska include salmon, herring, shellfish, and groundfish, the most recent fishery to become developed. Fisheries played an important role in the development of the state, particularly during the transition period after American acquisition from Russia. Alaskan fisheries have consistently ranked second among the states in volume and number one in value. Two ports in Alaska, Kodiak and Dutch Harbor, rank in the top ten in the U.S. for pounds landed and four Alaskan ports have been in the top ten for value of seafood landed. There are an estimated 422 seafood processing plants in Alaska which seasonally employ over 30,000 people. This employment figure is more than any other state and is more than the Gulf states combined. The Alaska state government and many municipal governments collects taxes and fees levied on the fishing industry. The Alaskan fisheries provide significant employment and income for residents of Oregon and Washington; in turn, much of the capital for fisheries investment comes from these two Northwest Pacific states.

Historically, salmon fisheries in coastal waters, and king and tanner crab fisheries in coastal and marine waters have had the greatest impact on revenue and employment. However, the most rapid developments have occurred in the open ocean groundfish fishery. Over the last 10 years, the groundfish fleet has transformed from a 100% foreign fleet, through a brief period of foreign-domestic fleet joint ventures, to a 90% American fleet. The groundfish resource supports 25 onshore processing plants and about 90 catcher processors/freezer longliners.

Oil and Gas Resources

Approximately 40 of 54 state oil and gas lease sales held in Alaska since 1959 have involved the leasing of tidelands or submerged lands. The majority of offshore oil production and all offshore gas production has taken place in Cook Inlet, although oil production in state waters off the North Slope of Alaska is increasing. In the current five year state leasing schedule (1990-1994), 7 of the 14 scheduled lease tracts involve tidelands or submerged lands.

The federal outer continental shelf (OCS) is divided into four regions, with Alaska being one of them. The OCS in Alaska covers approximately 772,200 square miles. During the 15 years of federal oil and gas lease sales, approximately 12 (of 27 proposed) lease sales were held and included nearly 50 million acres in offerings. Lease sales and exploration activities have occurred in numerous areas off Alaska: the Beaufort and Chukchi Seas; Norton Sound; the Bering Sea; Bristol Bay, off the Aleutian Islands; and in the Gulf of Alaska. The majority of current exploration activity is occurring in the Beaufort and Chukchi Seas off the North Slope of Alaska.

There are currently no producing wells in federal waters off Alaska. The revenue generated from all lease sales between 1976 to 1986 in the Alaskan OCS region amounted to nearly $6 billion The most recent federal five-year plan (1990-1994) calls for seven sales in the Alaska region. Federal "mean conditional case" estimates of oil in the Alaskan OCS total 12.57 trillion barrels of oil and 62.72 trillion cubic feet (tcf) of gas. These figures represent 44% of the U.S.'s oil potential and 38% of the gas potential, respectively.

Offshore Minerals

Minerals have been produced in Alaskan coastal waters since the early 1900's. The majority of activity has occurred in state waters in Norton Sound in Northwest Alaska, where placer gold deposits are being dredged on state leases using bucket dredges. Approximately 66,000 ounces of gold worth nearly $30 million have been dredged between 1988 and 1989. Pending regulatory challenges, the Alaska Department of Natural Resources has approved leasing and exploration of placer platinum deposits will commence in state waters off Goodnews Bay in Southwest Alaska. Other applications for mining in state waters are being evaluated for areas in southcentral Alaska, the Gulf of Alaska, and off the Seward Peninsula.

Mining in federal waters has lagged behind state waters. A federal lease sale is scheduled in Norton Sound for 1991. Federal mineral investigations have also occurred near Goodnews Bay, and a lease sale could follow. Sand and gravel resources in federal waters off Alaska's North Slope have also received attention during the past five years. An Environmental Impact Statement for offshore gravel mining in support of oil and gas development was prepared, but no further action has been taken.

Fish and Wildlife

Alaska's marine fish and wildlife resources have historically played a major role in the human habitation and economic development of the state. The abundance of marine mammals, seabirds, and fish supported the spread of Alaskan Natives throughout the coastal area, and are still an important part of Native subsistence harvests. Marine mammals brought the Russians to Alaska to harvest seal and sea otter furs, and American whalers to western and Arctic Alaska. Today, tourists still travel to remote areas of the state to observe marine mammals and seabirds.

Historical Relationship Between the Federal Government and the State of Alaska

From 1867 until statehood in 1959, the federal government managed Alaska. The historic and current relationship between the two governments influences the potential for cooperation on management of ocean resources. In general, west coast states have a greater proportion of lands under federal public ownership than the rest of the nation, and Alaska is no exception. Some statistics on land ownership in Alaska are provided below:

TOTAL (millions of acres)	
Federal	220.0
State	104.4
Native Corp.	44.0
Private/municipal	85.1
TOTAL	365.5

In the last 20 years, two major pieces of federal legislation, the Alaska Native Claims Settlement Act (ANCSA) of 1971 and the Alaska National Interest Lands Conservation Act (ANILCA) of 1980, continued to influence land ownership patterns and the relationship between the state and federal government in Alaska. ANILCA was particularly important because it dictated the disposition and management of federal lands between the U.S. Fish and Wildlife Service, the U.S. Forest Service, the National Park Service, and Bureau of Land Management. Concerns over the potential results of federal lands legislation resulted in the formation of a joint federal-state land use planning team to provide recommendations for use of federal lands that were adopted by ANILCA. This joint land use council continues to exist, although it performs a minor procedural role rather than addressing major policy issues of mutual federal and state concern. A similar joint federal-state fish and wildlife planning team was established to provide oversight of the Trans-Alaska Pipeline, but was disbanded soon after the pipeline was completed.

Three major federal laws affect federal-state relations on offshore interests. The Marine Mammals Protection Act of 1972 defined the responsibilities of the Alaska Dept. of Fish and Game and the National Marine Fisheries Service in the management of marine mammals in coastal and marine waters. The Magnuson Fishery Conservation and Management Act established the North Pacific Fisheries Management Council for management of commercial fisheries within the EEZ; Alaska nominates 9 of 15 seats on the council. The federal Outer Continental Shelf Leasing Act does not provide any specific joint management opportunities for coastal states. In Alaska, participation has been limited to: state review of leasing, exploration, development, and production plans; requirements for public participation; and reviews for consistency with the state coastal management program and approved local district programs. State comments using the first two mechanisms are advisory only; consistency is limited to spill-over effects on coastal resources in state waters. Contentious issues include conflicts between commercial fishing and oil and gas development, and where to draw the line separating state and federal waters (and hence revenue) in oil-rich areas.

Alaska's recent statehood, relative amount and economic reliance on federal lands and waters, and the history of joint management groups has established a pattern, if an uneasy one, of state and federal coordination on management of some but not all ocean resources.

Existing Ocean Management Capacity

Federal Programs and Agencies

Table 1 shows the federal agency characteristics in Alaska relevant to ocean management. The federal presence in Alaska is greater than in most west coast states (for example, the Minerals Management Service of the U.S. Dept. of the Interior [MMS] treats Alaska as a subregion on a par with the Gulf and West coasts). The federal agency presence reflects the high percentage and volume of federal lands and the nature of the resources on federal lands and waters. As a result, complaints about federal management are not so much related to lack of staff and presence as they are to management objectives that may be different than the state's.

State Programs and Agencies

State ocean management capacity in Alaska is a function of three items: programs applicable to oceans management; agency expertise, staff, and budget; and policy formation by the State Legislature and the Governor.

Program Capacity

There are several programs that are potentially applicable to increased state participation in ocean management. However, most of them address single issue or resource-specific regulatory requirements. The following programs are different in that they are both multidisciplinary, multiple use, and require the cooperation of the major state resource and policy-setting agencies.

The Alaska Coastal Management Program was empowered in 1978 in response to the federal Coastal Zone Management Act. A task force composed of the major state resource and policy agencies was formed to develop the standards and guidelines of the state program, which are used as the starting point to develop local coastal management programs. This approach assures a multi-disciplinary planning process that considers the concerns and responsibilities of the major line agencies. Project consistency review regulations were adopted in 1984 to improve program implementation and provide a highly coordinated project review system with specific time limits and an appeal process. The output is one state consistency determination for a project coordinated among the affected state agencies and coastal districts, rather than several separate determinations. Agencies and coastal districts are required to work together in an interagency committee, and essentially forge a unified state policy position on a specific project. In addition, the procedure provides greater predictability to permit applicants; relatively few decisions are appealed.

The State Area Planning Process is required by state statute to manage lands received from the federal government as a result of statehood. This regional planning process brings together state resource agencies, local governments, resource users, and interest groups to classify state-owned lands and waters (largely by resource value) for the types of activities that are allowed under each classification. Representatives of these groups sit on a planning team and policy committee to oversee plan preparation. Policy guidelines for allowing uses and how they are to occur are then prepared by subdistrict for each classification. The area planning process is intended to provide direction on state agency management of state lands and waters, and to precede any disposal of state lands and waters for leasing, sale, or transfer to municipalities.

Agency Capacity

Table 2 shows the technical, manpower, and budget characteristics of the major state agencies involved in coastal and marine management. Alaska is strong in single marine resource expertise; integrated, multiple-use capability is present only in the Department of Natural Resources (Area plans) and Division of Governmental Coordination (Permit Review/Coastal Consistency Implementation).

Policy-making Capacity

Policy-making lies in the hands of the Governor and Legislature. Neither of these groups has been a strong advocate of creating new coastal or ocean policy. With the exception of recent oil spill legislation (in response to the EXXON Valdez spill), there have been no major, multiple-use, coastal and ocean management initiatives, in the state since passage of the Alaska Coastal Management Act in 1978.

Local Program Capacity

In addition to state and federal agencies, some ocean management capacity exists through local coastal management programs. Coastal districts in several parts of Alaska have had experience in addressing offshore oil and gas and mining issues and projects over the last 15 years. Program development has increased local technical and policy capabilities in relevant areas such as marine fish and wildlife management and oil spill cleanup and response. It has also increased their ability to participate effectively in federal and state programs. However, application of these skills to marine projects has been limited primarily to coastal management consistency decisions and public participation opportunities. In the case of the North Slope Borough, municipal land management regulations are applied to offshore projects within the three-mile limit.

Outlook for Improved Ocean Management Capacity

Observations on the Alaskan Experience

The twelve years of Alaskan experience in implementing the Alaska Coastal Management Program give rise to several observations on the potential for improving state capacity in ocean management:

1) "We have met the enemy and he is us ..." syndrome

The Alaskan state resource management system is very similar to the federal system. The state is often viewed by local government the same way the state views federal agencies (eg. preoccupied with revenue generation and unresponsive to local concerns). For example, the Department of Natural Resources is responsible for multiple use of state lands and waters (mining, oil and gas, timber, agriculture, and state parks). More than any other state agency, it is responsible for generating income; speaking up for resource developers in agency policy arenas has become an informal duty. Giving ocean management responsibilities to state government may not resolve current conflicts.

2) The "single resource agencies vs. comprehensive ocean management agency" argument

Several administrations have attempted to combine single-purpose agencies into an integrated resource agency (admittedly, the primary motivation was efficiency and budget savings). None of these attempts has been successful. In each case, a wide variety of groups opposed the action,preferring to keep their current advocates among state agencies rather than risk losing influence. Formation of a "super agency" has also generated fear of political manipulation by a new administration.

3) Problems in defining national vs. state marine resources

The question arises whether or not the coastal states can make a distinction between national and state resources, and equitably allocate resources and revenues to out-of-state users. On state lands and waters, Alaska has made several attempts to provide preferential use to state residents. Most residential preference initiatives have been struck down by the courts as unconstitutional and it is certain that the federal government will consider national interest and allocation issues before increasing state management authority.

Recent Initiatives and Action

Most of the ocean management initiatives and actions taken by the state have been on the basis of a specific project, issue, or event. Examples include:

- a generic Alaskan Attorney Generals position in 1989 supporting increased state responsibility in the EEZ
- participation in west coast oil spill commission (formed partially in response to the Exxon Valdez oil spill)
- continued state opposition to awarding OCS tracts to bidders in the Bristol Bay Lease Sale, where exploration and development has the potential to conflict with a valuable salmon fishery
- state proposals before the North Pacific Fisheries Management Council to allocate groundfish fishery quotas between floating processors and shore based processors

The history of multiple use, multi-agency initiatives has also been in anticipation of or in response to specific problems, legislation, or regulatory requirements. As indicated earlier, there have been no major coastal, ocean, or multiple-use policy initiatives since the late 1970's.

There are several factors that probably contribute to a lack of focused interest in increased state participation in ocean management:

- Alaska's strong and uncompromising marine interest groups, fishing and petroleum, make pursuit of integrated ocean management policy difficult

- state-wide preoccupation with revenue generation, job creation, and holding down government costs and employment

- state and federal management systems that, despite complaints, work relatively well

- the lack of an event or conflict creating catastrophe, outrage, or management need for ocean management

<u>Requirements If Alaska is to Increase Participation in Ocean Management</u>

In general, Alaska has the technical and regulatory expertise to increase participation in the management of specific ocean resources. Some additional staff and funding would be required, but the structure and history of resource management is in place. However, Alaska must overcome the same weaknesses as the federal government:

1) a lack of an integrated marine policy, and

2) a lack of an agency or mechanism to provide integration of resource agency marine functions

A second requirement is to translate Alaska's expertise and efficiency in integrated project review and permitting to providing advanced regional planning for ocean areas. The process for state area plans and developing coastal district plans could easily be applied to ocean areas.

Finally, Alaska needs additional motivation and justification to lobby for participation in ocean resource management. The traditional reasons, a larger share of the revenue pie and the feeling of having state and local concerns ignored by the federal government, are not enough.

Table 1. Federal Agency Ocean Management Capability in Alaska

Program Area/Agency	Function
Commercial Fisheries	
North Pacific Fisheries Management Council	• commercial fisheries management
National Marine Fisheries Service	• research in support of NPFMC
OCS Oil and Gas:	
Minerals Management Service	• oil and gas leasing, oversight and permitting for exploration, development and production
Federal Regulatory Energy Commission	• permitting, oil and gas transportation systems
Offshore Mining:	
Minerals Management Service	• mineral leasing, oversight and permitting for exploration, development and production
Bureau of Mines	• mineral research
Water Quality/Oil Spill Response	
Environmental Protection Agency	• regulatory oversight of air and water quality, COE permit review
U.S. Coast Guard	• regulatory oversight of oil spill response and cleanup
Fish and Wildlife Management	
U.S. Fish and Wildlife Service	• fish and wildlife research and management, national wildlife refuge management, COE permit review
National Marine Fisheries Service	• fisheries and marine mammal research and management, COE permit review
Other	
U.S. Army Corps of Engineers	• regulatory oversight of dredge and fill, placement of structures in navigable waters

Table 2 State Agency Characteristics

<u>Agency</u>
<u>Budget</u>

<u>Divisions</u>

<u>ManPower</u>

Division of Governmental Coordination

- Coastal Management
- Permit Review
- Federal Lands Coordination

<u>Expertise:</u> State Coastal Management Program, Local District Coastal Mana coordination, federal permit and agency coordination

Alaska Department of Natural Resources

- Oil and Gas
- Mining
- Geological and Geophysical Services
- Lands/Water
- Parks and Recreation
- Forestry
- Agriculture

<u>Expertise:</u> Land and water planning and management; oil and gas leasing and management; mineral research, leasing, and management; parks and recreation planning and development

Alaska Department of Fish and Game

- Commercial Fish
- Habitat
- Sports Fish
- Game
- Fisheries Rehabilitation, Enhancement, and Development
- Boards of Fisheries and Game

<u>Expertise</u>: Fish and game research and management; habitat protection, enhancement, and rehabilitation; permit and project review

Alaska Department • Environmental quality of Environmental Conservation • Environmental Health

<u>Expertise</u>: Air and water quality research and management; oil spill response regulations and oversight; seafood processing regulations and oversight; hazardous materials regulations and oversight; permit and project review

Critique of Ocean Policy Development in Washington State

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Introduction

The State of Washington has accomplished much in the past five years to enhance its capacity for ocean management. The State Deptartment of Ecology has developed policy and information to participate in the federal government's Outer Continental Shelf and marine sanctuary programs. The Governor has a special assistant to represent him in discussions with other states and federal agencies. A series of high quality reports was published by the Washington Sea Grant Program that provide a useful information base for the state. The Joint Select Committee on Marine and Ocean Resources proposed a comprehensive package of bills and will continue in existence until at least 1995. Finally, the Ocean Resources Management Act (1989) takes beginning steps to articulate a state policy and to bring some agencies and local governments into the process through specific planning requirements.

Washington's initiatives are at a beginning stage and need further elaboration. Some of the ocean policy statements in the 1989 law are too general to provide appropriate guidance for future decisions. Also, the steps taken to improve organizational arrangements have enhanced management capacity, but important links must still be forged between agency officials, scientists, legislators, and interest groups.

Ocean Policy Development

The Ocean Resources Management Act takes a modest step toward the development of substantive ocean policies for the state. It calls for a six-year moratorium on oil and gas leasing in state waters. This clear policy statement takes a "wait and see" approach, provides a clear termination date, and calls for new information through an "oil and gas analysis" and biological baseline to help determine whether to extend the moratorium. The analysis must be conducted by the Washington State Departments of Ecology and Natural Resources under the supervision of the Joint Select Committee, and funds are provided for the study. The analysis must show the potential revenue and economic impact from offshore oil and gas development the state would give up in exchange for avoiding the range of negative environmental risks that are identified. This provides an explicit way to structure future decision making and is one of the strengths of the bill.

Another strength of the bill is the goal of including local governments in the OCS process by providing guidelines and funds for reviewing and revising shoreline master programs in coastal counties. The goal is a worthy one but there are ambiguities in the statute's requirements. The state must adopt "ocean use" guidelines which are to be used in reviewing, "...and where appropriate amending...," shoreline master programs. The State Department of Ecology (DOE) does not have the power to mandate amendments to shoreline master programs. It can only review and approve or reject amendments submitted to it by local governments. Once the guidelines are adopted, the law calls for local governments to review their shoreline master programs "...to ensure that the programs conform with... this act and with the Department of Ecology's ocean use guidelines." The Act then requires that amended shoreline master programs be submitted to DOE by 30 June 1991. The objective seems to be that coastal counties must revise their master programs, but this is not made clear. Also, it is not clear who determines whether the master programs are adequate--the local government or DOE.

The policy section of the law, Section 9, contains only one general statement indicating how conflicts among uses in coastal waters are to be resolved: those uses that will not adversely impact renewable resources are to be given priority over uses which are likely to have an adverse impact on renewable resources. The implementing vehicle for this general policy is found in Section 11, called "planning and project review criteria." That section calls upon state and local governments to use the policies in Section 9 to guide their decisions about management, conservation, use, or development of natural resources in Washington's coastal waters. Further, when federal, state, or local permits or other approvals are required for a use "...that will adversely impact renewable resources, marine life, fishing, aquaculture, recreation, navigation, air or water quality, or other existing ocean or coastal uses...," that use must meet a list of eight specified criteria (e.g., significant need, no reasonable alternative, and compensation).

This new law is so general that it is bound to suffer from problems of interpretation and implementation. In attempting to establish a general standard applicable to all agencies, similar to the National Environmental Policy Act (NEPA) and subsequent state environmental policy act (SEPA), it invites either being ignored or being used in litigation to require self-execution by all agencies. The history of the implementation of NEPA-type statutes shows years of litigation before agencies fully incorporated the law into their operations. Legal questions had to be answered, and new funds authorized for doing impact analyses. Major issues related to the "threshold" question of when an EIS was needed, the relationship of NEPA to the organic statute of the agency, the question of whether agency decision-making had to change because of the analysis, and the definition of key terms such as "significant impact" and "human environment."

The same set of problems are likely to arise in trying to implement and interpret the policies and the planning and project review criteria in the Ocean Resources Management Act (ORMA). Key questions will be when the new criteria must be applied, and who decides that issue. In particular, what new ocean use will require that the new criteria be applied? Another question will be how the existing review processes under Washington's Shoreline Management Act, Hydraulics Act (fish and wildlife habitat protection) and SEPA are modified, if at all, to meet the requirements of the new law and whether that modification is sufficient. Further questions will arise over what a "conflict among uses and activities" is (if one person objects is there a "conflict" sufficient to invoke the policy?), and what uses "adversely impact" renewable resources.

Another major problem with this law is the lack of a responsible implementing agency and the failure to appropriate funds for implementation. State agencies are left to decide for themselves, independently, how the law should be implemented. Since this law is supplementary to existing authority and there is no advocate for its use, it may well be overlooked.

Ultimately, a more effective management statute will be needed. To be effective, that statute must cope with the actual problems of ocean management. This will require a careful specification of the uses to be managed. If offshore oil and gas, or mining, is the subject of concern, it should be so stated. If existing agencies already have a role to play, that role should be acknowledged, and expanded or contracted as necessary. The relationship among the agencies must be addressed. Criteria for decision-making should be carefully laid out and relate to the use being proposed. This may require a planning process which specifies in advance sites that are suitable and sites that are off-limits for certain development. A decision process must be set forth, specifying the rights and obligations of the parties. Finally, funds must be allocated and timeframes established to ensure that the policies are implemented.

Washington State may reach this stage in the future. One of the provisions of the ORMA requires that the Joint Select Committee determine if the procedures available in the Energy Facility Site Selection Law would be applicable and appropriate for offshore uses like oil, gas, or mining development. The Committee could consider other laws as well, such as the Shoreline Management Act or the State's Aquatic Lands laws, as vehicles for managing ocean uses. The Committee could choose to amend the Ocean Resources Management Act to address some of the issues noted above. Whatever approach is taken, ocean use, development, and management should be viewed comprehensively and not limited solely to the perceived adverse effects of offshore oil, gas, or mineral development.

Organizational Development

In developing governmental capacity for ocean management, the greatest challenge is to establish effective working relationships among organizations that have a stake in ocean use decisions (Underdal, 1980). This is not an easy task because resolution of ocean management issues requires the expertise of many organizations and the consideration of diverse policy preferences. Since organizations are slow to change, a major obstacle in developing effective working relationships for ocean management is what Miles (1989) refers to as "organizational constraints". Organizations are pre-occupied with the struggle to survive and expand, to be autonomous, secure, and prestigious. They compete to retain or expand jurisdiction and to command a high level of political support. Miles argues that major reorganization of agencies for the purposes of ocean management is unworkable and that the best strategy is a conscious effort to force linkages among the important organizational players.

From 1986-1990, existing ocean-related organizations in Washington have sought to retain or expand their jurisdiction, and some new organizations have been created. Organizational changes have occurred rapidly because of major pending federal actions such as Lease Sale 132 and the Western Washington Outer Coast Marine Sanctuary designation. Linkages among the players have occurred primarily through the technical advisory group that each player established for itself that included other agencies, scientists, and interest groups. In my view, a more effective and ongoing pattern of linkages is needed.

Within the state's executive branch, the Department of Ecology had policy leadership for ocean issues until 1987. When the Governor's Ocean Policy Work Group was initiated in 1987, chaired by a special assistant to the Governor who was located in the Washington Department of Fisheries, DOE's policy-leadership shifted to this new group. Washington State's participation in the Pacific NW OCS Task Force, an intergovernmental body, brought yet another organization to the group of players. Finally, in 1989, the state legislature gave the Department of Natural Resources, which is headed by an independently-elected Commissioner, a specific role in evaluating the moratorium on oil and gas development in the three-mile marginal sea. By 1990, therefore, three executive agencies, a non-statutory informal "working group", and an intergovernmental body were at work on different aspects of ocean policy for the state. Other agencies, such as the Departments of Wildlife, Community Affairs, and Trade and Economic Development, were keenly interested in ocean management issues but not given a direct role, except as members of technical advisory groups. The common policy theme was concern about, or opposition to, oil and gas leasing. The approach of each agency differed because each operated under different statutory or executive authority.

The Washington Legislature's role in ocean policy has varied over the years. The Oceanographic Commission of Washington, an advisory group that existed from 1967 to 1983, was primarily responsive to the Legislature since six of its eleven members were legislators. It gave the Legislature an independent source of information for policy development, which sometimes differed from that of the Governor. The Joint Select Committee, established in 1987, aggressively developed a package of bills with the aid of full-time staff. The Legislature funded the Washington Sea Grant Program studies, seeking advice on the status of the state's scientific knowledge and the need for additional study. In the 1989 Ocean Resources Management Act, the Joint Select Committee inserted itself into the moratorium review process, requiring state agencies to work under the direction of the Joint Select Committee when conducting their oil and gas leasing analysis for state waters. It is clear that the Legislature, through the Joint Select Committee, will be playing an ongoing policy development role.

The role of the scientific community in the state's ocean policy development has not been institutionalized. DOE has funded a few technical studies and pressed the Minerals Management Service (MMS) of the U.S. Department of the Interior to spend more of its money studying Washington's marine and coastal areas. The Washington Sea Grant Program studies were well-received, but there has been no follow-up to their recommendations and no ongoing role for the scientists who were used in the Sea Grant project. DOE, the Joint Select Committee, and the Pacific NW OCS Task Force each has technical advisory panels containing university and agency specialists. But the time these scientists can give to the agencies is limited. Normally, they review and comment on the products of others rather than generate their own reports.

Because ocean policy issues are so wrapped up in questions of ocean science, building scientific expertise and capability into policy development in a systematic way is critically important. This requires funding and necessitates a strong linkage between those doing science and those using the results. The agencies are keenly aware of the need for a strong scientific component, but no established mechanism has been created to bring this about.

Conclusion

It is evident from this brief review that Washington State has experienced considerable policy and organizational change relative to ocean policy and management in the past four years. The proposed oil and gas lease sale precipitated virtually all of this change and set the agenda for existing and new organizations. Coordination among the players was possible because of the clarity of the policy issue and the strong conservationist views of the participants about offshore oil.

When the state's ocean agenda broadens to include such issues as ocean dumping, aquaculture, recreation, or fisheries, it is unlikely that the existing organizational arrangements will allow a coherent ocean policy to emerge. Leadership in the executive branch is not at all clear since there are independent "centers" of authority in the state Departments of Ecology, Natural Resources, and Fisheries. The technical advisory committee as a vehicle for scientific input is inadequate because insufficient resources are committed to the development of science information. The Joint Select Committee's policy proposals could clash with those of the executive agencies if there is insufficient staff support and coordination with those agencies. Granted that democratic values and a pluralistic society are advanced through a healthy tension between the executive and legislative branches, there may be ways to design a more structured approach for reconciling diverse interests in the formulation of ocean policy.

In Oregon (Hout, 1990) and in North Carolina (Orbach and Queen, 1990), broad-based task forces have been established by law to provide advice on state-level ocean policy. Oregon's approach, a highly structured process to develop an Ocean Resources Plan and a Territorial Sea Plan, has been successful in plan-making because of the effective use of state officials, local leaders, and citizen activists in one forum. North Carolina's Marine Science Council includes diverse public and private interests that are periodically called upon to suggest policy alternatives for the state. The Council has the respect of governmental and legislative leaders and often uses an informal network of marine experts to help solve problems as they arise.

The Washington Legislature should establish a broad-based task force to deal with ocean policy development, structured so that linkages among executive agencies, and between scientists and managers, are strengthened. Its mandate should be comprehensive, dealing with a wide range of ocean issues, not only potential harm from extractive industries focusing on oil, gas, and mineral resources. In addition, the task force should be proactive, developing a program for the state in marine resource use and protection. Rather than return to the Oceanographic Commission model of the 1970's, the state should study closely the initiatives of sister states in developing appropriate policy and organizational strategies. Our use of the sea and our concern for its protection will increase in the future. We should be prepared with policy and organizational arrangements that can quickly and effectively respond.

Acknowledgement

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Notes

1. Products of the Ocean Resources Assessment Project conducted by the Washington Sea Grant Program:

State and Local Influence Over Offshore Oil Decisions: study of the roles and mechanisms of state and local governments in offshore oil decision-making, based on the experience in other states (Hershman, et al., 1988).

Hydrocarbon Potential of the Washington OCS: assessment by the Washington Department of Natural Resources, to help identify geologic formations that might be of potential interest to industry (Palmer and Lingley, 1989).

Coastal Oceanography of Washington and Oregon: regional oceanography text which contributed to 15 of the 22 scientific subjects mentioned in the law (Landry and Hickey, 1989).

Toward a Conceptual Framework for Guiding Future OCS Research: workshop to develop a framework to help determine "what's important?" and ensure that future research is both targeted and scientifically well-founded (Kasperson, Golding and Tuller, 1989).

Coastal Washington: A Synthesis of Information: report on existing information, information gaps, and research needs (Strickland and Chasan, 1989).

Information Priorities: Final Report of the Advisory Committee: report of the committee's observations and findings based on field trips and members' expertise (Ocean Resources Assessment Project 1988).

2. Draft Ocean Use Guidelines dated April 10, 1990 were circulating for review at the time of this writing. DOE is seeking consistency among the four

coastal counties in how they deal with ocean use. This will be a challenge since local governments in the past have had considerable latitude in the development of local shoreline master programs. DOE proposes general ocean use guidelines as well as specific guidance for oil and gas development, ocean mining, ocean disposal, energy production, transportation, research, and salvage.

3. It is obvious that the statute is aimed at control of oil, gas, or mining activity, but this is not so stated. The findings state there is insufficient information to assess the potential adverse effects of offshore oil and gas exploration and development (RCW 43.143.005(4)). Part of the legislative policy section notes that it is not currently the interest of the Legislature that recreational, commercial fisheries, and other renewable marine or ocean resource uses meet the new planning and review criteria, but that agencies may require conformance in the future (RCW 43.143.010(5)). Also, the planning and project review criteria are required when a use "adversely impacts" other existing marine uses (RCW43.143.030(2)) and one of the few uses that does not now exist off Washington's coast is oil, gas, and mineral extraction.

4. Joint Select Committees meet only when the Legislature is not in session. Their policy proposals must be advanced by individual committee members through the standing committees during the session. The package of bills of the Joint Select Committee on Marine and Ocean Resources suffered in 1989 because the chair of the Joint Select Committee lost his position as chair of the appropriate standing committee. Joint Select Committees also are highly dependent on staff for research, bill drafting, and the management of hearing and advisory committees. The Joint Select Committee on Marine and Ocean Resources lost its full-time staff person after a leadership struggle in 1989. Without significant staff support, the Committee may lose some of its policy development function.

References

Hershman, M., D. Fluharty, and S. Powell. 1988. State and Local Influence Over Offshore Oil Decisions. Washington Sea Grant, Seattle, WA.

Hout, E. 1990, in press. Ocean policy development in the State of Oregon. Coastal Management, 18(3).

Kasperson, R.L., D. Golding, and S. Tuler. 1989. Toward a Conceptual Framework for Guiding Future OCS Research. Washington Sea Grant, Seattle, WA .

Landry, M. and B. Hickey, eds. 1989. Coastal Oceanography of Washington and Oregon. Elsevier. Science Publishers B.V., Amsterdam, Netherlands.

Miles, E.L. 1989. Concepts, approaches, and applications in sea use planning and management. Ocean Development and International Law, 20:213-238.

Ocean Resources Management Act. 1989. Laws of Washington, 1989, 1st Ex. Sess., Ch. 2, Sects. 8-20; Rev. Code of Washington, Chs. 43.143 and 90.58.195.

Ocean Resources Assessment Project. 1988. Final Report of the Advisory Committee, Information Priorities, 1988.

Orbach, M. and W. Queen. 1990. "Ocean policy initiatives in coastal states: North Carolina's experience," Coastal Management, Vol. 18.

Palmer, S. and W. Lingley. 1989. An Assessment of the Oil and Gas Potential of the Washington Coast. Washington Sea Grant, Seattle, WA.

Strickland, R. and D. Chasan. 1989. Coastal Washington: A Synthesis of Information. Washington Sea Grant, Seattle, WA.

Underdal, A. 1980. Integrated marine policy: what? why? how? Marine Policy, pp. 159-169.

Ocean Policy Development in the State of Oregon

Eldon Hout
Oregon Ocean Resources Management Program

Abstract

The Oregon Ocean Resources Management Program is an unprecedented effort by a state to protect the long-term values and benefits of renewable ocean resources and activities. The program extends Oregon's comprehensive statewide planning and coastal zone management program seaward to provide a coordinated, comprehensive policy and management framework for state and federal agencies and Oregon's local governments. Its objective is to produce a framework for decisions that recognizes both the environmental links between the marine ecosystem and ocean resources and the economic importance of ocean resource use to coastal communities and the nation.

Oregon's initiative is an attempt to redefine the relationship between the federal and state governments with respect to resource management within a part of the U.S. Exclusive Economic Zone. The Oregon Program asserts the state's right and responsibility to plan for and jointly manage ocean resources and uses which affect the state, through creation of an Ocean Stewardship Area.

Introduction

In 1987, Oregon's legislative leadership took advantage of an opening "window of opportunity" to enact ocean policy legislation (Knecht, Cicin-Sain, & Archer, 1988). Ocean resource "problems" (a scheduled oil and gas lease sale in federal waters on the outer continental shelf [OCS] and industry interest in marine mining), "politics" (well-positioned legislative leadership from a coastal constituency genuinely committed to resource protection and managerial reform), and "policy" (discussion of ocean management schemes coupled with considerable guilt over the failure of the State to address the "wet" side of coastal zone management) did, in fact, converge. The result was enactment of the Oregon Ocean Resource Management Act.

As is often the case, Oregon's innovation in public policy was driven in part by real world events. Significant events and forces which have influenced Oregon's ocean resource planning process include:

1) Gorda Ridge

In late 1983, the U.S. Department of the Interior (DOI) proposed a lease sale for polymetallic sulfide minerals on the Gorda Ridge. The Draft

Environmental Impact Statement for the proposed lease revealed an absence of information on mineral resources, as well as major gaps in knowledge about ocean conditions, marine resources, and the potential impacts of development. Natural resource agency staff, academics, environmentalists, and some coastal residents reacted strongly to DOI's seeming haste to move forward with the leasing process. In early 1984, Oregon Governor Victor Atiyeh and Secretary of Interior William Clark created a technical state-federal task to determine the implications of a lease sale on the Gorda Ridge. The Gorda Ridge Task Force coordinated annual summer research dives from 1984 through 1988. Upon advice of the Task Force, DOI, the major research funding contributor, has now determined that leasing would be premature and has officially terminated the lease sale process and the Task Force.

2) Placer Minerals

Promising research findings and entrepreneurial interest in mining nearshore placer sand deposits (chromium and titanium) caused the 1987 Oregon Legislature to enact framework legislation to allow private sector exploration for hard minerals. 1987 S.B. 606 (ORS Chapter 274) gives the Division of State Lands authority to enter into contracts with private parties for the purpose of exploration for mineral resources. While the 1987 law neither commits the State to marine mineral development nor allows such development to occur until authorized by the Territorial Sea Management Plan (due to be completed in mid-1991), fisheries interests and coastal citizens have voiced strong opposition to the very idea of marine mineral exploration or development. Public opposition to marine mining increased to the point where there is considerable opposition to even public sector or academic data collection and analysis. Greenpeace and local fishermen protested with their vessels a recent Department of the Interior-funded research cruise. Preliminary returns from the cruise are not promising.

3) Offshore Oil and Gas Development

The failure of the U.S. Secretary of the Interior to respond adequately to the concerns of Oregonians regarding the scheduled 1992 OCS lease sale in the Oregon-Washington Planning Area was the most publicized ocean resource management issue. For many Oregonians, the purpose of the ocean resource management program was to develop a strategy to prevent oil and gas leasing in federal offshore waters. The views of Oregonians received recognition in the deliberations of the Pacific Northwest OCS Task Force described below and President Bush's June, 1990 decision to delay any leasing off Oregon and Washington until the year 2000.

4) EXXON Valdez

Public outrage at the consequences of major oil spills has added a new constituency supporting ocean planning. The nightly television images of oiled birds and dead otters in Prince William Sound focused the interest of many Oregonians on the more than 1400 offshore rocks and islands located off the Oregon coast which provide important habitat for birds and mammals. A latent belief that these and other marine habitats should be adequately protected has erupted into an issue of widespread public concern.

Full implementation of the Oregon Ocean Resources Management Act will result in two planning documents to guide state and federal decisions concerning offshore activities. The two plans are:

1) The Oregon Ocean Resources Management Plan--a comprehensive management plan for ocean resources and uses within the 200-mile U.S. Exclusive Economic Zone, including the Oregon territorial sea, was completed in June, 1990, and submitted to Oregon's Land Conservation and Development Commission for its approval by 01 December 1990 as part of Oregon's coastal management program.

2) The Territorial Sea Management Plan--a more detailed plan to manage resources in Oregon's territorial sea (0-3 miles), originally mandated to be completed and adopted by the State Land Board by July, 1991.

Ocean Resource Management Plan

The Oregon Ocean Resources Management Plan has four major elements: 1) an analysis of state and federal laws, programs, and regulations affecting ocean resources within the planning area, including gaps, overlaps, and conflicts; 2) a study of present and future ocean uses off Oregon, and an analysis of the state's management regime for such uses; 3) maps and other information about ocean conditions, uses, and resources, computerized to facilitate plan decisions; and 4) recommendations to develop or improve state agency programs for managing ocean resources.

The Plan also recommends that the 1991 Oregon Legislature extend the deadline for and broaden the scope of the more detailed Territorial Sea Management Plan. Such changes would allow fuller consideration of developments since the passage of the Oregon Ocean Resources Management Act in 1987, such as President Reagan's December, 1988 Proclamation widening the United States territorial sea from 3 to 12 nautical miles and the 1989 Oregon Legislature's decision to prohibit any leasing in the state's territorial sea for oil and gas development prior to 30 June 1995 (1989 Oregon Laws ch. 895 (S.B. 1152)). The Plan recommends extending that prohibition indefinitely and also prohibiting commercial mineral exploration in the state's territorial sea for five years.

The Oregon Ocean Resources Management Act was a legislative, rather than an Executive Branch initiative. Ocean resource management issues were not originally part of Governor Goldschmidt's legislative agenda, although he actively supported the legislation. The principal author, State Senator Bill Bradbury from the coastal community of Bandon, was supported in his efforts by all state legislators of both parties from coastal cities and counties. The Oregon Department of Land Conservation and Development (DLCD) and the Division of State Lands staff provided assistance in legislative drafting. Legislative spokespersons for other affected state agencies did not take any advocacy position on the legislation. Four environmental lobbyists offered general support. No one testified in opposition to the legislation.

Even though they received no funds to underwrite agency participation on the Task Force, other agency directors strongly supported the program from the beginning. Agency directors on the Task Force have willingly added the assignment to their workload. State agencies have spent approximately $866,000 for ocean planning and related activities during the 1987-89 biennium. The Legislature's direct appropriation was $374,452.

The Governor's recommended ocean budget for the 1989-91 biennium totaled $1.05 million for all agencies. The Legislature understood the real costs of the program incurred in the previous biennium, agreed with the agencies' priority consideration of ocean issues, and approved the Governor's recommended amount with almost no discussion. In response to the EXXON Valdez disaster, the Legislature appropriated an additional $40,000 to accelerate oil spill response planning.

The Task Force's only assignment was to prepare the Ocean Plan and make recommendations for its implementation. Plan policy recommendations are not self-implementing. The Task Force itself has no authority to adopt regulations. The Oregon Ocean Resources Management Act did not confer new authority on any agency to adopt specific regulations for ocean resources or ocean uses, although the Plan makes legislative recommendations for new agency authority.

The Ocean Resource Management Plan: Four Program Innovations

Boundary innovation: the ocean stewardship area

The Task Force has endorsed an ecosystems-based ocean resource management approach by asserting Oregon's ocean stewardship responsibilities through creation of an Ocean Stewardship Area. The Ocean Stewardship Area includes the entire continental margin from mean high water, across the continental shelf, and down to the bottom of the continental slope. The width of the continental margin varies from about 35 miles at

Cape Blanco to about 80 miles off the northern coast. Depth to the ocean floor at the edge of the margin varies from about 3000 meters off the southern coast to about 2200 meters off the northern coast.

Innovations in management: marine parks, gardens, and reserves

Statewide Planning Goal 19 and the Oregon Ocean Resources Management Act of 1987 both call upon the Task Force to make recommendations which will give priority to the proper management and protection of renewable resources. To carry out its legal mandate and meet its ocean stewardship responsibilities, the Task Force has recognized the need to institute special protective measures.

The Task Force considered a recommendation which could lead to the establishment of Rocks and Island Critical Habitat Areas. Most of the areas are located in the Oregon Offshore National Wildlife Refuge System, with the above-water areas managed by the US Fish & Wildlife Service as ecological preserves to protect the habitat and wildlife dependent upon the habitat. The aquatic areas around the rocks and islands fall under state jurisdiction. The establishment of access controls, buffer zones, or other protective measures will require close federal/state cooperation.

During public hearings held in November, 1989, the Task Force witnessed the head-on collision between fishermen concerned about any reduction in fishing areas and individual citizens and representatives of wildlife protection organizations who just as vigorously supported additional measures to protect threatened wildlife from the effects of human disturbance. A basic conflict of values surfaced, to no one's real surprise. It turned out to be the most divisive issue the Task Force would face. The Task Force eventually reaffirmed the status quo in state and federal fisheries management and the need to protect commercial and recreational fishing from the negative effects of other ocean uses.

Governance innovations: the ocean advisory council

The Task Force has concluded that a permanent mechanism is needed to retain the values of a multidisciplinary, interagency, joint public-private approach to ocean planning, policy formulation, and coordination. The Task Force recommends legislative establishment of an Ocean Policy Advisory Council comprised of state agencies, ocean users, coastal local government, and citizen representatives. The Council would coordinate preparation of the more detailed Oregon Territorial Sea Management Plan within the framework of the Oregon Ocean Resources Management Plan. The Council also would serve as a visible forum for discussion of ocean policy issues and proposed ocean development projects, coordinate the ocean resource interests and expertise of state and federal agencies, and assure that local governments are full participants in ocean policy discussions.

Innovations in state-federal relations: the struggle for co-management

Both the Oregon Legislature and the Governor expect Oregon's ocean program to be an agent of change in ocean governance within the federal system. The Governor anticipates the emergence of a totally new intergovernmental relationship, the ultimate objective of which would be state-federal co-management of all ocean resources within the Ocean Stewardship Area, if not the entire EEZ. Steps toward co-management have been taken in the case of potential placer mining and OCS oil and gas development.

Placer mining

An Oregon/U.S. Department of Interior Placer Task Force has been established and is investigating the economic and environmental feasibility of placer mining in state and federal waters off Oregon. The preliminary investigation will provide key information for developing state and federal approaches to placer mining. The State has prevailed on the Department of the Interior to include federal funds to study the environmental risks of placer mining as well as to undertake an assessment of market conditions for these minerals. Based on recent, preliminary results, the Placer Task Force may soon follow the path of the disbanded Gorda Ridge Task Force.

Oil and gas development and environmental studies

At the request of Oregon, Washington, and northwest Indian tribal governments, Congress instructed the Department of the Interior to create a Pacific Northwest Regional Outer Continental Shelf (OCS) Task Force; this body was established in January, 1989. Unfortunately, progress on substantive issues was slow at first. The new political leadership at the Minerals Management Service (MMS) appeared to take the Northwest Task Force seriously, assigning the MMS Deputy Director to represent the agency.

Pursuant to congressional direction requested by the two states, the Interior Department signed a cooperative agreement with the Pacific Marine Fisheries Commission to subcontract with the Oregon Department of Fish and Wildlife, Washington Department of Fisheries, and the Pacific Northwest Intertribal Fish Commission for a three-year commercial fisheries data study. The work includes elements viewed by both states as essential to meet state ocean resource management needs even if an oil and gas lease sale is not held until after the year 2000, pursuant to the President's June, 1990 decision.

Other state/federal agency cooperation

As Oregon's program gains visibility and generates policy recommendations on a variety of ocean resource management issues, federal agencies have begun to listen more carefully and respond more positively to Oregon's ocean resource management concerns.

Citing interest in Oregon's unique ocean planning program, the National Oceanic and Atmospheric Administration (NOAA) assigned a senior staff member to coordinate federal agency participation in Oregon's ocean program. NOAA readily approved Oregon's Ocean Resources Management Act as an additional element of the State's federally-approved Coastal Management Program.

The Oregon Ocean Resources Management Task Force established excellent working relations with the U.S. Fish and Wildlife Service, various NOAA agencies (especially the National Marine Fisheries Service), the U.S. Environmental Protection Agency, and the U.S. Army Corps of Engineers. These agencies, having been active in the ocean plan preparation phase, will eventually carry out the letter and spirit of new State agency programs which are developed as a result of the plan's recommendations.

The ability of Oregon to point to a comprehensive planning document, prepared with the active participation of federal agencies and carrying the combined weight of both state and federal agency agendas, strengthened the State in its dealings with the Minerals Management Service. The work of the Oregon Ocean Resources Management Task Force also demonstrated to Oregon's congressional delegation that State agencies, federal agencies operating in Oregon, and Oregon's citizens were taking their stewardship responsibilities seriously. Oregon is willing to use its scarce fiscal resources to collect data, conduct careful analyses, and carefully articulate public policy in an open process. Moreover, the Governor wanted to move beyond litigation, continued reliance on the congressional appropriations process, and political confrontation as the customary ways to achieve Oregon's ocean resource management objectives.

Conclusion

Sound planning will be necessary to protect, conserve, and secure an optimal economic return from Oregon's ocean resources. Planning can ensure a collaborative, efficient, and balanced decision-making process. The private sector is often the prime mover in ocean resource development. What does or does not happen offshore, and at what pace, usually depends on market conditions and the judgment of ocean users. However, resource allocation decisions are best made in advance of development requests, if at all possible. New offshore uses may represent economic trade-offs that diminish existing ocean uses rather than simply adding to existing levels of income now derived from ocean resources.

Oregon's ocean planning program is viewed nationally and internationally as a forward-looking and innovative approach to ocean governance. The State's strategic geographic location and outstanding ocean resource diversity and productivity present Oregonians with an opportunity to play an increasingly important role in Pacific Rim affairs. With its own ocean policy and management house in order, Oregonians will have prepared themselves to make credible contributions to any future examination of new forms of ocean governance at the national and international levels.

References

1989 Oregon Laws ch. 895 (Senate Bill 1152).

Good, J.W. and R.G. Hildreth. 1987. Oregon Territorial Sea Management Study. Prepared by the Marine Resource Management Program, Oregon State University, and the Ocean and Coastal Law Center, University of Oregon. Salem, OR: Dept. of Land Conservation and Development.

Knecht, R.W., B. Cicin-Sain, and J.H. Archer. 1988. National ocean policy: a window of opportunity. Ocean Development and International Law 19:113-142.

Oregon Ocean Resources Management Act, Oregon Revised Statutes ch. 196.405-196.515 (Senate Bill 630).

Oregon Ocean Resources Management Task Force. 1988. Managing Oregon's Ocean Resources: Interim Report to the Joint Legislative Committee on Land Use. Portland, OR.

_______________. 1990. The Oregon Ocean Resources Management Plan: Draft for Public Hearings. May 1990 ed. Portland, OR.

Oregon. Outer Continental Shelf Oil and Gas Development Task Force. 1979. Final Report. Salem, OR.

Oregon State University. Sea Grant College Program. 1978. Oregon and Offshore Oil. Prepared for the Governor's Task Force on Outer Continental Shelf Oil and Gas Development. Corvallis, OR.

Parmenter, T. and R. Bailey. 1985. The Oregon Oceanbook: An Introduction to the Pacific Ocean off Oregon, Including Its Physical Setting and Living Marine Resources. Salem, OR: Dept. of Land Conservation and Development.

Senate Bill 606, Oregon 64th Legislative Assembly, 1987 Regular Session (Oregon Revised Statutes ch. 274).

Stander, J.M. and B.H. Echols. 1978. Oregon and Offshore Oil. Corvallis, OR: Sea Grant College Program, Oregon State University.

U.S. Dept. of Commerce. Office of Coastal Zone Management. 1977. State of Oregon Coastal Management Program. Washington, D.C.

California's Ocean Resources Management (CORM) Program History, Status, Promise

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Introduction

The following is a report on California's Ocean Resources Management (CORM) Program which commenced in January 1990. The Program's authorizing legislation, the California Ocean Resources Management Act of 1990, passed the legislature and was signed by the Governor in 1989 (AB 2000, 1989). The Program is composed of a Task Force and Advisory Committee which will prepare a report with recommendations on California's management of ocean uses. The report and recommendations will be delivered to the Governor and Legislature by 01 January 1993. California's Cabinet Secretary of Environmental Affairs is Chair of the Task Force. The author of this paper is Program Manager of CORM.

This report will present background to and report on the status of the CORM Program to October of 1990, and comment on its promise.

Background to the CORM Program

The California Ocean Resources Management (CORM) Program is the product of cooperative legislative and executive efforts to improve California's regime for managing its ocean uses. Because of the scope and interdependence of global ocean issues, it is essential to understand the CORM Program in its historic international and national contexts, particularly as it relates to the Law of the Sea Treaty of 1982, the U.S. Presidential Proclamations regarding the Exclusive Economic Zone in 1983, and the extension of the Territorial Sea in 1987. In order to keep this paper to the required length, however, I refer the reader to the literature, and focus on California. (CORM Program Draft Study Plan, 1990; Wade, 1989)

California

In summary, challenged by changing international and national ocean jurisdictions, uncertain authorities, increasing ocean uses, and evolving technologies, the California ocean constituency has been pressing for an improved state ocean management framework. The organized part of this constituency represents local, state, and federal government, the university systems, environmental and interest groups, and ocean industries. Each of these groups, and often subgroups of each, has its own management objectives and strategic agenda. Often these objectives and agendas have evolved in an iterative process over long periods of time, resulting in a rich ocean policy mix in California, but one dependent on increasingly obscure connections and unpredictable outcomes. Concurrently, the state has not identified as a whole its long-term interests in its offshore jurisdictions, nor has it evaluated its legal, fiscal, and institutional capacity to manage those interests.

It is important that California identify and evaluate its ocean interests since, with a population of 30 million, those interests apply to approximately 1100 miles of coastline extending through state waters to 3 n.m. seaward, and through the adjacent Territorial Sea to 12 n.m. seaward, and the Exclusive Economic zone to 200 n.m. seaward.

AB 2000

Though the Territorial Sea and Exclusive Economic Zone adjacent to California are federal waters, AB 2000 finds and declares, inter alia, that,

> "(i) The exclusive economic zone, the territorial sea, state waters, and terrestrial environments are an interdependent system that has to be managed through a cooperative effort between appropriate federal, state, and local agencies. The fluid, dynamic nature of the ocean and the migration of many of its living resources beyond state and federal boundaries extend the ocean management interests of this state beyond the three- nautical-mile limit currently managed by the state pursuant to the federal Submerged Lands Act..." (Sec. 36001).

In addition, AB 2000 is explicit with respect to California's policy regarding all its adjacent ocean waters:

> "(a) It is the policy of the State of California to do the following: (l) Assess the long-term values and benefits of the conservation and development of ocean resources and uses with the objective of restoring or maintaining the health of the ocean ecosystem and ensuring the proper management of renewable and nonrenewable resources. (2) Encourage ocean resources development which is environmentally sound, sustainable, and economically beneficial. (3) Provide for efficient and coordinated resources management in state and federal waters. (4) Assert the interests of this state in cooperation with federal agencies in the sound management of ocean resources. (5) Promote research, study, and understanding of ocean processes and resources to acquire the scientific information necessary to understand the ocean ecosystem and life- support systems and the relationships of ocean development activities and associated impacts on

> ocean and coastal resources of the state and adjacent zones of federal jurisdiction. (6) Encourage research and development of innovative, environmentally compatible marine technologies for protection, exploration, and utilization of ocean resources. (b) It is further the policy of the State of California to develop and maintain an ocean resources planning and management program to promote and ensure coordinated management of federal resources and uses with those in state waters, and with adjacent states, to ensure effective participation in federal planning and management of ocean resources and uses which may affect this state, and to coordinate state agency management of ocean resources with local government management of coastal zone uses and resources above the mean high tide line." (Sec. 36002).

AB 2000 mandates a state interagency Task Force with California's Cabinet Secretary of Environmental Affairs as Chair. The Task Force is to prepare the report regarding ocean management activities and impacts, including recommendations to increase coordination and consolidation of the state's ocean management activities. AB 2000 provides guidelines for a minimum of information that should be included in the CORM report. The bill also mandates an Advisory Committee and specifies a minimum of categories for its membership, including coastal local governments, federal agencies, environmental and interest groups, the legislature, and relevant ocean industries.

Secretary of Environmental Affairs

The designation of the Cabinet Secretary of Environmental Affairs as Chair of the CORM Task Force derives from the Secretary's existing responsibilities for ocean and other media, including:

* Advising the Governor as prescribed by OCSLA Sec. 19. This includes consultation (such as those resulting in stipulations for oil and gas lease sales 73 and 80) between the U.S. Department o the Interior and the Governor prior to approval of lease sales. (Merksamer, 1983): review and coordination of offshore policies and activities of state agencies, and liaison between state and local agencies and the federal government. Liaison duties are carried out through coordination and facilitation, primarily through convening ad hoc Joint Review Panels (JRPs). These panels are made up of representatives of responsible federal, state, and local permitting agencies in order to contract and review required environmental impact reports/statements for

offshore projects. (Kahoe, 1987)

* Administration of the Coastal Resources Energy Assistance Act of 1985 funded by OCSLA 8(9) monies. This program provides $25 million to coastal counties and $10 million to coastal cities to plan for and manage impacts of OCS oil and gas development. (Coastal Resources & Energy Assistance Program, 1989)

* Administration of the Local Marine Fisheries Impact Program funded by OCSLA 8(9) monies. This program addresses past and cumulative impacts to fishermen from OCS oil and gas development. The first year was funded at $2,150,000, the second year at $1,950,000, and the third year is proposed at $1,850,000. (Tillman, 1990)

* Oversight and coordination of ocean activities in California's adjacent federal waters with the goal to preserve and maximize the State's effective participation in its adjacent Territorial Sea and Exclusive Economic Zone (EEZ). The Secretary identifies and coordinates the State's evolving interests in federal waters off its coast including those for hard minerals (Sharpless, 1988 and 1987), revenue sharing, and State/federal decisionmaking.

* Serving as the Governor's designee on regional ocean forums such as the Dept. of Interior's OCS Policy Committee, the West Coast States/BC Task Force, the Gorda Ridge Task Force (now inactive), and on national organizations such as the Coastal States Organization.

* Serving as Chair of California's Air Resources Board. The Secretary also sits on California's Integrated Waste Management and Water Resources Control Boards.

These responsibilities and those for the CORM Program complement one another since their sum requires the Secretary to maintain an inclusive view of multi-media and transboundary uses and their interdependent effects and to recognize the need for integrated management and the potential for scientific, socio-economic, and political linkages.

Status of the CORM Program

CORM Task Force

The mandate of the CORM Task Force is to prepare the CORM Report. AB 2000 prescribes the 29 members of the Task Force, including the Chair. Twenty six members are chairpersons or executives of state agencies with ocean related activities. Other members are the chancellor and president of the California university system, and the director of California Sea Grant Program.

CORM Advisory Committee

The mandate of the CORM Advisory Committee is to advise the Task Force in its preparation of the report and to review drafts. The CORM Advisory Committee now numbers 120 members including representatives of coastal local governments, federal agencies, environmental and interest groups, the legislature, and relevant ocean industries. In addition, the Secretary has designated representatives of state agencies not named to the Task Force but with ocean interests, such as the Native American Heritage Commission and the Office of Emergency Services. In order to involve adjacent jurisdictions, the Secretary also designated as Advisory Committee members the Governor of Oregon and two Mexican Secretariats.

CORM Task Force Chair

The mandate of the CORM Chair is to provide all staff support, to call the Task Force together, to appoint the Advisory Committee with advice from the Task Force, and to submit the report and recommendations to the Governor and Legislature by January 1991. There is no budget for the CORM Program. The Program depends, therefore, on the Secretary of Environmental Affairs as Chair for leadership, staffing, and overhead. Currently, we have one full-time Program Manager, a graduate Sea Grant Fellow who will be leaving in December, and a part-time Executive Fellow. We are pursuing several avenues to maintain and increase this staff level.

CORM Program Objectives

We established objectives and a preliminary three-year agenda at the commencement of the Program. The objectives for the first year include the following:

* issue the draft scoping document for comment (CORM Program Draft Study Plan, July 1990);

* create a flexible Task Force and Advisory Committee organization congruent with the Program's objectives (CORM Program Subcommittee List, 1990); and

* prepare drafts of products that will provide a baseline for subsequent

discussion and analyses, including inventories of current and potential ocean uses (CORM Program List of Ocean Uses, and Use Inventories, 1990), inventories of State and federal ocean statutes and programs (CORM Program Draft State and Federal Legal Inventory Spreadsheets, October 17, 1990), inventories of State ocean education capacity and ocean data bases, and a preliminary bibliography.

In May, 1990 we held our initial Task Force meeting to receive Task Force comments on the Draft Advisory Committee list. On June 28, we held our first joint CORM Task Force - Advisory Committee meeting to receive comment on our administrative draft scoping document. On July 20, we issued our draft scoping document, called the CORM Draft Study Plan, with Request for Comments. As the comments came in, we held meetings with each of our twelve subcommittees in order to review and comment on preparation of draft products, primarily the inventories of state and federal ocean statutes and programs, and the ocean use inventories.

CORM Program Organization

The CORM scoping document, or CORM Draft Study Plan, includes the draft outline of the CORM report and recommmendations. This draft outline presents the unifying themes to which all CORM activities, subcommittees, inventories, and analyses relate. These themes are ocean uses and issues, identification of which is required by AB 2000. In turn, each of the twelve CORM subcommittees is focussed on one or more ocean use and is composed of both Task Force and Advisory Committee members. This subcommittee composition provides a continuing focus on the network of ocean uses and issues that otherwise might be diminished due to its complexity. It also provides potential integration of subcommittee discussions and analyses, and direct translation of subcommittee products to report requirements.

The report outline divides the report into legal and management sections. Under each section are a list of issues, each of which will be covered under each of three chapters: extractive ocean uses-living marine resources, extractive ocean uses-non living marine resources, and non extractive ocean uses. Obviously, we expect some overlap and redundancy in the uses and issues and eventually in some of the analyses. Since overlaps are a reflection of the complex oceanographic, coastal, atmospheric, and human management systems we are dealing with, we will work to clarify them as we begin analyses of options for the integration and coordination of California's ocean policy.

Promise of the CORM Program

The CORM Program promises California a thoughtful process to evaluate the state's ocean uses, issues, and management capacity. In addition, the CORM Program will deliver recommendations that will facilitate the state's adaptation to changing ocean circumstances, its accommodation of varied ocean interests, and its management of ocean uses. The CORM Program envisions for California a future of sustainable ocean uses of fair and effective ocean use management.

By configuring the CORM Report according to ocean uses and issues within state, federal, and international jurisdictions, the CORM Program has made explicit its commitment to prepare substantial management options as required by AB 2000. The scope of the report will be inclusive and its view long-term.

There has been criticism of AB 2000 because it does not favor renewable over nonrenewable resources. In fact, that impartiality is one of its strengths. There has also been criticism of AB 2000 because its mandated product is a report rather than a plan. Again, I believe this is a strength of the bill since, in California, there exists no commonly accepted information base upon which the Legislature could have derived fair criteria and credible standards to frame an ocean plan. Instead, AB 2000 recognizes the historic participation in California's vital and varied ocean activities of numerous local, federal, state, and international agencies, industries, and interest groups. It may result that the CORM Report includes in its recommendations an option to establish ocean use priorities, as well as an option to prepare a California ocean plan. But, as will be true of all the CORM Report recommendations, such options will be supported by substantive and consensual justification. Thus, AB 2000 poses California's ocean management questions with minimal prejudice, and challenges its Task Force and Advisory Committee to craft equitable and credible options to address California's ocean issues.

Maintaining this even-handed approach will not be easy. The CORM Program strengths are also potential pitfalls. Because the process requires a long-term view of complex and relatively nonpartisan matters, the Program risks loss of constituency interest. Because the Program is operating outside a crisis situation, it risks loss of priority. The present Secretary of Environmental Affairs is a dedicated Task Force Chair, but the CORM Program's lack of budget leaves it critically dependent on whoever holds that Chair. Only to the degree, therefore, that the Secretary of Environmental Affairs is committed to and provides consistent cabinet-level leadership, administrative, professional, logistical, and clerical support, will the Program prepare and deliver on time the report envisioned by AB 2000.

California's gubernatorial elections are next month and a new administration will be taking office in January, 1991. In order for the CORM Program to fulfill its promise, it is imperative that the new administration engage itself immediately and productively in its support.

In its first nine months, the CORM Program has accomplished a great deal, and the work has just begun.

References

AB 2000. California Ocean Resources Management Act of 1990. Chapter 1215, Statutes of 1989.

Coastal Resources and Energy Assistance Program Annual Report. Office of the Secretary of Environmental Affairs. Sacramento, CA. December 1989.

CORM Program Draft State and Federal Legal Inventory Spreadsheets. Office of the Secretary of Environmental Affairs. Sacramento, CA. October 17, 1990.

CORM Program Draft Study Plan and Request for Comments. Office of the Secretary of Environmental Affairs. Sacramento, CA. July 1990.

CORM Program Subcommittee List. Office of the Secretary of Environmental Affairs. Sacramento, CA. 1990.

CORM Program Use Inventories. Office of the Secretary of Environmental Affairs. Sacramento, CA. 1990.

Kahoe, M.A. 1987. "States Role in OCS Development: The California Model". Proceedings Coastal Zone Management Conference. Seattle, WA.

Merksamer, S.A. Memorandum to Gordon Duffy, Secretary of Environmental Affairs. February 1983.

Sharpless, J. Secretary of Environmental Affairs. Comments on Proposed Rules for Leasing and Postleasing of Minerals Other than Oil, Gas and Sulphur in the Outer Continental Shelf. Letter to Minerals Management Service dated September 30, 1988; Comments on Proposed Rule for Prelease Prospecting for Marine Mining Minerals Other than Oil and Gas. Letter to Minerals Management Service dated June 19, 1987.

Tillman, T.L. "Update to the Local Marine Fisheries Impact Program." Office of the Secretary of Environmental Affairs. Sacramento, CA. June 1990 .

Wade, S. O. 1989. "California and Its Adjacent Federal Waters." Proceedings OCEANS 89 Conference. Seattle, WA.

Offshore Louisiana: A Case Study

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We chose this title for our presentation at this session on "State Ocean Roles in the Gulf" because the state and federal "ocean" off Louisiana has been the scene of decades of development activity to an extent unheard of in any other coastal state. Louisiana has been blessed with a great abundance of offshore resources in the form of mineral deposits and fisheries stocks. This has led to a "gold rush-boom" mentality in the drive to extract these resources with very little comprehensive long-range planning or policy. We wish to present an overview of Louisiana's experience in managing its coastal and offshore resources.

History of Louisiana's Offshore Development

There are some striking examples of the major development activities that have occurred in offshore Louisiana. The first offshore oil and gas rig out of sight of land in Louisiana waters was established in 1947 and marked the "birth" of the offshore oil and gas industry in this country. Today, over 90% of the 4,000 mineral mining structures in U.S. coastal waters are located off the Louisiana coast. The nation's first and only deepwater oil port, the Louisiana Offshore Oil Port, was completed in 1981, 18 miles off the Louisiana coast and has recently been moving one million barrels of oil per day through its facilities. The world's only offshore sulphur mining operations, located just off the Louisiana coast, have been mining molten sulfur for 30 years. Recently, a new deposit was discovered equal in size to all the state's previously known deposits combined. This find promises to support 30 more years of offshore sulphur mining in Louisiana coastal waters. The molten sulphur from the new mine will be transported to land in "thermos bottle" tanker ships.

Louisiana ocean waters are traversed extensively by the workboats, supply boats, crew boats, and helicopters that service the offshore oil and gas rigs. Offshore waters also experience heavy shipping traffic to and from the ports of New Orleans (number one in the nation in cargo tonnage), Baton Rouge, and Lake Charles. The latter two ports rate among the top fifteen U.S. ports. Every year, thouands of ships bring oil to the refineries and petrochemical plants along the American "Ruhr valley" from Baton Rouge to New Orleans and to similar plants and the liquified natural gas facility at Lake Charles, in the southwestern part of the state.

The state's commercial and recreational fishing industries have benefited from the enormous fisheries resources off the Louisiana coast. In 1989, Louisiana's commercial fishery ranked first in the nation in poundage and second in value of the catch. Additionally, it has been estimated that the recreational fishing industry is as valuable to the state as the commerical fishing industry. Louisiana's continuing fisheries abundance (though estimated to be lower than historical levels) may seem surprising in light of the fact that a great deal of waste has been dumped in the state's waters.

Large amounts of heavily saturated brine have been pumped into Louisiana's ocean waters from the Louisiana salt domes that hold a significant portion of the nation's Strategic Petroleum Reserve and by the discharge of produced waters from offshore oil and gas operations. Offshore oil and gas operations have also dumped large amounts of drilling fluids into Louisiana ocean waters. There is extensive dumping of dredged spoil in these waters by the U.S. Army Corps of Engineers and the area has experienced several "test burns" of hazardous wastes by ocean incineration vessels.

The U.S. Supreme Court has added a complicating factor to all this offshore activity by holding that Louisiana's ocean "coastline" is ambulatory, meaning that areas of these coastal waters now owned and regulated by Louisiana could become subject to federal ownership and regulation if Louisiana's coastal wetlands continue to shrink at the current rate of 50 mi^2/yr and the "coastline" moves inland.

Offshore/Coastal Conflicts

With the extensive development occurring in Louisiana's coastal and offshore areas, it was inevitable and predictable that serious conflicts would occur between user groups.

One of the most serious conflicts has occurred over habitat destruction. There is a general perception in the fishing community (both recreational and commercial) that the oil and gas industry has been responsible for declines in fisheries stocks due to habitat destruction resulting from wetland alteration and water pollution. Indeed, scientific evidence suggests that activities such as the discharge of produced wastes and drilling fluids, the hundreds of minor oil spills that occur each year, and dredging of oil and gas canals in wetlands nursery habitat have a detrimental effect on commercially important fish species. Whether or not these factors are the major ones in the observed decline in fisheries stocks is unknown and it is certainly true that other factors such as dredged spoil disposal, non-point source pollution, and pollution from the Mississippi River also contribute to habitat destruction. Nevertheless, the perception still remains that the oil and gas industry is a major culprit.

Added to these perceptions is the very real threat of a major oil spill devastating Louisiana's offshore and coastal environment. Louisiana, with its vast coastal wetlands and extensive production and transportation of oil in its territorial sea, is perhaps more vulnerable than any other state to environmental disasters from ocean oil spills near its coast. Indeed, Louisiana wetlands serve as nursery grounds for a significant amount of commercially important fishery species found throughout the Gulf of Mexico.

It would have seemed logical that, sooner or later, the thousands of offshore oil and gas rigs with their attendant underwater piplelines and the hundreds of commercial fishing vessels fishing offshore Louisiana with underwater gear would result in severe "space" and "use" conflicts. However, extensive damage to fishing gear from these underwater hazards occurred for several years without widespread concern because it was happening in an "oil boom" atmosphere.

It is perhaps ironic that oil and gas structures themselves (not the discharges that come from them) are considered by many fisheries scientists to have a beneficial effect on fisheries stocks. These structures provide a hard substrate, which is naturally absent in the northern Gulf, on which lower food chain organisms can settle and grow. The extra biomass produced by these encrusting organisms supplements the food chain on which commercially important fish depend. Therefore, oil and gas structures are thought to increase fishery production rather than being only fish attractors. Unfortunately, U.S. Department of Interior and Department of Defense regulations require that oil and gas structures be removed when production ceases, thereby reducing the beneficial effect they are thought to have on fisheries production. From this dilemma arose the idea of using some oil and gas structures for artificial reefs. While the idea of leaving some oil and gas structures in place or moving them to designated offshore areas seems attractive for fisheries production and recreational purposes, it has been resisted by commercial fishermen who fear increased hazards to navigation and fishing gear. Another issue that has arisen is the danger to marine mammals and endangered sea turtles from the use of explosives to cut off rig pilings below the mud line, currently a requirement for proper removal. Other techniques are more dangerous to humans and more costly and could influence an oil company's decision on how to handle an obsolete rig.

A great deal of friction has occurred in Louisiana between recreational and commercial fishermen on the issue of "over exploited" species. Each group seems to preceive that the other side is "hogging" the resource. While such conflicts have always been present, they have been precipitated recently by the actions of the Gulf of Mexico Fisheries Management Council in closing the commercial red drum fishery in federal waters and in considering a partial closure of the brown shrimp fishery to protect juvenile red snapper.

Louisiana's coastline is one of the most littered areas in the U.S. and "litter researchers" point to offshore industries, including oil and gas, ocean shipping, and fisheries, as major contributors to the problem. While litter is not of the same significance as habitat destruction, it has been demonstrated that it can be a serious threat to some wildlife. It is also an indicator of general environmental attitudes that could spill over into more serious areas.

Louisiana's Responses to Offshore Conflicts and Issues

Louisiana's ocean "policy" for dealing with these ever-increasing and often conflicting offshore uses over the past 43 years has consisted of "after the fact," ad hoc solutions to whatever problem needed resolution at a given time. Louisiana has not developed a comprehensive policy for its offshore waters as several coastal states have recently done. In sum, Louisiana has usually "reacted" to events in the waters off its coast as they have occurred, rather than developed an "anticipatory" long-range ocean plan and policy.

The state has addressed the problem of habitat destruction primarily on an agency-by-agency basis with the exception of a series of memoranda of understanding between the Coastal Management Division (whose activities will be discussed below) and other agencies having jurisdictional responsibilities in the coastal zone and offshore. These MOU's function primarily to delineate authority in case of agency conflicts rather than establish a comprehensive plan or policy in which the various agencies participate. Therefore, state agencies continue to essentially "work alone" in their respective jurisdictions in the coastal zone and offshore. For example, the Department of Environmental Quality has recently proposed regulations to ban produced water discharges into coastal waters and is currently developing regulations under Section 401 of the Clean Water Act to enable it to take a larger role in protecting wetlands. The Department of Health and Hospitals has closed several contaminated oyster beds and attempted to control sewage discharge into coastal waters. The Department of Wildlife and Fisheries has responsibility for the living resources of the coastal zone and territorial sea and almost exclusive jurisdiction over state wildlife refuges. The Department of Wildlife and Fisheries also has special authority to impose conditions on coastal use permits by virtue of its MOU with the Coastal Management Division.

Despite the clear and present danger Louisiana faces from the threat of a major oil spill, the state has yet to develop a comprehensive oil spill contingency plan or assure the availability of the necessary equipment and personnel to respond to a large oil spill. The Louisiana Offshore Oil Port (LOOP) has its own oil spill contigency plan, equipment, and personnel to deal with spills resulting from the operation of its facility. However LOOP's oil spill response capability would be inadequate to deal with an oil spill of the magnitude of the EXXON Valdez. As a result of fears generated by the that spill, comprehensive oil spill legislation was introduced during the 1990 Louisiana legislative session. Even though the Mega Borg oil spill off the

Texas coast during that legislative session brought home the very real threat to Louisiana, political pressure from the oil industry resulted in the passage of such a weakened version of the bill that its author asked the Governor to veto it, which he did. As a substitute, the Governor issued an executive order establishing a commission named the Oil Spill Prevention Task Force to prepare a statewide oil spill prevention and contingency plan. Therefore, even though this task force is now meeting, Louisiana is still without an adequate oil spill response capability.

After several years of extensive damage to fishing gear caused by oil and gas-related underwater "obstructions," Louisiana finally lobbied to have a compensation program for commercial fishermen, the "Fisherman's Gear Contingency Fund," included in the federal Outer Continental Shelf Lands Act Amendments of 1978. The following year, the Louisiana Legislature enacted the "Fisherman's Gear Compensation Fund" to compensate fishermen for gear damage occurring in state waters. Both of these programs are funded by "assessments" on the oil and gas industry.

Faced with the fact that most of Louisiana's working offshore oil and gas rigs would become "non-producers" over the next 20 years and that the U.S. Department of Defense was mandating that these rigs be removed as they "played out," the state lobbied Congress to pass legislation allowing obsolete rigs to be used as artificial reefs for enhancing offshore fish production, sport fishing, and diving. In 1984, Congress enacted the National Reef Enhancement Act and, in 1986, Louisiana adopted its own Louisiana Fishing Enhancement Act, designed to facilitate the use of decommissioned offshore oil and gas rigs as artificial reefs. However, several issues remain to be resolved. The threat rig removal poses to sea turtles and marine mammals is currently being handled by observing the area around the rig for twenty-four hours before removal to make sure there are no turtles or mammals present. This may or may not provide adequate protection over the long run. A more serious impediment to the program is the fact that all rigs used for artificial reefs so far have been placed far offshore in deep water to accommodate the concerns of commercial fishermen regarding navigation and gear hazards. The distance of the rigs from shore has resulted in them not being much used for recreational purposes. All attempts to establish nearshore reefs continue to be met with strong resistence.

The Fisherman's Gear Compensation Fund and Louisiana Fishing Enhancement Act have alleviated some of the friction and conflict between the oil and gas industry and Louisiana commercial fishermen. However, a great deal of animosity still exists from commercial and recreational fishermen who perceive that the oil and gas industry has been responsible for a great deal of habitat destruction with a negative impact on fisheries stocks. Another conflict occurring in Louisiana's coastal waters which has yet to be adequately resolved involves the damage caused to oyster lessees by oil and gas activities damaging their oyster leases.

Louisiana did not adequately anticipate or plan for the conflicts that have arisen over fisheries resources. However, the activities of the Gulf of Mexico Fisheries Management Council have stirred up great controversy in Louisiana's commercial and recreational fishing industries since the council was established in 1978. The closure of the commercial red drum fishery in federal waters a few years ago provided the impetus for the Louisiana Legislature to drastically reduce red drum catch in state waters by giving this species gamefish status. The predicted collapse of the red snapper fishery (partially as a result of by-catch of juvenile red snapper in shrimp nets) has prompted the Gulf Council recently to consider a proposal to partially close the brown shrimp fishery in state waters, which would significantly affect Louisiana's economy. The furor that this proposal generated resulted in the Gulf Council delaying its implementation for the time being. Louisiana representatives on the Council voted against the closure and against drastic reductions in the commercial and recreational red snapper harvest. This is essentially a "wait and see" approach. Such actions by the Gulf Council have encouraged Louisiana's fishery managers to begin developing scientific fishery profiles and management plans for each state fisheries species, rather than continue in a "laissez faire" approach to fisheries management. To date, there remains a great deal of animosity between recreational and commercial fishermen and the perception by each group that the other side is "hogging" the resource.

So far, Louisiana has responded to its marine debris problems as have other states--with organized beach clean-ups and educational programs. However, more comprehensive preventive measures will be necessary, especially if federal law prohibiting the dumping of plastics at sea (MARPOL Annex IV) fails to achieve its intended results.

As the above examples indicate, Louisiana's "ocean policy" has historically consisted primarily of a series of ad hoc, "reactive" approaches to issues after they occur, rather than a holistic, long-range planning approach. However, two pieces of coastal legislation in Louisiana have begun to focus the attention of state officials on a more "forward-looking" approach to ocean and coastal issues. Seventeen years ago, the legislatively-created Louisiana Advisory Commission on Coastal and Marine Resources produced its final report after a two year study. The most important--and lasting--recommendation of the final report was that Louisiana adopt a coastal zone management program. It was felt by the Commission that development of such a program would adequately address the coastal and marine issues then facing the state well into the future. There were no recommendations addressing a forward-looking "ocean policy" per se. In 1978, as a result of the primary recommendation of the Commission and to take advantage of the Coastal Energy Impact Fund provisions of the 1976 amendments to the

Coastal Zone Management Act (which compensated coastal states for adverse impacts from offshore oil and gas development), the Louisiana Legislature enacted the "State and Local Coastal Resources Management Act." From this Act, Louisiana developed the Louisiana Coastal Resources Program which received federal approval in September, 1980. The Act defines the Louisiana coastal zone as extending to the "the seaward limit of the state of Louisiana as determined by law." This has generally been taken to mean the three-mile territorial sea limit in effect in the U.S. prior to the 1988 Presidential Proclamation of a 12-mile U.S. territorial sea. However, Louisiana has not "officially" given up its claim to a territorial sea claim of three marine leagues (and a state statute so provides), although the U.S. Supreme Court has ruled against the state on this issue.

The State and Local Coastal Resources Management Act has led to a more comprehensive approach to resource management issues in the Louisiana coastal zone including the territorial sea and has been somewhat effective in slowing down the rate of habitat destruction in the coastal zone and offshore. As an example, the Coastal Management Division of the Louisiana Department of Natural Resources is currently attempting to use federal consistency provisions of the Coastal Zone Management Act to change U.S. Army Corps of Engineers practices in ocean dumping of dredged spoil to make more beneficial uses of the spoil in Louisiana's battle with coastal erosion. Additionally, the Coastal Management Division is requiring that oil companies change their practices in wetlands and offshore to reduce the environmental impacts. In 1989, the Louisiana Legislature created the Louisiana Wetlands Conservation and Restoration Authority, with the authority to develop a wetlands conservation and restoration plan and policy, and the Office of Coastal Restoration and Management in the State Department of Natural Resources which provides administrative coordination between Coastal Restoration and Coastal Management. These two pieces of legislation provide the potential for developing a long-range coastal and marine resource policy in Louisiana and, while not directly focusing on development of an "ocean policy" for Louisiana, they constitute a basis from which such a policy can be formulated.

Conclusion

A comprehensive "ocean policy" for Louisiana's offshore waters is long overdue. Over the next few years, we will be working with others to encourage the state to "revisit" a long-range study of its marine resources management efforts after a 17 year hiatus.

Preliminary Findings of an Ocean Policy Study in Mississippi

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Introduction

Coastal and ocean activities have traditionally played a relatively minor role in Mississippi's cultural, historical, and political heritage. The historical dominance of the state's economy by agriculture and forestry assured that the Mississippi River Delta and central interior regions would become the cultural and economic heartland. Even though Mississippi's coastal area is developingfaster than any other portion of the state, its comparatively small size (the state's three coastal counties contain about 81 miles of ocean coastline) and lack of a major coastal city has limited its ability to influence state policy in coastal and ocean matters. Sustained and effective coastal and ocean policy initiatives are also hindered by a combination of powerfully entrenched coastal economic groups that seek to restrict government interference in their activities, coupled with a chronically underfunded and understaffed marine resource management infrastructure.

Consequently, the state's present institutional framework is geared primarily toward the management of single ocean uses such as fisheries or offshore oil and gas development. Few formal structural mechanisms exist to promote the integrated and comprehensive management of the state's ocean areas. For example, unlike many coastal states, no government-sponsored coastal and ocean advisory panels, interagency management committees, or citizens advisory groups are currently in place.

In 1989, the Mississippi-Alabama Sea Grant Legal Program received funding from the National Sea Grant Program to produce an ocean policy study for the state. Patterned after similar studies undertaken in North Carolina, Hawaii, Oregon, and Florida, the study will focus on the major ocean issues facing the state and will identify areas where additional or improved state management initiatives may be warranted. Although the Mississippi study has received substantial assistance and cooperation from a number of state agencies, it has received no direct funding or official sponsorship from the state government.

The goals of the Mississippi study will be slightly different from those of other state studies published to date. Because Mississippi's ocean management infrastructure is at such an early stage of development in comparison with most coastal states, the study's primary emphasis will be to encourage the state to adopt an effective ocean management institutional framework rather than to provide detailed issue-specific policy recommendations. The study will examine specific ocean use issues, but solely within the context of developing a working agenda and information source for future policymakers once a proper management framework is put into place. Instead of providing specific recommendations, a list of ocean management challenges facing state policymakers will be included in the study. Implementation of specific recommendations should probably not take place until a more effective ocean management infrastructure is developed, including steps that allow for greater citizen participation and inter-agency policy debate.

Organization and Research Methodology

Prior to beginning research on the ocean policy study, surveys were mailed to members of the academic, government, and private-sector communities who have special knowledge of Mississippi's ocean and coastal areas. There were two primary reasons for sending out the surveys. First, we wanted to find out from those who were most interested in the state's management of its ocean resources whether certain ocean issues were significant enough to warrant discussion in the study. And second, we felt that a survey and accompanying letter of explanation would be the most cost-effective way of informing selected individuals that an ocean policy study was being undertaken and of soliciting their help to review and comment on draft portions.

We received survey responses from over forty ocean and coastal professionals. Generally, every ocean issue that was listed in at least 75 % of the responses as of "great significance" or of "some significance" to the State of Mississippi will be included in the study. A few issues that received less than 75% will also be addressed because of their close relationship to issues of greater concern. The only ocean issues that were eliminated from the study based upon results of the survey were: geophysical testing and exploration; alternative ocean energy sources; marine hard mineral mining; maritime traffic separation schemes and marking of hazards; and military uses of the ocean.

After an introductory section describing the present administrative structure governing ocean resources in the State of Mississippi, fourteen major subject areas will be included within the study:

1) state administration of ocean resources
2) submerged lands jurisdiction and extension of the territorial sea
3) offshore energy
4) oil/hazardous substance spills
5) marine pollution
6) ocean dumping
7) living resource management
8) protection of cultural and historical resources
9) protected marine areas and barrier islands

10) marine recreation
11) marine education and research
12) state-federal consistency
13) management frameworks for improved interstate, interagency, and citizen cooperation
14) model legislation for the establishment of a Mississippi Ocean and Coastal Advisory Council

Each subject area will be divided into three sections. The first section will provide background information on the topic. This will include a discussion of the socio/economic and environmental significance of the issue as well as an overview of the existing management framework within the national and international context. The second section will discuss each issue as it directly relates to the State of Mississippi. Information will be provided on the issue's present status and the role that the state currently plays in its management. The final section will discuss the ocean policy challenges that need to be addressed by state policymakers in the future. References will be provided at the end of each section to assist those who may be wish to look at a particular ocean issue more closely.

Summary of Preliminary Findings

The following very briefly summarizes some of the findings of the Mississippi Ocean Policy Study to date. Some sections of the study are not complete; the draft report will not be sent out for review and comment until January 1991.

State Administration of Ocean Resources

The administrative framework governing the use and management of Mississippi's ocean resources is compartmentalized and relatively uncoordinated. In the executive branch, the Governor has a Special Assistant for Natural Resources. However, ocean resource management is but a small portion of this individual's broad area of responsibility. Moreover, the assistant's role is purely reactive and consists primarily of responding to problem issues at the request of the Governor.

The Secretary of State's office is a multi-faceted service and information agency charged with many statutory obligations, including the leasing and sale of state submerged lands. While the Secretary of State is the elected trustee of the state's public lands, his/her mandate in that regard is limited to state submerged lands ownership issues.

Most responsibility and authority for implementing ocean-related policies belongs to Mississippi's administrative agencies. The Department of Wildlife, Fisheries and Parks' Bureau of Marine Resources is the lead agency in marine resource management. As the agency responsible for implementation of the state's Coastal Program, as well as many ocean management duties not covered under that regulatory scheme, BMR is involved in practically every aspect of ocean and coastal management. The Department of Environmental Quality's Bureau of Pollution Control is responsible for the designation of water quality parameters for the state and issues all water pollution permits for activities affecting state waters. Other agencies with responsibilities over ocean activities include the Bureau of Geology and Energy, Department of Archives and History, and the Department of Economic and Community Development.

In the Mississippi State Legislature, several standing committees consider ocean-related legislation. Senate committees include: the Committee on Wildlife and Marine Resources; Committee on Ports and Industries; Committee on Oil, Gas and other Minerals; and the Committee on Environmental Protection, Conservation and Water Resources. Committees in the House of Representatives include: the Committee on Conservation and Water Resources; Committee on Game and Fish; and Committee on Oil, Gas and Other Minerals. None of these committees consider ocean issues exclusively; furthermore, there are no legislative staff members in either house who have specialized knowledge of ocean and coastal affairs.

At least seven state government agencies have authority or involvement in the use and management of ocean resources. However, there is no unified framework for ocean governance and no formal institutional mechanism to bring all of the affected entities together. Agencies will occasionally cooperate on an ad hoc basis to evaluate certain permit requests or to solve a specific problem, but generally, each agency independently develops and implements its own ocean policy goals.

State Submerged Lands and Extension of the Territorial Sea

Mississippi has been awarded regulatory authority over a large ocean area as a result of the United States Supreme Court decision in United States v. Louisiana, 470 U.S. 93 (1985), which held that the entire Mississippi Sound is a historic bay and that its waters are inland waters owned by the states of Mississippi and Alabama. Rather than being limited to a territorial sea of three miles measured from the mainland coastline, Mississippi state waters extend to a point three miles seaward of the barrier islands or approximately eleven to eighteen miles offshore. State jurisdiction may be extended even farther depending on what future steps Congress takes to clarify discrepancies in the dozens of laws governing the ocean environment brought about as a result of 1988 Presidential Proclamation that expanded the territorial sea of the United States from three to twelve miles.

Mississippi's submerged lands management policy was developed in association with the state's coastal program. Consequently, the management regime is primarily devoted to coastal and near-shore submerged land issues. There is no comprehensive policy for planning and management of submerged lands of the territorial sea. Instead, policy decisions continue to be made by state agencies with single regulatory missions, such as the management of living resources or offshore energy.

The state needs to examine the feasibility of developing a comprehensive state policy and regulatory process regarding the leasing and other use of state land. Some progress has been made as a result of recent legislation regulating public trust tidelands, but that legislation is exclusively devoted to nearshore tideland uses and not to the broader range of activities taking place in the territorial sea.

There should also be an evaluation of the impact of the extension of the territorial sea on the following state interests: oil and gas revenue sharing in the twelve mile area; federal consistency for activities occurring in the ocean zone between three and twelve miles; recognition by federal agencies that state water quality standards and certification requirements extend beyond the current three mile limit. If the extension of state jurisdiction into the extended territorial sea is found to be essential for the accomplishment of important ocean management objectives, the state should cooperate with the Coastal States Organization, Southern Governors Association, and other national and regional bodies to vigorously convey that position to the federal government.

Offshore Energy

Recently, many Atlantic and Pacific coast states have rejected oil and gas drilling within their coastal waters due to rising popular protectionist sentiment. To accommodate the citizens of these states, the federal government has removed the corresponding federal waters from leasing consideration. As a result, increased burdens will likely be brought to bear on the Gulf Coast states, where the petroleum and petrochemical industries and the states have generally enjoyed a friendly relationship. As the pressures of exploration and development increase within the Gulf, Mississippi should adopt a coherent risk assessment approach balancing the development and preservation of its natural resources.

The state should address the following issues relating to the development of offshore energy resources: the feasibility of earmarking a portion of the Outer Continental Shelf Lands Act Section 8(g) funds for coastal communities to help local governments offset the onshore impact of outer continental shelf (OCS) drilling; implementation of a mechanism to ensure that the governor and state agencies take better advantage of the opportunity to comment on proposed OCS leasing programs; the advisability of having continental shelf lease sales on a yearly basis as is presently the practice or changing to biennial or triennial lease sales as is the practice in other regions of the nation; evaluation of the impacts of chronic low-level petroleum spills that are not addressed in the existing environmental impact statement; and consideration of high-level official consultation with other Gulf states to determine a common strategy to deal with increasing drilling pressures caused by the crisis in Kuwait and the reluctance of other regions to allow new exploration or drilling. Drilling in the Gulf should be ordered and paced and other regions should be forced to carry their fair share.

Oil Spills

Mississippi's coastal waters serve as a major transportation corridor (via pipelines and tankers) for crude oil and petroleum products. One of the nation's largest oil refineries, as well as a number of other large industrial concerns is located in coastal areas. The state is currently in the process of reevaluating its oil spill prevention and response program. It has chosen to take this step in light of the recently enacted federal "Oil Pollution Act of 1990" (H.R. 1465) and of perceived weaknesses in the cleanup efforts of two spills in 1989, when a Chevron pipeline spilled 4,200 gallons of oily water into Bayou Casotte and a ruptured barge near Horn Island spilled 32,000 gallons of light crude into Mississippi Sound. The following measures should be included in any reevaluation of state policy: whether comprehensive state oil spill legislation should be enacted; how to improve the inventory system to more accurately catalogue the location and availability of specific types of oil cleanup equipment; the feasibility of purchasing state-owned cleanup equipment so that it would always be available when needed; revisions to the state contingency plan to better coordinate intra-state administrative cooperation and to encourage coastal counties and communities to become more familiar with the plan; the feasibility of conducting periodic oil spill drills; the feasibility of developing a formal state policy on the use of advanced cleanup technology such as microorganisms and chemical dispersants; and, formation of a policy that specifically spells out when and how state funds, as opposed to federal or private funds, will be used to cleanup a spill.

Ocean Dumping and Marine Pollution

There are a number of major dredging projects currently taking place along the Mississippi coast. Of greatest significance is dredging associated with the U.S. Navy's development of Singing River Island near Pascagoula as a new home port, and the deepening of the Gulfport Ship Channel from 34 feet to 38 feet. Until recently, dredge spoils were disposed of in upland sites. However, a special state/federal task force agreed to allow uncontaminated spoils to be disposed of in the deep waters of the Gulf, while toxic spoils would continue to go to upland disposal sites. In July, 1990, the U.S. Environmental Protection Agency proposed to designate an area located approximately 1.5 nautical miles southeast of Horn Island and 14 nautical miles south of the mainland as a ocean dredged material disposal site. The proposed site is located within state waters.

The significance of land-based and vessel-based marine pollution in Mississippi Sound is just now being recognized. Pollution from seashore industries, agricultural and residential run-off, and municipal waste is especially severe in the Pascagoula River system, Biloxi Bay system, and the St. Louis Bay system. Although the open Sound is still relatively pollution-free in comparison to coastal areas located near river and bay systems, localized pollution problems are increasing.

Vessel pollution continues to plague state waters and beaches. A recent survey of beach cleanup data indicated that Mississippi had about 3000 pounds of litter per mile of beach, the third highest amount in the nation. Intentional or accidental discharges from vessels and oil platforms still occur frequently despite recently enacted federal and state marine litter laws.

Living Resources Management

In 1989, commercial fishery landings in Mississippi reached 292.2 million pounds, fifth largest in the nation. Despite depressed conditions in the shrimp and oyster fisheries in recent years, the commercial and recreational fishing industries continue to contribute up to $100 million annually to the state economy. Issues that should be examined and acted upon include: an evaluation of whether the funding and staffing levels of the Bureau of Marine Resources are sufficient to carry out its management responsibilities; the severity of longstanding problems associated with incomplete collection of harvest data; the feasibility of requiring licenses for saltwater recreational fishermen; the feasibility of adopting a limited entry program for the shrimp fishery;) whether the state needs to adopt an oyster management plan, including a reevaluation of the century-old law that allows riparian owners the exclusive right to plant and gather oysters within 750 yards from the shore; and the feasibility of establishing a management plan to better deal with land-based point source and non-point source pollution that is contaminating oyster beds and fish nursery habitat.

Protection of Cultural and Historical Resources

The Antiquities Law of Mississippi (Miss. Code Ann. 39-7-1 Cet seq.D) declares all sunken or abandoned ships and wrecks imbedded in state submerged lands to be the sole property of the state. It also establishes a permit system by which a permit may be issued to enter into contracts with state agencies or private parties for the discovery and salvage of sunken or abandoned ships. However, the Department of Archives and History is seriously understaffed and no guidelines are currently in place to assist the agency in making such permitting decisions. The Department is interested in developing a state management program incorporating federal guidelines recently proposed by the National Park Service, as well as guidelines from innovative programs in other states, but funds are not available to implement the new program or to survey and inventory existing shipwreck sites.

Protection of Marine Areas and Barrier Islands

While state law does empower the Mississippi Commission on Wildlife, Fisheries and Parks to establish aquatic sanctuaries (Miss. Code Ann. 4-9-29), the state has not yet set aside any marine areas. There has also been no effort to designate a national marine sanctuary or national estuarine sanctuary in state or federal waters off the Mississippi coast. However, several of the barrier islands off the Mississippi coast are part of the National Gulf Seashore and are, therefore, partially protected by the National Park Service.

Mississippi has chosen not to cede any of its jurisdictional authority over the barrier islands to the federal government. Consequently, National Park Service enforcement actions are primarily limited to protecting resources and providing for the orderly use of the seashore. Most serious crimes must be dealt with under applicable state law and by officers of state or local agencies.

The state's Coastal Zone Management Program provides significant protection for those barrier islands not within the National Gulf Seashore. However, there is concern that certain variances and exemptions could allow for the development of privately owned tracts on a few of the barrier islands, which may be in conflict with National Park Service barrier island management practices.

Management Frameworks for Improved Interstate, Interagency and Citizens Cooperation

Although state agency personnel interact on a regular basis with colleagues from other agencies and with the public, there is no formal institutional mechanism that provides for coordinated state action concerning ocean policy decisions. Each agency and legislative committee tends to formulate its own policy goals guided by its unique perception of the interests of its constituents. With the exception of public hearings mandated by law under certain circumstances, the general public is often excluded from the ocean policy decision-making process.

Moreover, because the environmental and resource allocation problems in the Gulf of Mexico, and in the Mississippi Sound in particular, are the result of multi-state and international activities, effective solutions will require a multi-state, cooperative effort. With the possible exception of fisheries research conducted under the auspices of the Gulf States Marine Fisheries Commission, no program is currently in place to provide for coordination of ocean and coastal planning, policy coordination, and state action in the region.

Mississippi should seek a leadership role in the effort to develop a more formal regional coordination structure. Mississippi should adopt the following measures to improve its ocean management program. Legislation should be enacted that promotes and insures coordinated management of the ocean and coastal resources within the jurisdiction of the state and with adjacent states. This legislation should establish a Mississippi Ocean and Coastal Policy Advisory Council comprised of appointed representatives from the Governor's office, state agencies, the public, ocean users, and local government. Among other purposes, the Council would provide a broad-based forum for discussing ocean and coastal resource issues, assist in the coordination of agency actions, establish several technical advisory committees to aid in the preparation of a State Ocean Management Plan, and encourage and coordinate interstate and state/federal cooperative programs.

As envisioned, the State Ocean Management Plan would provide specific recommendations to develop or improve state agency programs to manage ocean resources and would serve as a basis for agency or legislative action. It is not intended to serve as a compulsory coastal and ocean use plan. A compulsory use plan that is developed independently from the Legislature would likely run into serious and probably fatal political opposition.

Additionally, the state should take a leadership role in developing a mechanism for greater regional cooperation in ocean and coastal planning and protection. One alternative would be to use the existing Southern States Energy Board Interstate Compact as a framework to improve cooperation between the Gulf States in matters pertaining to the protection of the ocean and coastal environment, especially oil spill response capabilities. A second alternative would be for the states to work more closely with the Environmental Protection Agency's Gulf of Mexico Program located at the John C. Stennis Space Center, Mississippi. The Gulf of Mexico Program has already sponsored a number of standing committees on various environmental issues of importance to the Gulf. The program might also agree to create a regional ocean policy committee made up of state, local, and federal representatives with the aim of developing a more coordinated ocean management framework in the Gulf region.

Conclusion

The primary purpose of the Mississippi Ocean Policy Study is to convince state policymakers and others that there are a number of ocean-related issues that are important to the state and that cannot be ignored. Unless the state takes reasonable steps today to improve its ocean management capabilities by establishing a coordinated management framework, it will be faced with much more difficult and expensive choices in the years to come.

II. PLANNING, POLICY, AND DECISION-MAKING IN THE COASTAL ZONE

Public Trust Tidelands in Mississippi: Implementation of the Phillips Petroleum Decision

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The subject of public trust tidelands has attracted popular attention in Mississippi for more than two years. This is due to a 1988 decision, Phillips Petroleum v. State 484 U.S. 469, in which the United States Supreme Court affirmed the Mississippi Supreme Court's decision two years earlier, Cinque Bambini v. State 491 So. 2d 508, that all lands subject to the ebb and flow of the tide, up to the line of mean high tide and regardless of the navigability of the waters over them, belong to the state in trust for its people.

The public trust doctrine did not make its Mississippi debut in the Bambini decision; Bambini upheld an unbroken line of judicial decisions stretching back more than a century. Why all the fuss? The decision was made to implement the public trust doctrine. Mississippi's Secretary of State, Dick Molpus, is the elected official responsible for the administration of public lands, including trust lands. He accepted the obligations of trusteeship and immediately set in motion a series of events aimed at establishing a comprehensive program of tidelands management which would ensure maximum benefit of the tidelands and submerged lands for all citizens of the state.

In June, 1988, four months after the Phillips Petroleum decision, Molpus appointed a 26-member Blue Ribbon Commission consisting almost exclusively of residents of Mississippi's three coastal counties and asked the group to make comprehensive recommendations for administration of the public tidelands trust. The commission was assisted by a team of technical experts from the Secretary of State's office (including the Assistant Secretary for Public Lands and Elections and the Director of Public Lands), the Bureau of Marine Resources, the Bureau of Geology, and the Attorney General's office. To assist the Commission further, and to implement the tidelands program once established, Molpus opened a satellite office on the Gulf Coast, 160 miles from Jackson, the state capital, and staffed it with a lawyer and an administrative assistant.

The commission, through the work of five committees, studied five areas of tidelands concerns: the boundary question; conservation and development; lease program management; littoral and riparian rights; and taxation. The commission met, as a whole and in committees, over a period of six months in open meetings in each of the coast counties. Every meeting was advertised to the public; there was broad media coverage. At every meeting, every member of the public who wished to speak was heard.

An interim report was published and public hearings were held in each of the coastal counties. A comprehensive final report addressing each of the five areas of concern was then submitted to Molpus, who adopted the report and made it available to the Mississippi State Legislature when it convened in January, 1989.

During its 1989 session, the Legislature enacted a Tidelands bill (Senate Bill 2780, MCA 29-15-1 et seq.) which responsibly incorporated most of the commission's recommendations, including a direction to the Secretary of State to prepare a preliminary map of public trust tidelands. The legislature recognized the ambulatory nature of the trust boundary, as had the Bambini decision, and as recommended by the Blue Ribbon Commission. The Secretary of State was logically directed by the Tidelands Act to depict the trust boundary "as the current mean high water line where shoreline is undeveloped...". By far the greater part of Mississippi's coastline, including bays, tidal rivers, and bayous, is in its natural state.

However, the Legislature departed from commission recommendations in one crucial respect. The commission had advised that the tidelands boundary in developed, or filled areas, be fixed at the mean high water line immediately prior to the time of development or fill. By following this directive, natural changes which served to ambulate the boundary would be recognized and fill would be excluded. However, the Legislature directed that "in developed areas or where there have been encroachments, [the Secretary of State's preliminary] maps shall depict the boundary as the determinable mean high water line nearest the effective date of the Coastal Wetlands Protection Act." The Wetlands Protection Act (MCA 49-27-1 et seq.) had been adopted in 1973 to halt wetlands loss caused by wholesale dredge and fill operations. The result of this provision of the Tidelands Act is to give to their current occupants all filled tidelands, regardless of whether the fill was authorized, as long as the filling was accomplished prior to 1973. Although the acreage of filled tidelands in Mississippi is comparatively low, it includes the most valuable and most accessible waterfront property on the Gulf Coast, including 26 miles of pumped in sand beaches, which are the area's major tourist attraction.

Immediately following the 1988 legislative session, Molpus filed suit in Jackson for a declaratory judgment that the portion of the Tidelands Act discussed above violates that section of the state's constitution which prohibits the donation of public lands to private persons or corporations. This suit by the State, through the Secretary of State, against the State, is admittedly unusual. This suit has been stayed, however, pending resolution of the identical issue in a suit pending on the coast, referred to as the Byrd suit (William D. Byrd v. State of Mississippi, et al, No. 17,879 in the Chancery Court of Harrison County, Mississippi, Second Judicial District).

The Byrd suit had been filed during the 1989 legislative session to confirm title to a parcel of filled property south of the seawall in Biloxi. Improvements on the property consist of a Japanese car dealership. The state was named as principal defendant. After enactment of the Tidelands bill, the suit was amended to seek declaratory judgment on the constitutional question; the complaint as amended is virtually identical in relevant respects to the suit brought in Jackson by the Secretary of State. But because the original complaint in Byrd predated the Secretary of State's suit, and probably because it was to be heard on the coast rather than in Jackson, the issue has been advanced through the local suit.

That issue, as stated above, is the constitutionality of the attempted grandfathering of tidelands filled prior to 1973. Additionally, the Secretary of State has advanced public trust arguments against the attempted alienation of filled tidelands.

Argument on the declaratory judgment was heard on 18 April 1990. The same chancellor whose tidelands opinion had been affirmed by the Mississippi Supreme Court in Bambini and by the U.S. Supreme Court in Phillips Petroleum ruled immediately following oral argument that the Tidelands Act is constitutional. His written reasons, filed two days later, made interesting references to history, the mosquito problem, and even religion, but few references to legal precedent.

Needless to say, that judgment has been appealed by the Secretary of State to Mississippi's Supreme Court. The record has been lodged and appellant's original brief is due November, 1990.

Shortly after the decision of the Chancery Court, the Secretary of State, in accordance with his legislative directive, published Preliminary Maps of the Public Trust Tidelands. The maps use four legends to distinguish three types of areas. First are those areas which are in an essentially natural condition; in these areas the public trust boundary is today's mean high water line. Secondly, the maps show areas where dredging artificially brought tidal influence to an area not previously subject to the ebb and flow of the tide; the trust disclaims ownership of these areas although there is usually a servitude or easement of public use in these areas. Thirdly, the maps delineate those areas which have been filled and show the approximate location of the historic and of the current mean high water line on these properties. Finally, while not separately delineated, the maps do note that the public trust boundary is the toe of any seawall where beach renourishment has occurred.

The Tidelands Act provided for a 60-day comment period following publication of the maps, after which the Secretary of State had 20 days to revise the maps "accordingly" and publish final maps. Because of the contest between the historic line and the 1973 line, which is to be decided by the court as discussed above, the Secretary of State has been enjoined from further implementation of the Tidelands Act pending resolution of that issue.

Boundary determinations continue to be made, however, on a case-by-case basis in areas which are not under challenge. In 1989, the Secretary of State instituted a program of expedited boundary determination for properties which are subject to imminent transfer. In areas where there has not been any substantial fill below the line of mean high tide, or which are still in their natural state, or which border an artificially created or expanded body of water, the Public Lands Division of the Secretary of State's office issues the owner or seller a letter confirming that the public trust boundary is the current mean high water line or that the property is unaffected by tidelands considerations. These letters are relied upon by lending institutions and title insurance companies. As a result, property transfers continue to be made unhindered.

Although the nature of filled properties as public or private has not yet been finally decided, in all other areas there seems to be general acceptance of public ownership of lands under tidally-affected waters. The challenge to the Secretary of State at this time is to execute leases with those who occupy public tidelands in a manner which exceeds certain statutorily authorized uses. Administrative rules for leasing have been adopted and in use for more than a year; with experience, hopefully, comes the wisdom with which to anticipate and resolve problems before they arise.

Implementation of the Phillips Petroleum decision in Mississippi is well on its way. The framework is in place and the public appears to generally accept and acknowledge trust ownership. The Mississippi Supreme Court has before it the final decision on the extent of that trust which they resolutely affirmed in 1986. We await the Court's decision, and in the meantime are working to establish leases in the as-yet-uncontested areas.

Qualitative Analysis of a Coastal Region Within a Geographic Information System

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Abstract

Geographic Information Systems (GIS) are gaining popularity as evaluative tools for spatially related data. As with any computer-generated product, caution must be exercised when interpreting the results of GIS. Additionally, common analytical methods are not suitable for every application. Ingenuity is further required for GIS in the coastal zone due to the differences in land and water attributes.

A GIS was used to locate optimum deployment sites for the Delbuoy wave-powered desalinator. Ocean wave conditions required for the efficient operation of Delbuoy were combined with the human geography of an arid coastal region. Using common demographic, economic, and climatic variables, the islands of the Eastern Caribbean Sea were classified by their perceived need for water produced by Delbuoy. Using wave climate parameters, locations were found which met inherent physical requirements of Delbuoy.

It is essential to recognize when variables are qualitative versus quantitative. If "need" were a defined quantity, multivariate statistical analysis could have been performed on the dependent variables (island attributes). Since this was not the case, other methods were used to investigate the effect of the attributes on "need" and to arrive at indices from which optimal sites could be chosen. Often, land-oriented GIS analyses sum attributes based on value judgments (ie. weighting factors) or by overlaying all available attributes and obtaining an unwieldy number of thematic categories. Additionally, these methods fall short in the nearshore zone due to disparate land and ocean attributes.

Principal Component Analysis was used to remove colinearity from the attributes for use in cluster analysis. Clustering determined similar groups of islands. Cluster analysis can provide insight on the interrelationship of the islands and how the attributes describe need in an arithmetic overlay. Results of the cluster analysis were directed back toward the arithmetic overlay to improve the weighting factors.

The problem of mixing ocean and land attributes of the coastal zone was somewhat resolved by presenting the composite need and wave climate categories on one map. Regions of great need and good wave conditions were easily seen. Results of the qualitative analysis, geographically presented, vividly pinpointed locations for more detailed analysis.

Introduction

A viable alternative to fossil fuel-powered desalination exists which utilizes the untapped, renewable resource of ocean wave energy. That alternative is the Delbuoy system, a wave-powered, saltwater desalinator designed to be small-scale and of low cost for regions which cannot afford large capital investment or the burden of high operating and maintenance costs (Pleass, 1978). Costs of materials, operation, maintenance, project size, useful life, and site selection are a few of the many considerations in the decision-making process of a successful engineering project. Geographic Information Systems (GIS) are commonly used in the site selection process.

Certain elements of the Delbuoy system are quantifiable and can be generally agreed upon, such as the most efficient wave parameters for powering the pump. Other considerations, such as need for supplemental supplies of freshwater, are far more ambiguous. This research centered on site selection and used need for water produced by Delbuoy and the wave climate most suitable for Delbuoy as the two main criteria in the decision-making process.

Goals

The objective of this research was to develop a methodology which incorporated the suitability of the wave climate and the perceived need for fresh water in order to arrive at optimal locations for Delbuoy. Since resources are very limited, especially in the third world, optimization is important for both the end-user and producer. In addition, new, unconventional technology must be proven before it is embraced by society. Therefore, the future success of Delbuoy may depend on optimal site deployment. A model was required which quantitatively describes the relationships between man, machine, and nature. A two-phase "zoom" approach was taken to evaluate the Eastern Caribbean Sea. Phase I evaluated the region by quantifying factors on a spatial scale of islands. Parallel evaluations of land and ocean attributes were conducted and the results coalesced into a composite. Phase II focused in detail on the coastal zone in which Delbuoy would be placed (Gaffney, 1989), but is not described in this paper.

Constraints on the Model

Constraints are added factors which must be taken into account in the solution of a problem. Characteristics of the Delbuoy pump were developed by Hicks during scale modeling (Hicks, 1986). The range of most efficient wave heights for the prototype Delbuoy is 1.9-4.5 ft (0.62-1.48 m), with an optimum at 2.2 ft (0.72 m). Delbuoy has a broad frequency band response to incident waves. In the range of highest efficiencies, wave periods ranging from approximately 3.1-5.6 seconds produce the most power.

Optimization

Once the problem was formulated and goals set within permissible outcomes, the best alternative was desired. The wave height and wave period ranges constituted validating criteria for optimizing the wave climate suitability. Similar criteria do not exist to validate the level of human need for supplemented fresh water sources. Demographic and economic factors have been used to define need. Need thus defined has been used to provide a model optimum.

Procedure

The National Climatic Data Center's collection of Marine Surface Observations was used to determine average wave height and period to identify areas with suitable wave energy. For each 1° square, waves were grouped by direction of propagation. It was found that 60-80% of all waves in the Eastern Caribbean came from the northeast and 15-30% came from the southeast, corresponding to the tradewinds. The mean wave height was calculated for each direction in each subsquare. All means fell within the range for most efficient Delbuoy operation. The percentage of wave heights above 1.5 m was tabulated for each 1° square. Since waves above 1.48 m were determined to be less efficient, the larger percentages correspond to areas less suitable for the current configuration of Delbuoy.

Wave period is codified such that "2" represents periods < 5 seconds, 3 = 6-7 seconds, 4 = 8-9 seconds, etc. Precision was lacking, in light of the fact that Delbuoy's optimal range falls within a single code. Mean period was determined for each 1° square and ranged from 3.6-5.0 seconds.

Overall Wave Suitability

An indication of the overall suitability of the wave climate for each subsquare was developed by recognizing the most efficient waves for Delbuoy. Since the averages for all subsquares are within the requirements for efficient Delbuoy operation, a way of optimizing is needed. If H (wave height) and T (wave period) are plotted for a particular subsquare, the vectorial distance from the optimum point can give an indication of optimality. The percentage of waves above 1.5 m in height was added as an indication of unusable wave energy. A suitability factor, S, was thus calculated. Finally, to compare the amount of power actually extractable, the average wave power, P, was divided by S. In this way, high-energy wave fields were compared to those with less energy so as to reflect the amount of energy which can be realized by Delbuoy.

Determining the Need for Delbuoy

It would have been most direct to obtain a data set of fresh water costs and compare them to the cost of water produced by Delbuoy to determine where to deploy the desalinator. Water costs alone, however, cannot be considered the ultimate measure of an island's need for Delbuoy. It is also virtually impossible to adequately compare the true water costs to society due to wide variations in local costs, government subsidizing, sources and qualities of potable water. Additionally, geographical variations in Delbuoy operational efficiency and installation costs would have to be considered in this comparison.

The following regional socioeconomic variables were available for the year 1987: precipitation; infant mortality; population density; arable land per capita; energy consumption; percentage of household budget spent on energy and water; gross domestic product per capita (GDP); total land area; and imported food costs. These perceived measures of an island's need for fresh water are further described in the following section.

The nine thematic features (attributes) were used to identify the need for water produced by Delbuoy (need index). Within-site analysis (Miles and Huberman, 1984) evaluated the role each attribute plays in determining a need for Delbuoy on any particular island (site). A modified "effects matrix" was used to tabulate, codify, weight, and evaluate the effect each attribute has on quantifying an index of need.

The availability of potable water in an island hydrologic system is related to surface runoff, precipitation, evapotranspiration, and infiltration into the soil and ground water storage (Alford, 1984). Precipitation is the single most determinant factor in hydrologically evaluating sites in the Caribbean region and has been used as the prime indicator of water resource availability. The distribution of precipitation varies greatly spatially and temporally. Topography plays a role in causing rainfall. Mountainous regions of some islands can receive up to 200 inches while the coastal plains receive far less. Total land area has been included as an attribute due to its perceived effect on climate and on the availability of ground water.

High rainfall does not insure adequate quantity or quality of potable water, as case studies show bacterial contamination and high salinities prevalent on these islands (PAHO, 1983). An indication of health as related to water quality can be found in infant mortality. Populations having little access to safe drinking water are generally those with low life expectancy, high infant mortality, and low per capita income (PAHO, 1983). Yearly infant deaths/lOOO live births have been gathered for each island or political entity.

The smaller, drier islands often supplement water supplies by importing it from neighboring islands and generally pay much more for water. The percentage of household budget spent on water and energy was available for most of the islands. While a valid indication of water costs to households, this measure is not an accurate indicator of the true cost of water to society. Trinidad and Tobago, for example, subsidize public water, resulting in a very low percentage of household budget being spent on water and energy (PAHO, 1983).

Forces which constrain a country from developing a clean, plentiful water supply are often economic. Unfortunately, conventional desalination methods all use fossil fuel-based power to operate and require large capital expenditure and maintenance. To measure an island's inability to produce fresh water by desalination, measures of wealth and energy usage were used. Per capita gross domestic product (GDP) can give an indication of the economic power of a nation to develop. Energy consumption per capita was used as an indication of the availability of energy to the population. Generally, a higher energy consumption reflects a society that has a higher standard of living. However, by itself, centralized electricity does not guarantee a higher standard of living.

Population density may indicate the supply of available resources relative to the human demands being placed upon them. Any environment can support only a finite number of people; it was surmised that a high population density will be present on islands having sufficient resources.

Indicators relating to the inherent ability of Delbuoy to increase agriculture by supplying water were acres of arable land per capita and imported food expense per capita. Imported food expenditures relate to a society's ability/inability to supply basic food needs of the population, but it can be skewed by tourism.

An iterative process which utilized arithmetic overlay, principal components analysis, and cluster analysis was used to converge on an optimal solution. Cross-site analysis (Miles and Huberman, 1984) was the comparison of the different islands to address the original goal of determining the optimal island for Delbuoy deployment.

Arithmetic overlay

An arithmetic overlay procedure (U.S. Fish and Wildlife Service, 1977) was used to determine an index of need for each island. Each attribute was codified and weighted positively or negatively according to its perceived value described earlier. Weighted attributes were then added together to produce a composite map of need for Delbuoy. Codings attempted to cancel
pB3 the effects of disparate orders of magnitude. The resulting index of need ranged from nominal values of -0.96 to 5.16. The higher the index, the lower

the island's perceived need for water produced by Delbuoy. In gathering and evaluating the attributes, several weightings and manipulations were conducted, all resulting in basically the same conclusions regarding the neediest islands when using the same evaluation philosophy.

An evaluation is a judgement, made by an evaluator, using a specific value system, at a certain time, for a specified purpose (Sincoff and Dajani, 1976). As such, if any component of the judgement changes, the evaluation will result in a different solution to the problem. Therefore, some questions needed to be asked to address the sensitivity of the analysis. Which attributes dominate the analysis? Do these seemingly arbitrary indices have meaning? Has colinearity of the attributes been adequately addressed? Are two islands with the same index of need demonstrably similar?

Principal Component Analysis (PCA)

PCA was used to remove colinearity from the attributes for use in cluster analysis. Clustering then determined similar groups of islands. Insight from these procedures was directed back toward the arithmetic overlay to improve the weighting factors. PCA is a factor analysis technique which develops a new set of linearly independent components, ordered by the amount of variance they explain (Kalkstein et al., 1987). PCA of the 36 islands resulted in a three-component solution accounting for 72% of the variance in the raw data set.

Component 1 explained 37% of the variance and was characterized by GDP, infant mortality, precipitation, imported food costs, and energy consumption, emphasizing the economics of an island. GDP appeared highly correlated with imported food costs and energy consumption. Component 2 explained 22% of the variance and depended heavily on acres of arable land, population density, and total land area, emphasizing the geographic make-up of an island. The highest loadings for component 3, which explained 13% of the variance, were imported food costs and acres of arable land, emphasizing an island's agrarian need.

Cluster analysis

Cluster analysis was used to classify islands into similar groups based on the regional attributes, which presumably identify need for supplemental fresh water supplies. Using a hypothetico-deductive method (Romesburg, 1984), if the arithmetic overlay system has been successful in identifying the neediest islands, the cluster analysis will provide insight on the interrelationship of the islands and how the attributes describe need.

Clustering measures the degree of similarity between each pair of components for each pair of islands. Average linkage was used in the clustering procedure and takes the average of the closest and furthest Euclidian distances to link islands (Kalkstein et al., 1987). Results of the clustering analysis, using the 3-component solution, indicated that four discrete clusters of similar islands exist. Attribute averages have been presented for each cluster and are shown in Table 1. The resulting four clusters were intuitively appealing from graphical analysis of precipitation, which showed the appearance of discrete groups of islands. The clusters also corresponded well in a scalar sense with the numerical results of the arithmetic overlay procedure.

The largest group, Cluster 1, was made up of 19 islands characterized by average values for most of the attributes. GDP was inordinately high for the other three clusters, as was energy consumption. Clusters 2, 3, and 4 were so uniquely different that those islands have been qualitatively categorized separately. Cluster 2 was differentiated by its low population density and corresponding high amount of arable land. The islands in cluster 3 have a high per capita energy consumption. Cluster 4 islands are highly populated.

Conclusions

Cluster 1, characterized as average Caribbean islands, has been divided into three qualitative categories based on the index of need: less needy; needy; and very needy.

Clusters 2 and 3 have been characterized as very dry. The clusters have been left separate since precipitation could not be used to classify need. Islands in Cluster 2 appear to have the resources necessary to provide for their inhabitants. Islands in Cluster 3, however, exhibited characteristics of developing and heavily populated regions having high GDP and energy consumption yet experiencing the burden of providing that standard of living (as percentage of household income spent on water and energy attest). The islands in this cluster have the smallest acreage of arable land per capita; as their populations increase, they may have difficulty providing for the local population without supplemental sources of water.

Cluster 4 has been categorized as self-sufficient. The standard of living on these islands seems to be related to the availability of oil or an economy subsidized by a developed nation. These areas are also larger in size with probable ground water sources.

Several of the attributes used to indicate need had ambiguous cause and effect relationships. For example, when quantifying need, does an island with large amounts of arable land indicate sufficient existing agriculture or an island which could benefit from an external source of water for irrigation? The answer becomes clear by examining the interrelationship of all the attributes. Other factors were functionally related to each other such as GDP and energy consumption. Further analysis was then required to remove this colinearity. Alternatively, certain variables, such as precipitation, did not seem functionally dependent on any other attributes and were very important in determining the neediest islands.

For these reasons and others, strict arithmetic overlay, as employed with land use Geographic Information Systems, was not found to be a sufficient method to define "need." Clustering with principal components analysis (PCA) provided valuable insight as to the similarity of islands in the region as related to Delbuoy deployment and was a complimentary technique. The problem of mixing ocean/wave attributes with land/need features in the GIS was somewhat resolved by presenting all the qualitative categories on one map. Islands having great need for water produced by Delbuoy and wave climates suitable for the efficient operation of Delbuoy were easily identifiable.

References

Alford, D. 1984. Island Water Resources: Technologies for Increased Supplies for U.S. Insular Territories (draft working paper)

Gaffney, D.A. 1989. A Method to Determine Optimal Locations for a Seawave Powered Desalinator. Unpublished Ms. thesis, University of Delaware

Hicks, D.C. 1986. Physical and Mathematical Modeling of a Point Absorber Wave Power Device with Nonlinear Damping. Ph.D. dissertation, University of Delaware.

Kalkstein, L.S., G. Tan. and J.A. Skindlov. 1987. An evaluation of three clustering procedures for use in synoptic climatological classification. Journal of Climate and Applied Meteorology, 26(6.

Miles, M.B., and M. Huberman. 1984. Qualitative Data Analysis. Sage Publications, Beverly Hills, CA.

Pan American Health Organization. 1983. Project Development and Financing in the Water and Sanitation Sector in the Caribbean.

Pleass, C.M. 1978. The Use of Wave Powered Systems for Desalination: A New Opportunity. Wave and Tidal Energy.

Romesburg, H.C. 1984. Cluster Analysis for Researchers. Lifetime Learning Publications, Belmont, CA.

Sincoff, M.Z. and J.S. Dajani. 1976. Planning and Evaluation Parameters for Offshore Complexes. NASA Report No. NASA CR- 145040.

U.S. Fish and Wildlife Service. 1977. A General Design Schema for an Operational Geographic Information System. Report FWS/OBS- 77/22.

Table 1. ATTRIBUTE AVERAGES FOR EACH CLUSTER

CLUSTER

ATTRIBUTE	1	2	3	4
Pop/mi^2	462.0	203.0	276.0	1095.0
GDP $	2459.0	6117.0	6685.0	5957.0
Infant Mort	21.3	14.9	14.8	13.5
Precip In.	57.3	32.0	32.9	58.2
% Budget	5.3	3.6	11.0	6.1
Imported food $	386.0	1627.0	800.0	643.0
Energy Consump	1039.0	2308.0	6576.0	3060.0
Arable Land	0.37	0.84	0.11	0.21
Total Area	126.7	19.5	30.7	972.0
Avg Need Index		1.15	0.47	3.67
Very Needy	1.17			
Needy	1.68			
Less Needy	2.51			

Protecting Threatened Species: Turtles, Technology and Politics

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Abstract

Efforts to protect endangered and threatened sea turtles in the United States have been pursued for over two decades. This paper draws on one category of public policy, protective regulatory policy, to describe and explain the distinctive policy process for this issue, the role of technology - the turtle excluder device - in reconciling preservation and economic interests, and the implications of this case for similar marine resource management efforts.

Introduction

It's one thing to get a law on the books, quite another to make it work. This is particularly true for policies designed to protect specific resources or to regulate behavior. These policies, referred to as protective regulatory policies, use state power to regulate and protect society by setting out rules to govern specific undesirable activities (Wilson, 1983, 1973; Lowi, 1972; Ripley and Franklin, 1991). In the case of protective regulatory policies, government action appears to provide broad social benefits, with few costs except to those subjected to the new rules. Support comes from public interest groups, entrepreneurial politicians, and the general public. Opposition, often intense, comes from the affected group, industry, or economic sector (King and Shannon, 1986).

This paper will review the turtle issue as a case of a protective regulatory policy. Specifically, it will describe the process by which different management schemes were reached, the contrasts in perceptions about the problem to be solved, and the conflicts surrounding implementation efforts. It will close with some observations about the usefulness of the protective regulatory scheme for understanding and anticipating future efforts in resource management (1).

Background

The legal mandate for protecting threatened and endangered species is the Endangered Species Act (1973). Congress declared the purpose of the Act to be the means "...whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such...species" (16 U.S.C. 1531 (b)). Conservation includes "...all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures..." are no longer necessary (16 U.S.C. 1532(3)).

Congress charged the Secretary of the Interior and the Secretary of Commerce with categorizing species, subspecies, and even isolated populations as being endangered or threatened with extinction. Because sea turtles must return to land to lay their eggs, the federal Departments of Commerce and Interior signed a Memorandum of Understanding clarifying their joint responsibility: sole jurisdiction over sea turtles while they are in the water is lodged with Commerce's National Marine Fisheries Service (NMFS); while they are on land, responsibility lies with Interior's Fish and Wildlife Service (FWS) (2).

World-wide, there are seven species of sea turtles, six of which are found in the coastal waters of the United States (Hopkins and Richardson, 1984). These are the loggerhead, hawksbill, green, leatherback, olive ridley, and Kemp's ridley (3). All but the olive ridley were once common in the Gulf of Mexico and south Atlantic Ocean (4). The reasons for the declining populations include destruction or modification of habitats, over-use for commercial, scientific, or educational purposes, inadequate regulatory mechanisms, disease and/or predation, and other natural and human-related factors (NMFS, 1978a and b). The incidental catch of sea turtles in commercial fishing operations, such as shrimp trawls, had also been identified as contributing to the declining sea turtle populations. On the shrimping grounds, turtles are unintentionally captured in the net, where they can drown if submerged long enough.

Scoping Out the Issue

In 1970, the FWS listed the hawksbill, leatherback, and Kemp's ridley as endangered under the Endangered Species Conservation Act of 1969, a precursor to the Endangered Species Act. Having listed these species, NMFS and FWS began addressing the degree of protection required for the green, loggerhead, and olive ridley sea turtles. Designation as "threatened" or "endangered" carried with it very different levels of regulation, hence very real political implications. Public responses to proposed regulations and an accompanying draft environmental impact statement converged on four key issues: (1) whether the turtles should be listed as endangered or threatened; (2) whether turtle mariculture should be exempt from regulation; (3) whether subsistence taking of threatened sea turtles should be allowed; and (4) whether an exemption should be allowed for the incidental catch of turtles by commercial fishermen (NMFS, 1978a and b).

Final regulations released on 28 July 1978 removed the exemption for mariculture contained in the proposed rule and allowed subsistence taking only for residents of the Trust Territory of the Pacific Islands. The most controversial issue concerned the appropriate designations for sea turtles under the Endangered Species Act. Environmentalists believed the decline of sea turtle populations warranted the strict protective measures provided by the endangered label. However, data supporting such a designation were limited except for the green sea turtle populations in Florida and on the Pacific coast of Mexico.

The final regulations listed the three species (green, loggerhead, and olive ridley) as threatened throughout their range (with the exception of the Florida and Pacific greens) and exempted incidental taking as long as it took place at sea and by fisheries not directed at sea turtles (NMFS, 1978b). Data were not available at the time to determine if shrimping activities were sufficiently detrimental to sea turtles throughout their range to justify stricter action. Significantly, however, the final rule listed as one important goal the promulgation of regulations requiring the "...use of [a] panel to prevent, or substantially reduce, incidental catch of sea turtles without significantly reducing shrimp production" (NMFS, 1978b).

In summary, by listing sea turtles under the provisions of the Endangered Species Act, the NMFS and FWS had agreed that the decline in sea turtle populations was a problem that required government attention. NMFS judged that the threat stemmed from the reduction or loss of nesting habitat, the harvest of adults and eggs, and incidental capture through fishing operations. Moreover, by virtue of this listing and the 1977 Memorandum of Understanding with the FWS, NMFS had the authority to formulate and implement any additional regulations that it deemed necessary to protect the turtles. By stating specifically that a method should be developed to reduce the incidental catch of sea turtles in shrimp trawls, NMFS had set its agenda for further action on the issue. Mechanisms for stringent regulation of the incidental catch in shrimp trawls were, in fact, proposed soon after the 1978 listing.

Selecting Management Tools

By virtue of turtles being listed as threatened (green, loggerhead, olive ridley) or endangered (Kemp's ridley, leatherback, hawksbill), several management measures were automatically put in place. Foremost, the law prohibited the taking (killing, hunting, harassing, capturing) or harvest of these species as well as the importation, exportation, and all interstate and foreign commerce of sea turtles or products made from them. Other threats remained. The 1978 rule exempted incidental capture from fishing activities and provided no protection for sea turtle breeding areas. To address these issues, NMFS formed a sea turtle recovery team comprised of environmentalists, state agency and university scientists, and representatives from the fishing industry (5). The Sea Turtle Recovery Plan, completed in 1982, spelled out strategies to promote habitat protection, use of breeding programs, increased public education, collection of baseline population data, and reduction of incidental catch (Hopkins and Richardson, 1984).

The conflicts generated around the incidental catch question quickly overshadowed the other efforts at protecting and restoring turtle populations. In 1977, researchers from NMFS' Southeast Region began a three-year "shrimp trawl gear development project" aimed at reducing the incidental capture and mortality of sea turtles by shrimp trawls (NMFS, 1987a). Shrimpers were able to participate and recommend modifications by using their boats to test gear designs. By 1980, NMFS officials had determined that turtle excluder devices (TEDs) provided the best method for reducing incidental sea turtle captures and for maintaining the shrimp catch. These devices consist of a series of bars in the trawl itself which deflect sea turtles out of the net through a trap-door while allowing shrimp to pass through into the end of the trawl (Figure 1).

Introduction of the TED appeared to be the preferred approach to minimizing incidental take of sea turtles by shrimpers. Not only could the shrimpers continue to fish, but the prospect of reductions in bycatch would promote the value of the new device. Consequently, the use of TEDs by regulation became the best alternative to reduce incidental take. To pave the way for acceptance of this technological solution, NMFS chose to promote a voluntary TED use program in 1983 backed by the threat of mandatory use if the program failed (NMFS, 1983). The assumption was that the industry would be more amenable to a voluntary TED use program than mandated use, economically disastrous area closures, or reduced tow times. By 1985, however, NMFS estimated that less than 5% of the shrimpers were using the TEDs, compared to the target figure of 50% (6). In addition, new estimates linked some 11,000 sea turtle deaths to shrimping (Henwood and Stuntz, 1987; NMFS, 1987a).

NMFS had no choice but to turn back to the formal rule- making process. In an effort to make government action palatable, in late 1986 NMFS officials offered to develop regulations in consultation with shrimpers and environmentalists. The assumption was that shrimpers would prefer regulation that resulted from negotiation rather than fiat. Moreover, the agency held out the possibility that if progress were made through mediation, then it would not introduce regulations through the formal process. As with the voluntary TED program, the industry agreed to mediation as the lesser of two evils. Although support for the negotiated regulations by the industry was tentative, there was an agreement between 11 of the 12 parties to begin a step-wise implementation of TED use on 15 July 1987 (NMFS, 1986b). Final regulations, promulgated in June 1987, required the incremental implementation of TED use by area beginning 01 October 1987 (NMFS, 1987a and c).

With its TED regulations in place, NMFS had concluded a nearly 20-year effort to address all the major known threats to sea turtle populations and an almost 10-year effort to develop and promulgate regulations requiring net modifications to reduce incidental catch. The process took this long because NMFS went to great lengths to make TEDs acceptable to the shrimping industry by involving the industry in research and development programs, in the voluntary program, in negotiated TED regulations, and through opportunities to express views in public hearings.

More generally, the turtle issue evolved through the 1970's as a rather typical case of protective regulatory policy. The focus was on two small, technical agencies within the executive branch (NMFS and FWS) seeking to implement a broad but vaguely defined mandate from the Congress. The socially desirable goal, preservation and restoration of sea turtles, had broad public acceptance, or at least acquiescence. Actual participation in the selection and implementation of measures to achieve these goals was limited, however, to environmental organizations and a small number of scientific specialists, gear technologists, and the shrimp industry. Despite efforts to legitimize adoption of TEDs as the preferred solution, no consensus on methods to reduce incidental catch was reached between the government and the industry. Although the release of the final regulations was considered a victory by the environmental community, the battle simply shifted from the rituals and procedures of the rule-making process to broadly-based politics of implementation.

Implementing the TED Solution

By focusing on the incidental catch problem, the government singled out the shrimpers as the subjects for regulation. Selection of TEDs as the way to tackle the incidental catch problem transformed the policy debate from one about possible sea turtle extinction to the economic impact of TED use on the shrimping industry. Indeed, the different interpretations of the acronym TED by the major players reflected sharp lines of disagreement over both the causes and consequences of the TED solution. The environmental community was willing to endorse a technology that enabled the shrimp industry to fish and at the same time reduced the threat to turtles, hence its support for the "turtle excluder device." NMFS sought to meet its dual responsibilities for managing the nation's fish stocks with its charge to protect and restore threatened marine species by promoting TEDs as "trawling efficiency devices" that would reduce bycatch, increase shrimp capture, and at the same time, allow turtles to escape the nets. The shrimpers, however, saw the regulations as mandating the use of shrimp "trawler eliminator devices" and argued vigorously against their adoption. The bottom line, according to industry organizations, was that this added expense, when combined with increasing fuel costs and competition from foreign shrimp fleets, would cost shrimpers their livelihood (8). Their predictable response was to try and block the new regulations from going into effect.

As the implementation date for TED use in the Gulf of Mexico approached, the industry toughened its opposition through demonstrations and intensified efforts in the courts and the Congress. The protests generated widespread publicity and precipitated additional delays in putting the rules into effect. North Carolina unsuccessfully petitioned NMFS directly for relief for their shrimpers from specific provisions of the regulations. Reflecting the views of its large shrimping industry, Louisiana had filed suit against the Department of Commerce in a federal district court in October 1987 (9). One day before TED regulations were scheduled to go into effect in the Gulf of Mexico, the court ruled that, through NMFS, the federal government had followed proper procedures when it imposed the TED regulations (10). The judge supported this decision by noting that the administrative record included 12 volumes of scientific studies, data, and reports indicating the effectiveness of TEDs.

On appeal by the State of Louisiana, the Fifth Circuit Court of Appeals upheld the federal regulations mandating the use of TEDs or reduced towing times. The court stated that the federal government had followed appropriate procedures in issuing the regulations and that the shrimping community had had ample time to comply. The new implementation date for the regulations was set by the court for 01 September 1988. Court challenges had delayed implementation of the regulations by an additional six months. The judicial appeals had the added feature of increasing public attention to the issue, including that of Congressmen from key shrimping states like Louisiana and Texas.

Thwarted in their efforts to have the courts overturn the TED regulations, the shrimpers escalated the conflict in Congress. Although the sea turtle question had been discussed in Congress, the members were not directly involved until NMFS' publication of its proposed rule requiring the use of TEDs. At a 1987 hearing, agency officials defended their approach by asserting that voluntary TED use could not be considered successful with only 300-400 of the estimated 15,000 shrimp trawlers using the devices (11). At the request of the committee members, NMFS supplied the basis for its assessment that of the 47,000 sea turtles caught in shrimp trawls each year, more than 11,000 die. Industry spokesmen countered that the NMFS' data were too limited for realistic estimates and that its stranding data provided only circumstantial evidence that shrimping activities threatened sea turtles. The industry contended that other factors--overharvest, pollution, beach alteration, dredging, oil spills, explosions to remove oil platforms, and other fishing practices--contributed more to sea turtle mortalities than did shrimping (12).

Members of Congress from states with large shrimping constituencies like Texas and Louisiana sought methods to have NMFS rescind, or at least delay, implementation of the regulations. For example, in an appropriations provision, the committee found (despite more than 10 years of work) that the

"...regulations have not been developed with adequate scientific data and studies, nor has the economic impact of these regulations on small operators been adequately addressed" (U.S. House of Representatives, 1987b).

Another approach was to block implementation by attacking the reauthorization bill for the Endangered Species Act. Indeed, by mid-1988 the fight over implementation of TED regulations had become the major obstacle blocking the reauthorization of the Act. A final bill amending the Endangered Species Act delayed implementation of the regulations until May 1989. These amendments also required a study by the National Academy of Sciences on the status of sea turtles.

Additional protests, more delays by the Secretary of Commerce, and subsequent court challenges by the environmental community, resulted in the promulgation of modified regulations by the Secretary in early August 1989 (NMFS, 1989). This rule provided the shrimpers with the choice of either using TEDs or limiting their tow times to 105 minutes with 30 minute no-trawling periods. The rationale for this change was that it would "...provide those shrimp fisherman who have adamantly opposed TEDs...with an alternative that will allow them to continue fishing..." under the Endangered Species Act (NMFS, 1989). The rule invited public comment on conservation methods or measures to reduce the incidental catch of sea turtles, specifically, steps that would have "..less serious economic impacts on the shrimp fishing industry." Based on an overwhelming number of comments supporting the use of TEDS, albeit primarily from the environmental community, NMFS reinstated its 1987 regulations in September 1989. These regulations remain in effect as of December 1990. The chronology of these steps is summarized in Table 1.

Conclusions and Implications

In sum, NMFS tried for over two years to fully implement the TED regulations. It was clear that, despite the conservation values promoted by the Endangered Species Act, these values were not enough to override the more fundamental economic interests of the shrimping industry. The government seemed to agree on what needed to be done to protect sea turtles. At the same time, it sought a means that would minimize the most severe economic effects on the shrimping industry, hence NMFS's enthusiasm for a technological fix in the form of the TED. Through adoption of this piece of gear, the shrimpers could continue to fish, indeed, fish more efficiently, according to NMFS officials, and at the same time, reduce turtle mortality.

If the TED approach seemed an agreeable compromise for the government and environmental interests, it fell far short of meeting the shrimpers' concerns. Fundamentally, they rejected the conclusion--either explicit or implicit--that incidental catches in their nets were a primary cause of turtle mortalities. Second, few fishermen agreed that the new gear worked as efficiently as government officials claimed. Finally, they argued that mandatory adoption of the TEDs presented a safety problem and an additional economic hardship.

Despite extensive efforts by NMFS to involve the industry in all phases of technology development and rule preparation, the efforts to build sufficient consensus for the regulations among the affected industry simply failed. Because there was no agreement on the extent to which incidental catch was a primary cause of turtle mortalities, it was highly unlikely that the industry would enthusiastically embrace the new technology. Instead, the industry's strategy was to delay implementation for as long as possible, first through the prolonged rule-making process, then through states with strong shrimp industries, and finally, through an appeal to Congress.

In a more general sense, the protective regulatory scheme provides a useful framework for interpreting marine resource management issues. First, it helps anticipate the interests that will be involved in regulatory efforts (specific industries or activities; specialized government agencies), the nature of the process (resistance, often intense; extensive negotiation and compromise; full use of administrative procedures to defeat or dilute proposed regulations; appeals to successively higher levels of government); and limited interest or involvement by the general public. Second, because so much of marine resource management involves just this kind of targeted regulation, the process is probably similar for areas as diverse as oil and gas development, recreational and commercial fishing, or coastal development. Third, in the case of resources threatened with depletion or even extinction, the question might be asked whether such a prolonged and ostensibly democratic process serves the survival interests of the resource in question. Finally, recognition of the lengthy time involved in implementing protective regulatory policies helps define the points at which science and technology contribute to the process, and where other procedural, economic, and political considerations take precedence. These themes will be explored in greater detail in a subsequent paper (King and Risenhoover, in preparation).

The views expressed in this paper are those of the authors and do not necessarily represent those of the National Marine Fisheries Service or Texas A&M University.

Notes

1. This paper draws heavily on Risenhoover (1990) and focuses only on the federal protection of sea turtles, not the myriad of state and local laws relevant to the issue.

2. Memorandum of Understanding Defining the Roles of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in Joint Administration of the Endangered Species Act of 1973 as to Marine Turtles. Signed by Lynn Greenwalt, FWS, and Robert Schoning, NMFS, 18 July 1977.

3. The seventh species is the Australian flatback sea turtle (Natator depressus). Additionally, some list the Pacific green sea turtle as a separate species, Chelonia agassizi, from the Atlantic green sea turtle.

4. The olive ridley is found in tropical and temperate seas of the Pacific Ocean (50 C.F.R. 17.11).

5. Groups represented in formulation of the Plan included: the South Carolina Wildlife and Marine Resources Department; the Florida Audubon Society; the Caribbean Fisheries Management Council; the University of Central Florida; FWS; NMFS; Monitor International; the University of Georgia; and the Florida Department of Natural Resources.

6. See statement of J.E. Douglas, Jr., Acting Deputy Assistant Administrator for Fisheries, NMFS (U.S. House of Representatives, 1987a).

7. 22 August 1986 letter to Malcolm Baldrige, Secretary of Commerce, from Roger E. McManus, Executive Director, Center for Environmental Education. A copy of this letter can be found on page 643 of U.S. House of Representatives (1987a).

8. For example, see statement of L. Crosby, Manager, Bryan County Fishermen's Cooperative, Inc. (U.S. House of Representatives, 1987a).

9. United States District Court for the Eastern District of Louisiana. State of Louisiana vs. William C. Verity, Secretary, U.S. Department of Commerce. Civil Action No. 87-4948, 22 October 1987.

10. United States District Court for the Eastern District of Louisiana. State of Louisiana vs. William C. Verity, Secretary, U.S. Department of Commerce. Ruling. Civil Action No. 87-4948, 29 February 1988.

11. See statement of W. E. Evans, Assistant Administrator for Fisheries, National Oceanic and Atmospheric Administration (U.S. House of Representatives, 1987a).

12. See statements by R. Rayburn, Texas Shrimp Association, L. Crosby, Bryan County Fishermen's Cooperative, and M. Grunert, Texas Shrimp and Sea Turtle Survival Coalition (U.S. House of Representatives, 1987a).

References

Henwood, T.A. and W.E. Stuntz. 1987. Analysis of sea turtle captures and mortalities aboard commercial shrimp trawling vessels. Fishery Bulletin 85(4):813-817.

Hopkins, S.R. and J.I. Richardson, eds. 1984. Recovery Plan for Marine Turtles. Marine Turtle Recovery Team.

King, L.R. and W.W. Shannon. 1986. Political networks in the policy process: the case of the National Sea Grant College Program. Polity (Winter, 1986): 213-231.

_____ and A.D. Risenhoover. "Protective Regulatory Policy and Marine Resources Management" (in preparation).

Lowi, T.J. 1972. Four systems of policy, politics and choice. Public Administration Review, 32(July/August 1972).

National Marine Fisheries Service. 1978a. Final Environmental Impact Statement Listing and Protecting the Green Sea Turtle (Chelonia mydas), Loggerhead Sea Turtle (Caretta caretta), and the Pacific Ridley Sea Turtle (Lepidochelys olivacea) Under the Endangered Species Act of 1973. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

_____. 1978b. Listing and Protecting Loggerhead Sea Turtles as 'Threatened Species' and Populations of Green and Olive Ridley Sea Turtles as Threatened Species or Endangered Species. Rule, July 28, 1978. Federal Register 43(146):32800-32809.

_____. 1983. Environmental Assessment of a Program to Reduce the Incidental Take of Sea Turtles by the Commercial Shrimp Fishery in the Southeast United States. signed by William G. Gordon, Assistant Administrator for Fisheries, National Marine Fisheries Service.

_____. 1987a. Final Supplement to the Final Environmental Impact Statement Listing and Protecting the Green Sea Turtle, Loggerhead Sea Turtle, and the Pacific Ridley Sea Turtle Under the Endangered Species Act of 1973. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

_____. 1987b. Sea Turtle Conservation; Shrimp Trawl Requirements. Proposed Rule, 2 March 1987. Federal Register 52(40): 6179-6199.

_____. 1987c. Sea Turtle Conservation; Shrimp Trawl Requirements; Final

Rule. Rule, 29 June 1987. Federal Register 52(124): 24244-24262.

______. 1989. Sea Turtle Conservation; Shrimp Trawling Requirements. Rule, 10 August 1989. Federal Register 54(153): 32815-32818.

Ripley, R.B. and G.A. Franklin. 1991. Congress, the Bureaucracy and Public Policy. Fifth Edition. Nelson Hall Publishers, Chicago, IL.

Risenhoover, A.D. 1990. Federal Policy and the Endangered Species Act: The Politics, Perceptions, and Technologies of Protecting Sea Turtles. Thesis submitted to the Office of Graduate Studies of Texas A&M University in partial fulfillment of the requirements for the degree of Master of Science. December 1990.

U.S. House of Representatives. 1987a. Hearings to authorize appropriations to carry out the Endangered Species Act of 1973 during fiscal years 1988, 1989, 1990, 1991, and 1992. House Serial No. 100-8, 100th Congress, 1st Session. Washington, D.C., U.S. Government Printing Office.

______. 1987b. Supplemental Appropriations Bill, 1987. Committee on Appropriations. House Report No. 100-28, 100th Congress, 1st Session. Washington, D.C., U.S. Government Printing Office.

Wilson, J.Q. 1973. Political Organization.

______. 1983. American Government Institutions and Policies.

Figure 1. Turtle excluder device developed by the National Marine Fisheries Service to end the incidental catch of sea turtles in shrimp trawls.

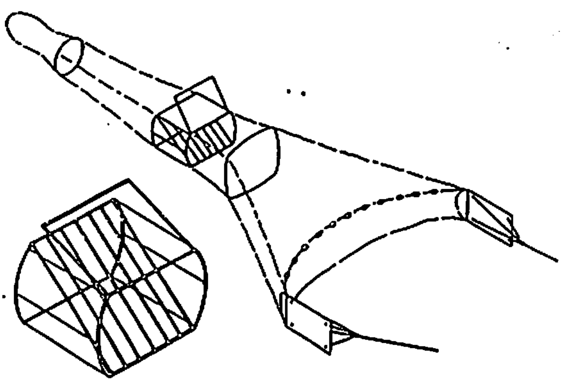

Table 1. Chronology of major actions regarding implementation of the National Fisheries Service regulations requiring the use of turtle excluder devices.

YEAR	MONTH	ACTION
1987	June	Regulations promulgated
	October	Regulations implemented off Cape Canaveral, Florida
1988	January	Regulations implemented off southwest Florida
	February	Enforcement suspended for two months by Coast Guard
	April	Regulations upheld by a Federal District Court
	July	Regulations upheld by a Federal Court of Appeals; implementation set for September
	August	Implementation delayed by Congress until mid-September
	October	Implementation delayed by Congress until May 1989
1989	April	Enforcement suspended for 60 days by the Department of Commerce
	July 10	Enforcement suspended indefinitely by Coast Guard
	July 20	Enforcement reinstated by the Department of Commerce
	July 24	Enforcement suspended by the Department of Commerce
	August	Regulations upheld by U. S. District Court
	August	Interim regulations promulgated by the Department of Commerce
	September	1987 regulations reinstated by Department of Commerce

Are Habitat Laws and Policies Responsive to Coastal Habitat Threats?

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Abstract

Confronted with a responsibility-authority disconnect, National Marine Fisheries Service Habitat Program personnel employ legal and administrative processes to influence federal and state decisions affecting habitats of living marine resources. Accomplishing this task requires reliance on federal laws providing authority to participate in governmental decision processes; ability to make recommendations to prevent harmful actions; and capability of using administrative appeal processes. Limitations of current authorities have led to proposed amendments to federal laws and revisions to administrative processes. A discussion of amendments to the Fish and Wildlife Coordination Act, revision of the Clean Water Act Section 404(q) appeal provisions, and other processes is provided.

Responsibility-Authority Disconnect

Simply having a statutory trusteeship for living marine resources is not enough. The ability to limit and prevent activities which could damage the environment sustaining these resources is also important. Historically, U.S. federal resource agencies have not had the authority to protect natural resources to the degree they wished. The ultimate decision whether to proceed with a project or action potentially harmful to habitats important to living marine resources has rested with a constructing, licensing, or implementing federal agency, and not the relevant natural resource agency...a responsibility-authority disconnect.

This is especially the case regarding the protection of coastal and marine habitats and the living marine resources (LMR), including anadromous fish, dependent upon them. The National Marine Fisheries Service (NMFS) has the responsibility at the federal level for protecting LMR. NMFS must depend on a variety of federal laws and administrative appeal processes to influence significantly federal decision-making. This paper outlines current authorities and administrative appeal processes available to NMFS. It also examines proposals NMFS has made to amend, revise, or create authorities to improve its ability to prevent actions potentially harmful to LMR in marine, coastal, estuarine, and riverine environments.

Responsibility to Conserve Marine and Coastal Habitats

NMFS has the primary federal responsibility for the conservation, management, and development of LMR and for the protection of certain marine mammals and endangered species. This responsibility forms the basis of the NMFS Habitat Conservation Policy, 48 Fed. Reg. 53142-47 (1983). NMFS' responsibility for LMR and their habitats derives, in part, from the mandates of the Magnuson Fishery Conservation and Management Act (Magnuson Act) and Reorganization Plan Number 4 of 1970. The Magnuson Act charges NMFS with conserving and managing the fisheries in the U.S. Exclusive Economic Zone and anadromous fish throughout their range. In 1970, Reorganization Plan Number 4 transferred the Bureau of Commercial Fisheries from the U.S. Fish and Wildlife Service (FWS) of the Department of the Interior, to the Department of Commerce to create NMFS within the National Oceanic and Atmospheric Administration (NOAA). This transfer included all the Bureau's authorities, including responsibility for recreational and commercial marine fisheries and freshwater commercial fisheries. Therefore, NMFS is vitally concerned with habitats which support these fisheries since it is upon them that the well-being of the resources and the fishing industry depend.

Authorities Under Federal Law

Several federal laws provide NMFS access to governmental decision-making. Laws also provide the authority to make recommendations to protect, restore, and enhance the habitats of LMR and, as discussed later, constitute a framework for administrative appeals. A listing and citation of pertinent legislation appears in an appendix to this paper.

Fish and Wildlife Coordination Act

The primary authority available to NMFS for influencing federal water resource decision-making is the Fish and Wildlife Coordination Act (FWCA). The FWCA proclaims that fish and wildlife "conservation shall receive equal consideration and shall be coordinated with other features of water-resource development programs" (16 U.S.C. § 661). Whenever any public or private agency proposes to modify a body of water in any way under federal permit or license, that entity must first consult with FWS, NMFS, and the relevant state agency to identify any possible adverse effects on fish and wildlife resources. Through this consultation, interested resource agencies are able to provide recommendations to reduce or eliminate adverse effects on living resources under their purview. The effectiveness of the FWCA in protecting coastal habitats is, however, limited. First and most importantly, its authority is consultive. Although the federal construction or regulatory agency must solicit resource agency views, resulting recommendations need only be fully considered. Second, NMFS is not explicitly listed in the FWCA; instead, NMFS provides FWCA comments under authority of Reorganization Plan Number 4. Third, the FWCA does not provide any mechanism to measure its effectiveness over time. Finally, the national rate at which resource agency recommendations are accepted and the value of these recommendations in protecting marine and coastal habitats is unknown.

Magnuson Fishery Conservation and Management Act

A second important statute for conserving LMR and their habitats is the Magnuson Fishery Conservation and Management Act (Magnuson Act). The Magnuson Act provides NMFS with broad authorities to conserve and manage fisheries in the 200-mile Exclusive Economic Zone (EEZ) and to oversee the conservation of anadromous fish throughout their range. The Magnuson Act established eight regional Fishery Management Councils which develop fishery management plans and associated regulatory regimes. NMFS works closely with the councils to develop and implement the plans and to guide the regulation of commercial and recreational marine fisheries.

With respect to protection of marine and coastal habitats, the authority of the Magnuson Act is limited. Fishery Management Councils may make recommendations on habitat issues; however, these suggestions are not binding and federal agencies may pay them scant attention. Recently, all eight Councils adopted regional habitat policies. In late 1990, the Magnuson Act was amended to require that all fishery management plans include a discussion of affected habitats, and that the council comment on or make recommendations concerning any activity that, in the council's view, is likely to substantially affect the habitat of an anadromous fishery resource under its purview. The usefulness of these new provisions in protecting habitat is not yet known.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) promotes the conduct of federal activities in harmony with protection of the environment. NEPA requires federal agencies to prepare an environmental impact statement (EIS) for each proposed major federal action which significantly affects the quality of the human environment. These statements provide decision-makers with alternatives which may be less damaging to the environment than those proposed. The scoping process under NEPA provides an open forum in which the public and other concerned agencies may comment on a proposed project early in the planning phase.

NEPA provides NMFS with limited authority to affect the design and operation of projects or activities which may destroy LMR habitat. While NMFS may comment extensively during development of an EIS, its recommendations are not binding and must only be taken into account. Additionally, NEPA tends to focus on large projects only. Small projects or activities which do not significantly affect the environment individually do not require preparation of an EIS. Therefore, the localized or cumulative effects of many small projects are excluded from a detailed NEPA review.

Federal Water Pollution Control Act (Clean Water Act)

The objective of the Federal Water Pollution Control Act (FWPCA), as amended by the Clean Water Act (CWA), is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. § 1251(a)). Means to achieve this objective include creating a system of permits for the discharge of pollutants, establishing ocean disposal criteria, and providing a regulatory mechanism for permitting dredged or fill material and disposal of sewage sludge. While all components of the FWPCA are important to protecting the marine environment, dredge and fill permits issued under Section 404 of the CWA are of particular interest to NMFS. Under this section, the Secretary of the Army, through the Chief of Engineers, U.S. Army Corps of Engineers, is responsible for issuing permits allowing the discharge of dredged or fill material into marine waters. Under authority of the FWCA, NMFS comments extensively on permit applications; however, such comments are, by definition, consultive in nature only.

Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) created a system for the management of coastal resources through federally-approved state coastal zone management plans. Any project to be constructed within a state's designated coastal zone must be found consistent with its plan. The ability of NMFS to conserve coastal habitats through such plans is confined to assisting individual states in developing adequate plans and in supporting the NOAA Office of Ocean and Coastal Resource Management, which oversees the CZMA program, with its biennial program reviews. NMFS has traditionally played a relatively minor advisory role in assisting states in implementing CZMA plans and making consistency determinations.

Federal Power Act

The Federal Power Act (FPA) affords NMFS its only prescriptive authority concerning the protection of marine and anadromous fish habitats. Under this statute, NMFS may condition hydroelectric project licenses to ensure construction of fishways, and may write conditions for license exemptions. In addition, NMFS recommends license conditions for proposed hydroelectric projects under the FPA. Such recommendations are consultive in nature.

Additional authorities

Several other federal laws provide NMFS with a measure of authority to protect living coastal resources. The Endangered Species Act and Marine Mammal Protection Act provide NMFS with some authority to protect the habitat of endangered or threatened species and marine mammals through critical habitat designations. The Marine Protection, Research, and Sanctuaries Act provides comprehensive research authority regarding the effects of pollution on the marine environment. The Pacific Northwest Power Planning and Conservation Act provides NMFS authority to make recommendations to require mitigation and the enhancement of anadromous fish habitat at and between hydroelectric projects. This authority is limited, however, to the Northwest U.S. and the acceptance of these recommendations is not mandatory.

Administrative Appeal Processes

In addition to the federal laws summarized above, NMFS has two important administrative appeal or "due process" mechanisms. NMFS initiates these elevation or referral processes when the consultative authorities provided by federal law are found to be inadequate to arrest a serious threat to coastal habitats.

Clean Water Act section 404(q) Memorandum of Agreement

Section 404(q) of the Clean Water Act (CWA) instructs the Secretary of the Army to enter into agreements with other federal agencies to "minimize, to the maximum extent practicable, duplication, needless paperwork, and delays in the issuance of permits" (33 U.S.C. § 1344(q)). This provision promoted development of Memoranda of Agreement (MOA) between the U.S. Army Corps of Engineers (Corps) and NMFS, FWS, and the Environmental Protection Agency (EPA). These MOAs provide a framework for the interagency review of proposed permits and a means for NOAA to elevate a Corps District Engineer's permit decision to higher administrative levels within the Department of the Army for review. In particular, NMFS may elevate an individual case to the NOAA Administrator for transmittal to the Assistant Secretary of the Army for Civil Works (ASA(CW)) for his/her review. NOAA may only elevate based on specific criteria, including need for policy level review of issues of national importance, the development of new information, and insufficient interagency coordination. Full consideration and coordination includes, in part, adverse environmental effects.

The ability of such a process to halt issuance of a particularly damaging permit is limited. First, the ASA(CW) is not required to accept or review the elevation package, thus allowing the project to be permitted without addressing NMFS' concerns. Second, the elevation criteria in the MOA do not allow NMFS to elevate a case solely on the basis of environmental harm. Third, even if the ASA(CW) or the Chief of Engineers instructs the District Engineer to reexamine the proposed permit, it can still be issued in virtually the same manner found objectionable to NMFS originally. The present agreement is ill-fitted to deal with interagency disputes regarding program practices, a matter dealt with almost exclusively through the courts.

Referral to the Council on Environmental Quality under NEPA

As part of the NEPA process, a decision regarding a major federal action may be referred to the President's Council on Environmental Quality (CEQ) to provide early resolution of the issue if it may involve sufficient adverse environmental impacts. The CEQ was established by NEPA as a decision-making body "conscious of and responsive to the scientific, economic, social, esthetic, and cultural needs and interests of the Nation" (42 U.S.C. § 4328). If a federal agency determines that a proposed action as described in an EIS will have unacceptable environmental effects, it may refer the issue to CEQ based on violation of national environmental standards, severity, geographical scope, duration, importance as a precedent, or availability of alternatives (40 CFR 1504.2). CEQ then evaluates information submitted by the involved agencies, and may initiate negotiations, hold public hearings, and ultimately make a recommendation to the President for action on the issue.

However, the administrative rigors of referring specific issues to CEQ limit the use of this process. Appeals to CEQ may involve considerable administrative time and cost. In addition, referral to CEQ does not guarantee a favorable recommendation or that a favorable recommendation will be accepted by the President. Lastly, this process only addresses those projects for which an EIS has been prepared, not the multitude of other smaller projects which cumulatively may be more harmful to LMR habitat. The overall effectiveness of this device is largely unknown, perhaps because NMFS has not officially referred a case to CEQ since 1979. (1)

Additional Administrative Processes

In addition to these two formal mechanisms for resolving issues, NMFS' day-to-day involvement in coastal decision-making provides several other benefits. Documents or reports related to a specific problem provide an administrative record of the decision-making process and related issues. Through the Freedom of Information Act "discovery" process, this administrative record largely becomes accessible to third parties as the support for litigation to halt approval or construction of an objectionable project. Additionally, NMFS may make reports to Congress on a specific project or general issue or contribute information for studies conducted by the Government Accounting Office.

Proposals to Acquire Greater Authority for NMFS

Occasionally, decisions occur that do not provoke lawsuits or major Executive Branch objections; however, they may be highly contrary to NMFS recommendations or goals. Resultant disappointment and frustration has inspired proposals that NMFS should acquire greater authority to independently overturn or modify decisions by others. In response to limitations of the various federal laws and administrative processes discussed previously, NMFS is currently undertaking several initiatives to increase its "leverage" in the federal decision-making process.

Amending the FWCA

Beginning in the early 1980s, the U.S. Department of Commerce has sent forward several proposals to amend the FWCA. Foremost among the suggested improvements is the codification of the role of the Department of Commerce in the FWCA process. As stated previously, NMFS does not appear in the statute as a consulting agency.

Second, in an effort to address the President's policy of "no net loss of wetlands," it may be appropriate to include five sequential steps, as defined in NEPA regulations (40 CFR 1508.20), for mitigating the damages to coastal resources in the FWCA. These steps include: avoiding the effect altogether by not taking a certain action; minimizing effects by limiting the degree or magnitude of the action; rectifying the effect by repairing, rehabilitating, or restoring the effected environment; reducing or eliminating the effect over time by preservation and maintenance operations over the life of the project; and, as a last resort, compensating for unavoidable effects by providing substitute resources.

A third needed modification would include NMFS in the transfer of funds section of the FWCA. The FWS currently receives funds from constructing agencies to carry out studies under the FWCA. Inclusion of NMFS in this provision would provide additional funding for NMFS to study adequately the effects of proposed projects.

Fourthly, it may be appropriate for the FWCA to contain a provision requiring that federal agencies seeking permits provide statements that a proposed project is consistent with federally-approved fish and wildlife conservation and management plans (e.g., fishery management plans). Such a provision would decrease the possibility that agencies are working at cross purposes.

Finally, it would be helpful if NMFS and the FWS prepared a one-time report to the Congress on the effectiveness of the FWCA in protecting fish and wildlife resources and their habitat. A study of this type would provide valuable information to all agencies affected by the FWCA. There has been substantial negotiation and concurrence on modifying this law and NMFS is hopeful that the Administration will send amendments forward early in the first session of the 102nd Congress.

Revising the CWA Section 404(q) MOA

NMFS is also proposing to revise its primary method for appealing individual permit decisions by the Army Corps of Engineers, the CWA Section 404(q) MOA. A principal objective is to improve the criteria for elevating a specific case or issue. As currently written, NMFS cannot elevate a case solely on concerns about potential habitat degradation. Instead, adverse impacts must be described as a type of insufficient interagency coordination when, in fact, significant coordination may have occurred. Occasionally, NMFS finds itself forced to represent an issue as requiring formulation of new national policy when the issue may, in fact, be that a particular District of the Army Corps of Engineers has chosen to disregard existing national policy, creating thereby a disagreement on Corps' program practice--a matter not subject to elevation under the current MOA.

In this regard, NMFS has proposed developing separate pathways for elevating specific program problems and issues of national importance which are not tied to a specific permit, as is the case with the present arrangement. Elevation of a specific permit issue would be conducted on a time-limited format and would involve primarily field elements of the Corps and NMFS. The pathway for resolving issues not specific to an individual permit and affecting the operation of the Corps' program nationwide would involve all levels within the two agencies, especially headquarters personnel, on a less time-constrained format.

A final critical element being proposed is mandatory acceptance of an elevation request by the ASA(CW). As noted previously, the current MOA allows the ASA(CW) to decline review.

Additional proposals to acquire greater authority

Other measures may have the potential to improve the ability of NMFS to influence coastal decision-making. For example, the CZMA could be amended to allow federal agencies to appeal "positive" consistency determinations made by individual states. Currently, private citizens may appeal adverse determinations to the U.S. Secretary of Commerce. Should the state issue a positive consistency determination for a particularly environmentally damaging project, there is no provision in the CZMA for a federal agency to contest this ruling to the Secretary. By including an appeal process in the CZMA, NMFS (or the Army Corps of Engineers, for example) could question actions which received a consistency determination from the state, but were contrary to NMFS (or Corps) policies.

The Magnuson Act could be amended to increase the influence of Fishery Management Councils. If the councils were given greater authority to object to decisions which were directly adverse to their ability to carry out their legal mandates, it is possible that coastal and marine habitats and LMR, in general, would benefit.

A final method NMFS could employ to increase the protection of LMR and their habitats would be to work for inclusion of favorable language in other statutes. For example, NMFS was successful in promoting the inclusion of habitat-protecting language in the 1990 Tongass Timber Reform Act. The Act requires 100-foot setbacks (buffer zones) alongside all major anadromous fish streams in the Tongass National Forest in southeast Alaska.

Conclusions

Current habitat laws and policies are reasonably responsive to coastal habitat threats. NMFS and other resource agencies are given the responsibility under a variety of authorities to recommend measures to eliminate or reduce the effect of most threats to coastal habitats. Even with the limitations in authority discussed in this paper, NMFS has been effective in protecting marine habitat under its current consultative and appellate authorities. NMFS has also been successful in several recent administrative appeals, among which were proposals for housing/recreational developments in Louisiana and Florida, and a major shipping channel in Texas.

However, as suggested in this paper, several important gaps in the current regulatory system remain. The legislative and procedural fine-tuning discussed here would close these gaps, improving NMFS' ability to conserve marine and coastal habitats under the present regulatory framework.

Is consultative authority enough? Should NMFS have a veto like EPA's Section 404(c) which allows that agency to prevent issuance of a Corps' permit? It seems highly unlikely that this would occur; EPA's authority has been used only on few occasions and is a very costly exercise for the government. Given EPA's manifestly larger budget, and its little use of this mechanism, a reasonable argument could be made that NMFS could not afford a veto, especially given its small budget and staff. Accordingly, the optimum short- and mid-term approach seems to be to continue employing administrative appeal processes, preparing case files and administrative records of excellent quality, and as a final result, letting the courts make the calls. Nonetheless, there is a certain attractiveness in amendments to the FWCA, CWA, CZMA, or other laws providing NMFS leverage to cause other agencies such as EPA to invoke vetoes, or cause CEQ to ask the President to prevent construction of an especially habitat-destructive project. NMFS has not officially proposed such laws, although proposals to this effect, or at least mirroring this approach, seem not too distant.

NOTES

Views of the authors do not necessarily represent those of the National Marine Fisheries Service.

(1) For several years NMFS stated that it would refer the Galveston Bay Area Navigation Study, Texas, to CEQ. Eventually, the Corps agreed to further studies considered essential by NMFS and other involved resource agencies.

APPENDIX

Federal Law and Executive Action Conferring Authority on NMFS

Coastal Zone Management Act, 16 U.S.C. § 1451 et seq.

Endangered Species Act, 16 U.S.C. § 1531 et seq.

Federal Power Act, 16 U.S.C. § 791(a) et seq.

Federal Water Pollution Control Act, 33 U.S.C. § 1251 et seq.

Fish and Wildlife Coordination Act, 16 U.S.C. § 661 et seq.

Habitat Conservation; Policy for the National Marine Fisheries Service. 48 Fed. Reg. 53142-47 (1983).

Magnuson Fishery Conservation and Management Act, 16 U.S.C. § 1801 et seq.

Marine Mammal Protection Act, 16 U.S.C. § 1361 et seq.

Marine Protection, Research, and Sanctuaries Act, Title III, 33 U.S.C. § 1441 et seq.

Memorandum of Agreement Between the Department of Commerce and the Department of the Army to Establish Policies and Procedures to Implement Section 404(q) of the Clean Water Act. Signed March 25, 1986.

National Environmental Policy Act, 42 U.S.C. § 4321 et seq.

Pacific Northwest Electric Power Planning and Conservation Act, 16 U.S.C. § 839 et seq.

Tongass Timber Reform Act, Public Law 101-626 (November 28, 1990)

1970 U.S. Code Cong. and Ad. News 6325. Reorganization Plan Number 4 of 1970. 91st. Congress, 2nd. Session

A Comparison of Two States' Coastal Wetlands Management: Legal Issues and Policy Distinctions

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Given the existence of mounting claims on national resources, the economic drains embodied in such current government failures as the Savings & Loans and budget crises, and the doomsday predictions associated with earth-warming, sea level rise, and Malthusian population explosions, the necessity for a persistent pursuit of common sense coastal zone management efforts may seem insignificant by comparison. Yet, I believe the wisdom of our legislative consensus on this subject--coastal zone sanity--is even more evident today than it was 18 years ago. It is certainly more urgent. Therefore, I hope these sorts of discussions never become so tiresome to those yet to be convinced, or burdensome to the converted, that we fail to attain our goals for a lack of energy, determination, and perspective.

After working, agitating, litigating, teaching, and writing in the area of environmental protection for twenty years, I am more convinced than ever that successful attainment of sound coastal zone use and preservation goals will require constant vigilance, unceasing policy improvement, uncommon cooperation, and unflinching enforcement.

My forgetfulness and naivete are periodically exposed when I am surprised by new, fresh assaults that are made to gut hard-won environmental legislation and regulatory controls. There appears to be a unique continental North American subspecies, Homo sapiens vulgaris, selected for its compulsion to continually refight every natural resource protection policy victory and to distort those provisions it cannot eradicate through mischaracterization of motive and impact. I don't think we can ever claim that we have sound wetland protection "in-the-bag."

Let me share with you some aspects of the coastal wetlands protection programs in my two native states, Georgia and South Carolina.

Within the past twenty years, the legislatures of Georgia and South Carolina have taken dramatic steps to protect and wisely allocate the resources of their respective coastal wetland areas. Pressures will always be present to alter the natural condition and functions of these wetlands. However, the casual attitudes and policies of governments of the past will never again be left unchallenged. I believe that citizens of these states, and of the nation generally, have finally accepted and have at least a rudimentary appreciation of the importance of the holistic or integrated functioning of natural wetland systems. I think it is not claiming too much to say that the average level of citizen understanding of wetland ecological "facts" will tend toward rejection of broadscale alteration of these critical areas. Such an assertion rests on many presuppositions, such as (1) trust in rational decision-making by all levels of government, and (2) absence of national emergencies such as war, substantial curtailment of oil imports, or similar events that create or appear to create "either/or" circumstances where the integrity of large wetland areas is balanced against what are perceived as basic human interests. Then there is always the potential for avarice.

While citizens of both states have couched their arguments in various terms, the struggle for control of wetlands is essentially between those who recognize only traditional private property use limitations and those who claim that these areas have always been and ought to be held and administered so as to reflect their important and distinctive public attributes.

The debate is national in scope. States such as California, where rampant wetland alteration activities have already irrevocably damaged a significant portion of that state's wetland resources, are in the forefront in rethinking their relaxed disregard of the importance of these natural systems. The "public trust" is the term most often used to indicate the body or bundle of rights the public has in these intertidal and wetland areas. Whether such claimed public rights are recognized as being derived from ancient property law concepts, statutes, or recent judicial opinions, the interests sought to be protected or the limitations on private property rights relate to the natural functioning of wetland systems. People in South Carolina and Georgia who claim ownership rights often take the position that the property is theirs to use as they see fit, accepting only the most traditional zoning-type limitations on their activities. Persons interested in fostering and promoting public rights in these areas often resort to the "bundle-of-sticks" analogy. They claim that the "sticks" representing the public or "spill over" values of wetlands were removed before present owners received their titles and are now held in trust for the general benefit of the public.

Over the past fifteen or so years, court rulings in South Carolina and Georgia and in other jurisdictions reveal judicial acceptance of a variety of limitations on harmful alterations of wetlands. These cases demonstrate that courts will uphold as constitutional statutes, ordinances, and regulations whose primary purpose is to prevent harm to the public or to public interests. The focus of judicial inquiry is increasingly directed toward the declared purposes of such limitations, rather than only on how severely claimed private property interests are affected. The courts are concerned with ecological attributes of these critical areas and are belatedly making new use of an old common law maxim that pre-dates the settlement of this continent by Europeans: "Sic utere tuo ut alienum non laedas" (use your own property in such manner as not to injure that of another.) More frequently now, negative impacts of private uses "spilling over" into the public domain or adversely affecting public rights are legitimately prohibited.

South Carolina was historically slow to adopt coastal wetland protection legislation. As recently as 1970, the state had only one lawyer and one law student assistant, myself, who were assigned to water pollution control standards enforcement. This policy of negligence toward resource protection allowed a long period of significant tideland modification and marshland destruction. However, in terms of modern, integrated land use planning in its coastal zone, South Carolina has taken a much more enlightened position than its neighboring state, Georgia. Its different political climate and the absence of some of the constitutional strictures existing in Georgia resulted in South Carolina securing approval for its coastal management program under the Coastal Zone Management Act of 1972. In contrast, Georgia elected not to participate in the Coastal Zone Management Program, primarily for four reasons: (1) the existence of a powerful and persuasive, if not always candid, land development lobby; (2) tentative and halting natural resources administrative leadership; (3) certain "Home-Rule" constitutional provisions; and (4) a 1970 state statute imposing relatively stringent restrictions on estuarine area alteration or destruction. Those are my personal conclusions, and they differ greatly with the excuses given by Georgia's governor.

Notwithstanding these slow starts and provincial attitudes, both states are presently acting seriously to protect intertidal and marshland resources. In both states, these advances were made from the citizen level up, rather than having been initiated by state leaders. One of the implications of this fact is that consistent vigilance is necessary to maintain and develop the conservation advances already accomplished. Also, one must remember that an important reason why vast expanses of intertidal wetlands and beautiful barrier island resources exist in both states is because, historically, large segments of these resources have been under the trusteeship of private claimants and owners. We owe much of our conservation heritage in these areas to such private holders. One has only to observe the recent history of state ownership and management practices to appreciate the role of private protection and stewardship. It is almost beyond serious argument that state ownership of some of the barrier islands in Georgia has been a key element in their deterioration.

In both states, there is ample case law demonstrating judicial acceptance of imposition of public trust limitations and duties on governments. Historically, these limitations were imposed on the original English colonies and were accepted as law of the states after the Revolution. Notwithstanding this significant body of legal precedent and its modern acceptance, there remains tremendous, continuing tension between traditional tideland claimants and the respective states. This conflict is much more intense in South Carolina than in Georgia and was the origin of a provision in South Carolina's Coastal Zone Management Act waiving immunity for the purpose of quieting title between citizens and the state.

In both states, the general rule on conveyance of intertidal lands from the Crown or a state is that grants of lands without specific reference to the "low water mark" conveyed title only to the mean "high water mark." While the issue is still bitterly contested, even when a grant is sufficiently specific to grant land to the low water mark, various applications of the public trust doctrine impose limitations on what such an owner can do in these intertidal areas. It is clear that such owners have exclusive rights to shellfish, for wharfing out, and for any legal alterations of the bottoms that may be permitted. But public rights such as various forms of recreation, passage or navigation, fishing, and a potentially expandable list of use rights remain. The contest is dynamic, and I believe it will require generations for a "solution" to evolve. This developing solution will no doubt occur as expectations change and compromises and accommodations blunt the more intense and publicly visible instances of disappointment and frustration.

The South Carolina Supreme Court introduced confusion [Wyche, 1978(B)] when it appeared to use the terms "tidal" and "navigable" synonymously. The implications of this lack of clarity have to do with the extent of conveyances bordering tidelands. If the "prima facie" rule has truly been accepted by the court, there is a presumption that the State owns intertidal lands adjacent to tracts bordered by tidal waters. The Cape Romain case could be read literally to apply an additional requirement of navigability in fact. However, in cases subsequent to Cape Romain, there are ample holdings to the contrary sufficient to persuade that the prima facie rule is the law in South Carolina.

There are strong dissenting judicial and landowner opinions in South Carolina that any trust obligations that do exist apply only to submerged lands, i.e. below the mean low water mark. Others argue that accumulation of common law history, provisions of the State constitution, litigation reports, and statutory law combine to persuade one that the majority view existent in the nation is the correct view for South Carolina, i.e. the state holds the intertidal lands, or the foreshore, in trust for the people. The state is presently acting as if that view is the official one. Proponents of this view argue that the scope of limitations imposed by the trust includes a broad range of important public rights or uses other than the traditional uses of navigation, fishing, etc. This view has been accepted by courts in other states.

Controversy remains in South Carolina and other states over what, if any, public rights remain after the state conveys an intertidal tract. In this unsettled area of the law, there are three general responses: (1) no alienation of public trust lands; (2) legitimate conveyance only of certain, narrow private use interests with the public's rights reserved; and (3) conveyance of both private and public attributes of title in circumstances where such transfer enhances the purposes of the trust and does not substantially impair the public interest in the lands and water remaining. While it is not entirely without doubt, South Carolina probably is in this third category. Georgia falls somewhere between the second and third responses.

In 1977, South Carolina enacted its Coastal Zone Management Act, SCCZMA, thus qualifying for approval under the federal statutory program. The SCCZMA is an important step in the direction of estuarine and critical area protection. The general scheme is the establishment of a broadly representative administrative body or council to implement the coastal zone management program and to exercise direct regulatory control over certain activities within specified critical areas of the State, such as coastal waters, tidelands, beaches, and primary ocean front sand dunes.

The SCCZMA includes a list of factors the council must consider when deciding whether to approve or deny an application. There is a requirement to develop a comprehensive management program for the State's coastal zone, which is the heart of the concept of imposing some controls in this area of the state.

The major features of the SCCZMA are influenced largely by the minimum requirements of the federal Coastal Zone Management Act.

The jurisdiction of the program extends only to the critical areas mentioned above within coastal counties. Both states arguably have accepted liberal citizen standing standards for enforcement purposes, but I am uneasy about how long the courts would be so tolerant if significant numbers of citizens became active.

South Carolina's declaration of state policy and findings has in it something for everyone. This was a purposeful potpourri to satisfy varied interests. The practical effect of such a legislative cop-out is that it gives courts tremendous interpretive latitude. The state depends on "networking" arrangements between 9 principal state regulatory agencies to provide the state level implementation authority required by the federal act. Local governments are required to exercise their authorities in conformity with the state program in the critical areas within their jurisdictions.

As previously mentioned, the statute carefully provides for comprehensive plans, permitting standards, enforcement, and penalties.

Even though South Carolina included a beach erosion control provision in its original 1977 Act, the Legislature enacted a much more comprehensive control program in 1988. In that more recent statute, it declared that the original act simply was not effective enough to "... protect the integrity of the beach/dune system." The recent legislation is a beautifully though belatedly crafted act that, if wielded by bureaucrats with backbone, can be the beginning of a two-generation correction of 100 years of beach and dune system abuse.

The South Carolina statute, Georgia's similar Shore Assistance Act, and most of the federal environmental protection statutes of the 1970s share the revolutionary thread or theme, at least in this branch of the law, of a systems-sensitive approach. With significant straight-forwardness, they provide that we determine the natural functioning of natural systems and then require that these facts guide development of criteria and standards upon which permits are conditioned. I believe it would be difficult to over-emphasize the restoration and conservation potential of that concept.

Briefly, the 1988 South Carolina Beachfront Management Act requires that we find out how sand is moved around by water and winds and then set about stopping our destructive interference with those processes. Boundaries and interaction lines must be drawn that are supposed to evolve a peace and equilibrium between and among humans, their structures, the ever-changing sea-land interface and the forces that shape it.

Because my home states have the reputation of being backward in so many respects, I never thought I would see such sensible and high-potential policy enactments that look so explicitly toward restoration and maintenance of the very attributes that attract humans to the area. Thus, I am optimistic about the South Carolina Act in spite of the recent case there in which a federal District Court declared unconstitutional a provision of the Beachfront Management Act. In that case, a U.S. District Court held that the provision of the Act preventing new construction on residential lots, adjacent to the Atlantic Ocean, within 20 feet of the coastal baseline was an unconstitutional taking of the plaintiff's property. The baseline at this location was the crest of an ideal primary oceanfront sand dune. The court determined that the statutory limitation left no economically viable use of the plaintiff's property. This opinion does not jeopardize the entire statute. At least, if not modified on appeal, it probably means that persons who have invested in upland property in critical areas must be allowed an economically viable use of their land.

Based on reports from practitioners "on the ground" in South Carolina, it is my understanding that the management process is achieving acceptance and success in that state. If South Carolina remains committed to the goals and processes of the federal CZMA, it will be a vast change for the better when compared to the situation that existed prior to the adoption of the SCCZMA.

The coastal zone management situation is a little different in Georgia. As mentioned earlier, in a battle among special interests, those desiring to defeat comprehensive, modern land use management in Georgia's coastal zone, combined with weak state leadership, were successful in preventing that state from participating in the federal coastal zone management program. However, the state has generally been much more rigid in opposition to marshland destruction than has South Carolina.

In the late 1960's, a proposal was made to mine the phosphate underlying the marshes of Chatham County around Savannah. This and related threats provided the impetus for enactment of the Coastal Marshland Protection Act of 1970 (MPA). The statute and regulations prohibit the alteration of marshlands in the estuarine areas of the state, defined as those lands supporting certain types of vegetation in tidally-influenced waters lying within a tide elevation range of from 5.6 feet above mean tide level and below.

There is a disturbing little thread of inconsistencies in responses by the Georgia Department of Natural Resources (DNR) to applications to alter marshlands under the MPA. It is true that, with the exception of the I-95 highway right-of-way marsh filling, the Marshland Protection Committee, MPC, has been vigilant in prohibiting or minimize most instances of significant marsh destruction. But, if one were to examine the entire performance record of the Committee, administratively a sub-unit of the DNR, one would discover permitted activities, mostly on a relatively small scale, that tend to set precedents or establish expectations on the part of later applicants that the State can ill afford to accommodate. It is difficult or impossible to assess the motivations of the authorities in circumstances where they have yielded to special development interests. It is equally difficult to see a rational pattern in the departures. It seems clear the regulation of marshland destruction is sometimes infected by politics. Of course, there is some "law" involved, but like all environmental protection programs, there is a political context. And, in this context, even the stalwart sometimes feel they have to yield. It is to the credit of the scientists on the staff of the Marshland Protection Division of the DNR that the politics that beset the DNR generally have not bankrupted the entire marshland protection scheme.

Applicants may appear before the MPC to present their proposals--a process that is very informal and often subjective. The staff presents the applicant's proposal to the Committee with a recommendation for approval or denial. In general practice, if an applicant cannot secure a positive recommendation from the MPC staff, the application is in trouble. The most important contact with "officialdom" an applicant makes is with the MPC staff. It is at this stage in the process of an application that a form of negotiating occurs in which it is discovered what the MPC will allow. When the staff recommends approval, its presentation takes on some characteristics of advocacy. When it recommends denial, it is a formidable adversary.

The authority of the state to control activities occurring in its intertidal zone was made secure through a 1976 Georgia Supreme Court decision. The Ashmore case interpreted a 1902 statute and a related 1945 constitutional amendment as recognition by the legislature that title to the foreshore was in the State. Ashmore was an ocean/beach erosion and accretion controversy. Thus, the state's superior legal position under the MPA was secured early in its existence.

Though not pointedly directed to protect the usual estuarine and wetland resources, Georgia's Shore Assistance Act of 1979 addresses what it terms a "... vital natural resource system known as the sand-sharing system ..." and that this system is a "vital area" of the state. This expansive legislative finding and statement of purpose relates additionally to the state's constitutional provision for protection of "vital areas."

The general scheme of the Shore Assistance Act, the very name of which is an example of legislative euphemistic pandering to the development lobby in Georgia, is to control modifications of and structures in near shore waters and in the area of dynamic dune fields. It attempts to protect the "sand-sharing system," which it defines as an interdependent sediment system composed of sand dunes, beaches, and offshore bars and shoals. It is not as detailed as its South Carolina counterpart, but it has great potential.

The constitutional validity of the Shore Assistance Act was formally upheld upon a challenge by a wealthy oceanfront resident. The plaintiff objected to the state's disapproval of an erosion structure, the design of which dissipated energy in a fashion that was destructive of his neighbors' property. This decision was a coup for good neighborliness, deference to scientific analysis, and advocates of systems protection and good government.

Whether by design or neglect, neither the Georgia courts nor the State Legislature have, in express terms, embraced the public trust doctrine as a protective management scheme or property concept as has occurred in California and other jurisdictions where widespread environmental degradation is the norm. However, the state has accomplished much of the protections other states have provided pursuant to explicit acceptance of the "public trust" through evolutionary constitutional and statutory development such as the Coastal Marshland Protection Act, the Shore Assistance Act, and the constitutional provision dealing with vital areas. It is unlikely that, in the foreseeable future, the courts in Georgia will use the traditional statement of the public trust as a sole basis for estuarine area and wetland protection. Rather, it is probable that case law will evolve within the bounds of the political consensus that has found expression in the two statutes and the constitutional provision mentioned above.

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References

Blumm, M. C. 1989. Public property and the democratization of western water law: A modern view of the public trust doctrine. 19 Environmental Law 572.

Coastal Zone Management, No. 123, 1977 S.C. Acts 224 (Codified at S.C. Code Ann. 48-39-10 to 360 as amended)

Chavons v. South Carolina Coastal Council, No. D:89-0216-1 (D.S.C. Oct. 13, 1989) 20ELR20393.

Draft Coastal Zone Management Program, Georgia Coastal Management Board, Office of the Governor, Atlanta, Georgia. 1979.

Esposito v. South Carolina Coastal Council, No. D:88-2055-1 (D.S.C. Oct. 13, 1989) 20 ELR 20397.

Fever v. South Carolina Coastal Council, No. 88-3073-1 (D.S.C. Oct. 13, 1989).

Heath, M. A. 1983. A tidelands trust for Georgia. 17 Ga. L. Rev. 851.

Kundell, J. E., et al. Management of Georgia's Marshlands Under the Georgia Coastal Marshlands Protection Act of 1970. Institute of Government, University of Georgia. 1988.

Memorandum from Governor George Busbee to Honorable Juanita Kreps, Secretary of the U.S. Department of Commerce, dated June 21, 1979.

Smith, J. O. 1975 Citizen Enforcers: Influencing Water Allocation Decisions. Institute of Government, Institute of Natural Resources, University of Georgia.

____. 1978 The Law of Surface Water Allocation in Georgia. Institute of Natural Resources, University of Georgia.

____. Legal Aspects of Water Resources: A Survey of the Law in Georgia. ERC 05-83, Institute of Natural Resources, The University of Georgia, Athens, Georgia. (In conjunction with the Environmental Resources Center, Georgia Institute of Technology.

____, and J. L. Sammons. 1974 Public rights in Georgia's tidelands. 9 Ga. L. Rev. 79.

Smith, R. W. The Public Trust Doctrine in North Carolina.

_____. Reclaiming the Public Trust.

The Shore Assistance Act of 1979. Ga. Laws 1979, p. 1636.

The Coastal Marshlands Protection Act of 1970. Ga. Laws 1970, p. 939.

Wyche, B. W. 1978a The South Carolina Coastal Zone Management Act of 1977. 29 S.C. L. Rev. 666 (1978).

_____. 1978b Tidelands and the Public Trust: An Application for South Carolina. 7 Ecol. L. Q. 137.

"Progetto Adriatico": Learning for Planning on the Adriatic Coast

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This paper is focused on the Adriatic coast of Italy, from Trieste to Barletta, an area stretching for about 1,000 km, including a wide variety of situations and scenarios, affected by overpopulation, conflicting uses, and environmental issues, and visited by millions of tourist every year.

The study area may be divided into different coastal sectors. In the northern sector, from Trieste to Duino (50 km), a stretch of high coast borders a part of the Gulf of Trieste. To the south, a long stretch of low, alluvial coast extends from Duino to Cattolica (350 km), fringed by marshes and lagoons such as those of Grado, Marano, Venice (the largest one), and Comacchio, partially reduced by extensive reclamation. The central part of this long, curved shoreline includes the wide prominence of the Po Delta. By the 1950's, this flat coast had been developed into the most extensive coastal conurbation of the country.

From Cattolica to the Gargano promontory (400 km), the shore is bordered by a narrow strip of beaches. Only short tracts of high coast interrupt the continuity of this sandy strip, including the cliffs from Gabicce to Pesaro, the promontory of the Conero, and other short stretches near Ortona, Termoli, and Vasto. This coastal zone is now developed primarily for recreational and residential uses.

The coastline surrounding the calcareous promontory of the Gargano (80 km) is high and rocky. Small coves used for recreational activities are bordered by pocket beaches. South of the Gargano, from Manfredonia to Barletta (70 km), low and sandy beaches border the alluvial stretch of the Gulf of Manfredonia, still under reclamation. This area has been affected by industrial and tourist development only in recent times.

In the course of nearly a century (1871-1981), the percentage of the total Italian population living in the "coastal region"--strictly defined as the strip of the territory where environmental conditions and economic activity are directly influenced by the presence of the sea/land boundary--has grown from 10.0 to 14.5%, a 10 out of thousand continuous increase, in comparison to the average national value of 6.5 (Torresani, 1989a). If by the term "coastal region" is meant the total area of the 638 districts bordering the coast, the values, in the same period (1871-1981), would increase from 17 to 30% (Zunica, 1976; Cavanna, 1983).

In 1981, 18% of the total population of the regions bordering the

Adriatic Sea lived in the coastal zone, as strictly defined above, compared with 11% in 1871. Such a trend derives from a "coastal" population growth with a continuous rate of increase equivalent to 10.1 out of thousand, compared to 5.8 for all Adriatic regions.

Given such a remarkable and increasing concentration of population and therefore of activities along the Adriatic coast, a team of geographers from the University of Bologna, coordinated by Dr. Paolo Fabbri, has started the "Progetto Adriatico". The project's aim is to conduct a general geographic analysis of the Adriatic coast.

In the presence of a wide variety of environmental characteristics and related to the stages of population growth and the valorization of the Adriatic coast, some aspects sufficiently "homogeneous" have been preliminarily identified. The aim is to synthesize the results of the investigations both graphically and in a descriptive way, along with the development of a series of cartographic tables. Seven tables will be produced dealing with the following subjects: jurisdictional limits; weather conditions; population increase; urban development; sea-related economy; productivity and services; and tourism activities. The main part of the cartography will be a schematic table at a scale of 1:100000 for every trait of the coast, where the most important aspect is given by the historical evolution of the coastal territory. Other tables on a scale of 1:50000 will show the distribution of important coastal elements and generally surveyed directly on the field.

Settlement along the Italian coast has been subject to alternate phases. In antiquity, different and remarkable kinds of colonizations were made along limited parts of the coast by the Greeks, the Etruscans, and the Romans. Since the Middle Ages, colonization was undertaken by the maritime city-states ("repubbliche marinare"), in particular the city of Venice (Torresani, 1989b).

Long regressive phases in the extent and pattern of colonization and settlement were related with the decay of economic activities and the upsurge of a feeling of uncertainty due to Arabic invasions, particularly in the 7th-11th and the 16th-18th Centuries, and the spread of malaria in the often marshy, low coastal plains.

Along the Adriatic coast, cartographic sources of the 19th Century show an unsettled landscape over large areas. The ancient maritime towns, scattered in different points along the coast with little reciprocal interaction, were obviously an exception. Everywhere, there were problems of flooding, stagnation, and sea entries and malaria's foci were diffused.

These conditions were present not only in the coastal area of the northern Adriatic, which is bordered by marshlands and numerous deltas. In the central part of the area, behind the dune ridges and in lands where rivers could hardly flow into the sea, there were stagnations. Farther south, the areas surrounding the coastal lakes of Lesina and Varano were also repulsive, unhealthy environments. South of the Gargano promontory, a very long ridge of dunes included wide marshy areas and the lake of Salpi: there were all relics of the ancient lagoon where, in antiquity, the towns of Salpi, Salapia, and Siponto had flourished.

In the second half of the 19th-Century, the environmental situation of the Adriatic coast was still repulsive. The main factors behind the population growth and economic valuation of the Adriatic coastal territories can be identified and placed in a chronological sequence of increasing importance, in the following points:

- the establishment of the railway network and the enlargement of the road network;

- the drainage of coastal wetlands and the related progress of cultivated lands towards the sea;

- the development of ports and related industries;

- tourism, the last chronologically, yet with a strong and wide influence on the delicate equilibriums of our coast.

The railway was undoubtedly the first, great infrastructure which started a linear development along the middle Adriatic coast of Italy. Forced to locate out along the peninsular edge by morphological requirements and political choices, the railway was "the factor which concentrated and accelerated the population growth, along with the development of an urban network and the infrastructures related to it" (Fabbri, 1984).

It has been reckoned that the total population increase registered in coastal regions from 1861 to 1911 was equivalent to 135%, compared to 28% in inland areas--an extraordinary correlation between demographic growth and the coastal territory covered by the railway. It is sufficient to mention the example of Pescara, whose population in 1861 was 4,500; by 1921 its population was nearly 31,000.

The railway helped on the one hand to connect the major coastal cities and to create new developed areas. On the other hand, at the beginning, the railway helped worsen the already precarious environmental conditions in coastal regions. In fact, the railway often stressed a division between coastal and inland territories, whether it was constructed on dune ridges or a few dozen meters from the shore-line or on embankments in depressed zones. Access to the sea became very difficult along the whole coast of the middle Adriatic. Subsequently, this seriously prevented the coastal areas from developing in a harmonius way; in several places, the natural downflow of the rivers towards the sea was obstructed by the railway bed and new marshes were created.

Over a longer period of time and related to different techniques depending on different areas involved, land reclamation was another important factor spurring population growth, since it allowed the plains overlooking the sea to be at their best use. In the course of a century, reclamation conquered the coastal edge. Malaria was wiped out, cultivated fields replaced the marshlands, and, thanks to an appropriate levelling work, a rich horticultural industry now operates where the dunes once stood.

A new road network connected the new rural settlements in the large reclaimed coastal plains of the upper Adriatic and the littoral zone of the mid-Adriatic. A large part of the southern marshes was also reclaimed through extensive works of drainage, allowing subsequent agricultural development (Lodovisi, 1989).

A substantial incentive to coastal urbanization came from port industrialization. Before the Second World War, the main ports of the Adriatic had already showed signs of vitality through great works of transformation and a remarkable immigratory flux. Yet, it was in the 1950's that a real process of industrialization started along the Adriatic coast and this was largely related to oil exploitation (FABBRI, 1984).

Apart from the one-time mid-European port of Trieste, whose role had long been neglected, a real conurbation has grown in the Venetian hinterland (Porto Marghera - Mestre). Ravenna registered a population increase of 44% between 1951 and 1971, the period of this city's industrialization. Farther south, beyond Pescara, the territory surrounding Vasto and the region of Puglia, with Bari in the middle, are noteworthy with a 88% population increase.

The towns of Trieste, Marghera, Ravenna, Falconara, Manfredonia, Bari, and Brindisi are the centres of a new industrial development strictly related to refineries, the petrochemical industry, and power plants. Other cities, such as Ancona and Monfalcone, have improved their dockyards. For all these cities, the sea has been an important factor of industrial development. The industrialization and growth of other cities is due primarily to the availability of great infrastructures (railways, roads, motorways) and to the presence of plains rather than their position on the coast.

In sum, the processes of industrialization are at the same time causes and results of population growth and urbanization, and show an uneven distribution.

Since the littoral area was reclaimed, new railway networks were constructed, roads and motorways were enlarged, and industrial and service activities expanded. After the Second World War, favourable conditions rose which encouraged tourism.

Tourism, which had already been an important activity in some traditional seaside resorts during the 19th-Century, spread more and more rapidly at the beginning of this century and also from the 1920's to the 1940's. At first, tourism development was limited to parcels of land: there arose some cottages, and the pattern was typical of littoral expansion, as they were built either near a city or a small centre, constituting new nuclei, the so-called "marine"; these derived from many centres located in the immediate hinterland. Later, especially during the last 30 years, the flux of tourists towards seaside resorts developed on a mass scale. Thus, reflecting a major change in the way of life (vacation, leisure time, the spreading of transportation, the building of new littoral roads), the coastal area became the centre of a big tourist business.

The size of the settlements could no longer be related to small periurban parcels of land, as they spread through wide areas of dozens and even hundreds of hectares. Both small and great building firms became the new protagonists of coastal development on the Adriatic, exploiting rather remote lands--both unfruitful and cultivated ones--whether there were ridges of dunes, river mouths, or plains (Cencini et al., 1988).

The building activity along the coast in 1960's and 1970's further increased towards the southern regions (Marche, Abruzzo, Puglia). The pace of construction has only recently slackened because of an inevitable process of saturation and more stringent control of development by governmental agencies concerned about the environment.

In terms of urbanization, and therefore of "building" of the landscape connected with the phenomena of industrial and tourist development, the result is that today the built-up area along the Adriatic coast has an extension equivalent to nearly 600 km, while at the beginning of the present century it hardly exceeded 100 km.

REFERENCES

Cavanna, I. 1983. Evoluzione dei processi insediativi costieri in Italia dal 1871 al 1981. Note geografiche. Atti XX Congr. Geogr. It., v. II, t. III, 141-166.

Cencini, C., M. Marchi, S. Toressani, and L. Varani. 1988. The impact of tourism on Italian deltaic coastlands: four case studies. Ocean & Shoreline Management 11:352-374.

Fabbri, P. 1984. Processi di popolamento e di urbanizzazione della costa adriatica italiana in età contemporanea. Storia Urbana 8:61-77.

Lodovisi, L. 1989. Historical evolution of the coastal settlement in Italy: modern times. Pages 160-169 In: P. Fabbri, (ed.) Coastlines of Italy. American Soc. of Civil Engineers, New York.

Torresani, S. 1989a. Il processo di popolamento della costa adriatica (1871-1981). In: Bernardi, R. (ed.): Mari e coste italiane, Patron, Bologna, 91-122.

______. 1989b. Historical evolution of the coastal Settlement in Italy: ancient times. Pages 150-159 In: P. Fabbri (ed.) Coastlines of Italy. American Soc. of Civil Engineers, New York.

Zunica, M. 1976. Human influence on the evolution of the Italian coastal areas. Italian Contributions to the 23rd Int. Geogr. Congr., pp. 87-93.

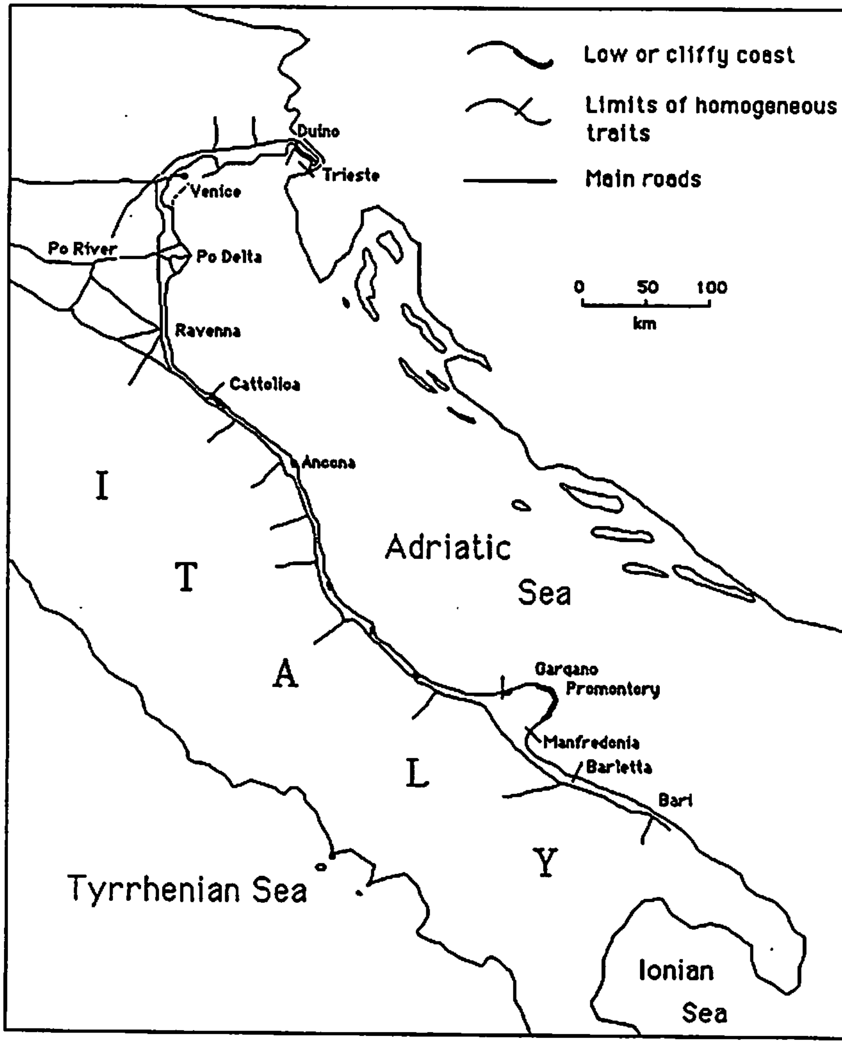


FIG. 1 - Main features of the Italian Adriatic coastland

Fig. 2 - Percentage of developed coast

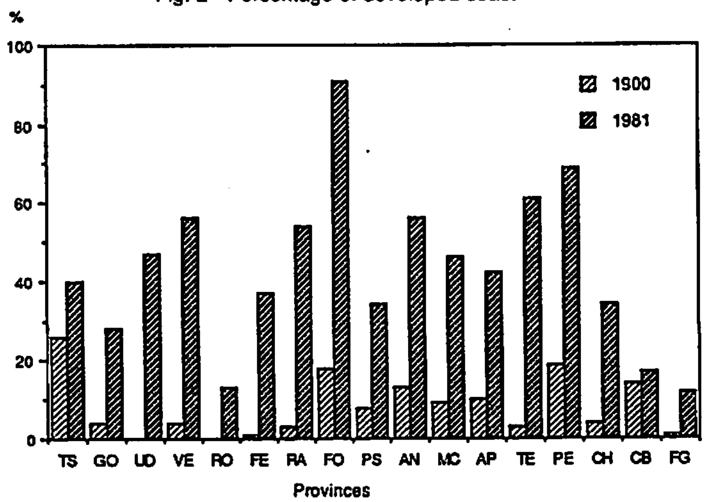
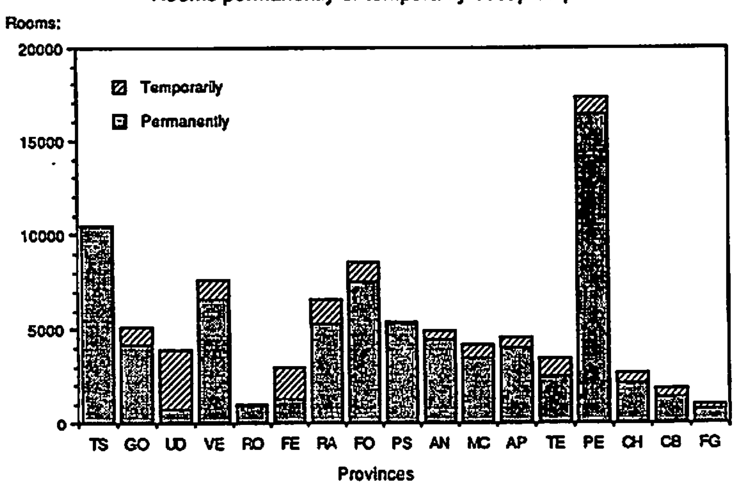


Fig. 3 - Coastal building density.
Rooms permanently or temporarily occupied per km/coast



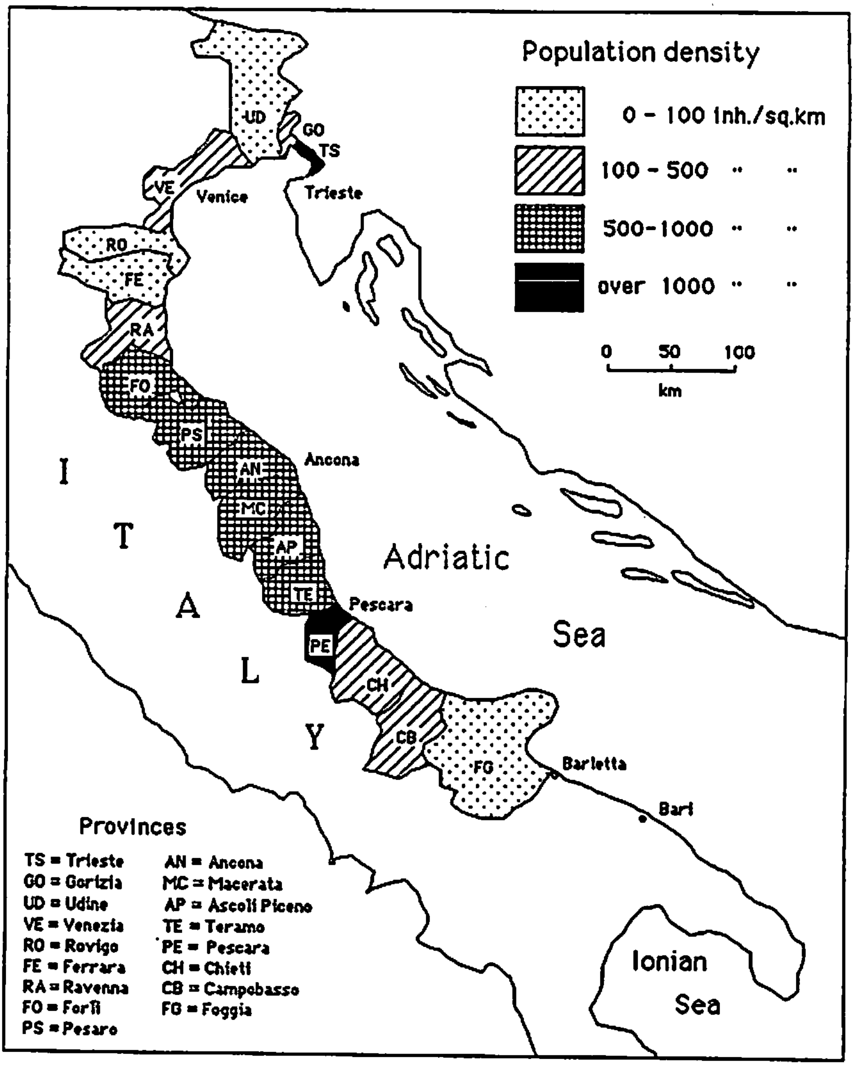


Fig. 4 - Population density along the Italian Adriatic coastland

The National Estuary Program: An innovative federal-state approach to the design of estuary governance policies

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Introduction

Estuarine areas have long been areas of environmental concern in the United States. Estuaries serve as the receiving waters for drainage of vast areas of land. In addition, their unique physical, chemical, and biological characteristics create an excellent environment for the growth of plants and animals (EPA, 1983a). In fact, estuaries are among the most productive and complex types of ecosystems. They not only serve as fish and wildlife habitats, but accommodate a host of human uses and interactions. Among these are fishing, commercial shipping, tourism, recreation, boating, flood control, waste disposal, industry, and waterfront development. Many people have chosen to live in estuarine areas. It is clear that much of the population of the U.S. exerts direct and indirect pressures on the nation's estuaries (EPA, 1989a). Therefore, it is important to have an effective mechanism for managing these valuable resources.

This paper explores the development of the National Estuary Program (NEP) as a rapidly evolving tool in the nation's environmental management efforts, focussing particularly on the themes and characteristics of the program. It also examines the importance of this program's adaptability and learning capacity with respect to the diffusion of innovative estuary management techniques over time. Finally, the paper discusses the role of the management conference as a public choice mechanism for identifying issues and solutions to estuarine problems and explores possible impediments to program implementation.

Past Attempts at Estuary Governance

There has long been a federal interest in water quality problems in the nation's estuaries. Early federal attention is demonstrated by the Federal Water Pollution Control Act (FWPCA) of 1948. Major amendments to this law were adopted in 1965, followed by a complete revamping of the law in the form of the Clean Water Act (CWA) in 1972, with further important amendments in 1977 and, most recently, in 1987. These laws have reaffirmed the strong federal commitment to the improvement of the nation's waters. This water quality legislation provided construction grants for sewage treatment plants, a National Pollutant Discharge Elimination System (NPDES), a permit program to regulate discharges into U.S. waters, and funding for the creation of Section 208 area-wide management plans, among other things.

The federal government has also financed a series of comprehensive action-oriented studies of the Nation's water quality. An early federal-state collaboration in estuary pollution control was the 1966 Delaware Estuary Comprehensive Study, which set wasteload limits to the estuary which were enforced by the Delaware River Basins Commission and later by the U.S. Environmental Protection Agency (EPA). This was followed by the 1970 National Estuary Pollution Study, which highlighted estuaries as a major federal policy issue during a period when major new federal action on water pollution control and coastal zone management was being formulated. Other federal legislation has been enacted to provide for the management of the nation's fisheries, a regulatory program for dredge and fill activities has been strengthened using different legislation, and a requirement for the utilization of environmental impact statements was introduced by the National Environmental Policy Act (NEPA) of 1969. The federal government has also sponsored regional programs to address issues of growth management and water quality. These programs are best illustrated by the federal river basin programs. In 1972, the Coastal Zone Management Program (CZMA) was created within the National Oceanic and Atmospheric Administration (NOAA) to help coastal states preserve, protect, enhance, and develop their coastal zones.

Included in this federal clean water legislation are two particularly important estuary governance programs that have shaped the development of the National Estuary Program (NEP). These two programs are the Great Lakes Program (GLP) and the Chesapeake Bay Program (CBP). Both programs were established to address specific water bodies where planning and regulatory requirements of the Clean Water Act were seen by Congress as inadequate to restore and protect water quality. Both programs are comprehensive approaches to managing and improving water quality using ecosystem-oriented parameters in multi-jurisdictional settings. They both have been guided by a series of consecutive five-year plans which set increasingly complex goals and objectives, and they both utilize intergovernmental agreements to implement the plans at the state level.

One of the great lessons learned through the CBP and the GLP was that pollution controls evolve in an adaptive, phased pattern (EPA, 1989b). The process which both programs followed involves identifying pollution problems based on impaired uses, linking those impairments to pollutants, isolating the origin of the primary pollutants, developing corrective actions, and implementing those corrective actions (EPA, 1989b). In other words, time has shown "that success depends on a phased process of identifying pollution problems, evaluating alternative solutions, and recommending and implementing cost-effective actions to alleviate these problems," (EPA, 1990a). Essentially, an estuary management process needs to be organized as an adaptive system which addresses increasingly complex issues while progressively integrating existing management and governance mechanisms.

The reason for this phased process is a basic limitation in our capacity to deal with complex ecosystem problems. This is especially true in cases of programs in multi-jurisdictional settings. By attacking problems at the simpler levels, and then progressing on to tougher, more complex issues, there can be a better utilization of problem-solving resources. It is also easier to gain political acceptance by focusing on progressively more complex issues after agreement is achieved at a simpler conceptual level.

Another of the lessons learned was the importance of a sound monitoring program and the need to coordinate existing monitoring programs. Monitoring is essential so that future trends may be modeled and evaluated (EPA, 1989b). Without a solid monitoring program, managers and legislatures are unable to evaluate whether the prescribed actions have been successful or if the agreements have been implemented (EPA, 1989b).

The National Estuary Program

Despite federal and state legislation and ongoing water quality and coastal zone programs, the nation's estuaries are still plagued by problems of incompatible uses and environmental degradation. It has long been recognized that "the problems in our estuaries are too big and too complex for any one agency, community, or interest group to address alone," (Davies, 1989).

Congress established the National Estuary Program with the passage of the 1987 amendments to the Clean Water Act (1987 Water Quality Act; P.L. 100-4; Section 320, Clean Water Act as Amended; 33 U.S.C. 1330) in order to expand the number of estuaries which could receive special attention through a joint federal-state planning initiative. The NEP is managed by the Environmental Protection Agency. The EPA is to identify nationally significant estuaries that may be threatened by pollution, development, or overuse and to facilitate the preparation of a Comprehensive Conservation and Management Plan (CCMP) through the use of a management conference. The CCMP is to ensure and enhance the ecological integrity of the estuary (EPA, 1989b).

The National Estuary Program consists of seventeen estuaries in fourteen state jurisdictions (Figure 1). These estuaries have been added to the program in incremental fashion. The latest additions to the program came in April, 1990 when President Bush designated five more estuaries as being nationally significant (Kurkjian and Franklin, 1990). This incremental growth in the NEP has fostered a learning capacity within the program. Essentially, it allows the newer estuaries to learn directly from the experiences of other estuaries that have already completed stages in the management conference process.

The newest estuaries, as well as subsequent additions to the NEP, must submit nominations from the state(s) governor to the Administrator of the EPA to include an estuary in the program. It is important to realize that this is a demonstration program; estuaries are selected not solely on the basis of these requirements, but also on the degree to which the estuary can enlarge the pool of management and governance experience for the nation's estuaries.

The National Estuary Program Themes and Characteristics

The NEP approach to creating a Comprehensive Conservation and Management Plan for each estuary contains two important elements: a specific series of steps for identifying and solving problems and a collaborative decision-making structure termed the "management conference" (EPA, 1989b). These elements combine to give the NEP certain characteristics which distinguish it from past estuary governance efforts. The first characteristic is that the NEP emphasizes partnerships. This is because the problems to be addressed are interjurisdictional in nature and are often too complex to be addressed by a single agency, community, or interest group. The management conference is the mechanism for creating these partnerships.

The second distinguishing characteristic is that the NEP provides strong management and regulatory tools to help carry out these plans. These tools range from traditional technical assistance in monitoring, to helping communities find innovative financing mechanisms for their protection programs, to the NEP's ability to coordinate and leverage other programs such as the National Oceanic and Atmospheric Administration (NOAA) and the Department of Agriculture's Soil Conservation Service (SCS). By leveraging other environmental and resource-based programs, members of the estuary's "management conference" gain access to and provide direction for the resources and expertise of these other agencies.

The third and most critical characteristic which distinguishes the NEP from other attempts at basin-wide programs is that it utilizes these partnerships and tools to emphasize action through systematic problem solving. In other words, the NEP is intended to produce results. It is not intended to be just another planning exercise or procedural requirement in order to get federal funds; in fact, virtually no federal implementation funds are available from the NEP. The Comprehensive Conservation and Management Plan to be developed by the management conference is designed to bind its participants to specific financial, institutional, and political commitments in order to address priority problems (EPA, 1990a).

The NEP Management Process

The NEP's primary goals are the protection and improvement of water quality and the enhancement of living resources (Sec. 320 of the 1987

Amendments to the Clean Water Act). By definition, this involves numerous federal and state agencies and resource users who all hold a portion of the jurisdiction and power to implement these goals. The management conference is composed of these groups. The shared authority and efforts of the conference is the means to develop the CCMP for an individual estuary program, rather than the creation of a new management authority. This process has three initial steps conducted concurrently with activities to satisfy the seven principal purposes of a management conference as specified in the 1987 law. Due to the individuality of the programs, as well as the varying degrees to which states already practice estuary management and governance, there are differences in the structured process among the 17 programs.

The first step in the management conference is to elucidate the environmental concerns that the NEP is going to address. The identification of environmental concerns and the reevaluation of these concerns is one of the primary focuses of the program. A second step is to develop a Data Information and Monitoring System (DIMS) that will facilitate the collection and organization of the essential data to be used by the management conference. The third step, which has been carried out primarily by the more recent NEP programs, is the development of "action now agendas". These are priority actions that can be undertaken early in the management conference process to build participation and enthusiasm for the planning effort without further study and evaluation.

The remaining seven activities of the management conference are directed towards satisfying the seven statutory purposes of the 1987 law. The first three purposes are: the development of a status and trends report; the identification of the probable causes of the environmental concerns that have been identified; and a report documenting proposed relationships between pollution loads and potential uses. Frequently, the reports from the first three purposes are combined and distributed as one inclusive status and trends report. The fourth purpose is the development of the Comprehensive Conservation Management Plan. The CCMP contains both management plans to address the issues identified in the combined status and trends report as well as an implementation plan, a monitoring plan, and a federal financial consistency review. The CCMP is intended to address critical problems and outline corrective actions that will help attain/maintain uses of the resource that are threatened due to current human interactions with the environment. The last three purposes (implementation, monitoring, and federal consistency) are met through the implementation section of a CCMP. An implementation plan must demonstrate the institutional and financial commitments necessary; establish a monitoring program to keep track of the effectiveness of implementation; and review federal financial assistance programs for their consistency with the CCMP. Once all seven of these purposes are completed, the CCMP is ready for acceptance by the EPA, whereupon implementation can begin. This is the stage that several of the first-tier estuaries are currently entering. For example, the Buzzards Bay draft CCMP was released for public review and comment in the fall of 1990, the first of the four original NEP estuaries to do so.

The NEP Management Process and Issue Selection

The planning and decision-making process established by Congress for estuaries in the NEP is highly structured and synoptic. A broad range of goals, issues, and policies are typically included and each NEP must complete all steps of assessment policy options and selection. At the same time, the management conference encourages, and indeed requires, participation by diverse and varied constituencies at the state and local levels, thereby assuring a wide range of views. This participatory feature is buttressed by a consensus building element so that agreement about priorities among issues is possible. Thus, the management conference provides flexibility and adaptability into what would otherwise appear to be a purely synoptic planning process imposed on participating states by the federal government. This flexibility allows the different estuary programs to follow a similar process while allowing to address or emphasize different issues. Even when the issues appear to be the same in two estuaries, they are not always identical in importance, scope, and complexity. The varying degrees of attention that these concerns receive is the result of differing public perceptions, differing causes, differing jurisdictional complexity, and differing state capacity to carry out environmental management programs. Essentially, states vary in their commitment and capacity to deal with these complex environmental concerns. The NEP appears flexible enough to handle the diversity of issues and remedial actions that are required to address these concerns.

Implementing the CCMPs

Serious questions remain regarding the implementability of the CCMPs. The NEP approach removes a large portion of the implementation responsibility from the federal government and places it with the states. Unlike past basin-wide planning and management programs, there is no promise of significant implementation funding. Moreover, many of the issues identified are broader than the water quality responsibilities of the sponsoring agency, EPA, often including such issues as fisheries and coastal zone management responsibilities--both of which are under the jurisdiction of the National Oceanographic and Atmospheric Administration. Thus, a necessary condition at the federal level would be the creation of a mechanism between the EPA and NOAA for managing estuarine ecosystems in a well informed, well financed manner, at the same time that related state pollution control, fisheries, and coastal zone management agencies are working together through the NEP management conference.

The first steps in this direction were taken when the EPA and NOAA signed a Memorandum of Understanding (MOU) in 1988 that addressed the question of CCMP implementation. According to this MOU, the CCMP is to be submitted to states for incorporation into their approved Coastal Zone Management Programs. Thus, the CZMA is the mechanism for federal level implementation of specific CCMPs. Although the plans are developed with interagency cooperation at the federal, state, and local levels, and the CCMPs provide for implementation, the question of state implementation remains. Because of the diversity both in the selection of environmental concerns and the reactions to these concerns, the CCMP may include action plans not easily dealt with at the institutional level. In many cases, these concerns are addressed because the current system either has no capacity to deal with the concern, or the current regulatory system has failed to deal with these concerns. Thus, institutions and policies may need significant modification at the state and local level.

Assuming that the problems identified in the CCMPs do get on the political agenda of each state, the next challenge for managers is to design an effective implementation program. Failure to consider the politics of implementation is likely to render any policy objective or recommendation, however important and worthwhile, weak and ineffective. Implementation typically looks more like a disorderly learning process than a predictable process (Berman, 1978 and 1980). Given these conditions, it is incumbent upon state resource managers and policy makers to design and utilize institutions which have the capacity for learning required to implement management programs for dynamic estuarine ecosystems.

Conclusions

On the basis of this analysis, we conclude that the NEP approach is flexible enough to stimulate the selection of diverse issues and remedial actions that are required to address concerns of particular estuaries, while at the same time providing the federal government with a policy framework that can be standardized across a wide range of estuary types. The NEP is a fascinating example of a "diffusion of innovation" based on a body of experience derived from the Great Lakes Program and the Chesapeake Bay Program and containing a phased approach to adding estuaries which will foster continuing improvements in the process through experience in a wide range of settings. This incremental approach encourages lessons to be learned as the program progresses and allows a diffusion of innovations within the program itself. Finally, the major potential constraint on program success would seem to be the capacity of the states themselves to manage their environmental resources. They must have the will, imagination, and financial resources to implement the program. If they do not, the program will fail.

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References

Berman, P. 1978. The study of macro and micro-implementation. Public Policy 26:157-184.

_____ 1980. Thinking about programmed and adaptive implementation: matching strategies to situations. In: Helen Ingram and Dean Mark (ed). Why Policies Succeed or Fail, Beverly Hills, SAGE.

Davies, T. 1989. A partnership for action. Delaware Conservationist, Summer, 1989. pp 4-5.

Environmental Protection Agency. 1983a. Chesapeake Bay: A Framework for Action. Sept. 1983.

_______. 1983b. Chesapeake Bay Program: Findings and Recommendations. Sept. 1983.

_______. 1985. Five Year Program Strategy for the Great Lakes National Program Office 1986-1990. Aug. 1985.

_______. 1988a. Five Year Program Strategy for the Great Lakes National Program Office. Dec. 1988.

_______. 1988b. U.S. Progress in Implementing the Great Lakes Water Quality Agreement: Annual Report to Congress.

_______. 1988c. Memorandum of Understanding with regards to the National Estuary Program. Office of Ocean and Coastal Resources.

_______. 1989a. Marine and Estuarine Protection:Programs and Activities. Office of Water. Feb. 1989.

_______. 1989b. Saving the Bays and Estuaries: A Primer for Establishing and Managing Estuary Projects. Aug. 1989.

_______. 1989c. The Second Progress Report under the 1987 Chesapeake Bay Agreement, Chesapeake Executive Council. Dec. 1989.

_______. 1990a. Progress in the National Estuary Program: Report to Congress. Feb. 1990.

_______. 1990b. The National Estuary Program: Final Guidance on the Contents of a Governors Nomination. Jan. 1990.

Kurkjian, S. and J.L. Franklin. "Bush gives $5m for N.E. bays", Boston Globe, pp. 1A,22A, April 21, 1990.

Public.Law. 100-4,1987 Water Quality Act; Section 320, 1972 Clean Water Act as Amended; 33 U.S.C. 1330

U.S. Department of the Interior. 1966. Delaware Estuary Comprehensive Study. Preliminary Report and Findings. Federal Water Pollution Control Administration. Philadelphia, Pennsylvania.

U.S. Department of the Interior. 1970. The National Estuarine Pollution Study. U.S. Government Printing Office. Washington D.C.

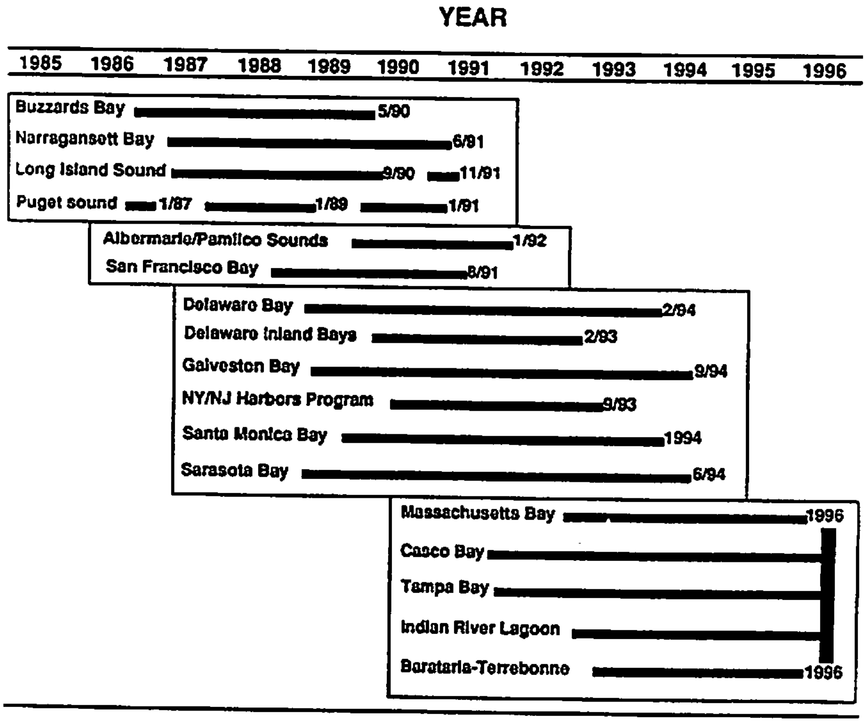

Figure 1

Start-up Dates and and Completion Deadlines for Estuaries accepted Into the National Estuary Program

Special Area Management As A Basic Method for Planning and Guiding the Development of Ecuador's Coastal Resources

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Introduction

International awareness of environment and development issues has expanded greatly since the Stockholm Conference of 1972, which was the first time the nations of the world met to develop a strategy for dealing with global and national environmental concerns. Since the Stockholm conference, the United Nations and a variety of international organizations and donor countries have played an important role in stimulating awareness and national leadership in natural resources management in many developing countries.

Foreign assistance activities in natural resources management during the 1980s included natural resource profiles, scientific studies, preparation of environmental plans, creating impact assessment procedures, management of parks and nature reserves, technical training, and institutional strengthening. Despite these efforts, recent global assessments of the state of the environment indicate that problems continue to worsen world-wide. (World Commission on Environment and Development, 1987).

Groups such as the World Resources Institute (1989) are raising a new call to action that seeks international leadership to help every developing country solve its basic economic problems by adopting sustainable forms of development and vigorously protecting and managing its natural resource base. "Sustainable development" is the key criteria for this decade, and encompasses environmental, economic and institutional dimensions. Natural resources must be managed by developing nations so that they remain productive over the long-term. Development programs and initiatives must be economically viable. Finally, private and public institutions must be in place that can carry out the needed planning, research, decision-making, and implementation activities after foreign assistance has diminished. To put sustainable development programs in place, donor countries such as the United States must help analyze problems, engage in the planning process, become involved in organizing national programs, and support implementation efforts so that results are achieved.

This represents a considerable challenge both to the donor community, which is being asked to carry out projects which are much more activist in nature than past efforts (Brown,1990) and developing countries themselves, who continue to face enormous difficulties in financing and carrying out programs to meet even basic needs over the short-term. The "sustainable development" criteria are even more difficult to apply in the coastal zone, whose environmental systems are dynamic, often poorly understood, usually held in public trust, and utilized by both vast numbers of individuals in a subsistence economy, and powerful, large commercial groups whose interests frequently clash.

How can a poor nation achieve sustainable forms of development in its coastal zone, and how can donor nations succeed in playing a leadership role without undermining recipient nation efforts to devise an approach that it can sustain?

An Approach to Achieving Sustainable Development

Mostafa Kamal Tolba, Executive Director of the United Nations Environment Program, identified six basic elements of what he calls the "concensus approach" to sustainable development (Tolba, 1984):

- *increasing local environmental or natural resources management capacity
- *building upon the experience of the North so that lessons are learned from their mistakes
- *including environmental concerns in development planning
- *gather enough hard data about the environment to make sure plans can be implemented
- *keeping the public informed of the stakes involved
- *concentrating on systems particularly at risk.

These elements must be forged into a specific program of action in each country, in each biogeographic region, and, ultimately, each locality where resources are being used and where resource management needs to take place (Uphoff, 1986).

The Coastal Resources Center at the University of Rhode Island has included all of these components in its ten-year program of assistance to Ecuador's new Coastal Resources Management Program (CRMP). Funding for the development of the Ecuador CRMP has come through a cooperative agreement with the U.S. Agency for International Development's Office of Forestry, Environment and Natural Resources, the USAID Ecuador Mission, the University of Rhode Island (URI) and the Ecudoran government. (USAID, 1987)

This paper examines the specific strategy being used by the Ecuador CRMP to build its capacity to manage the allocation and use of coastal areas and resources by focusing on five critical zones within the nation's 2,860 km coastline.

The Ecuador Coastal Resources Management Program

In January, 1989, President Rodrigo Borja of Ecuador signed Presidential Decree 375, formally establishing the Ecuador Coastal Resources Management Program after three initial years of work through the URI/USAID cooperative agreement. A key element of the program is the preparation and implementation of special area plans for five coastal areas, which include at least one in each coastal province, as well as the Galapagos Islands. Other basic components of the program include issue-oriented interagency working groups focusing on mangroves, water quality, mariculture and coastal development, a ranger corps to improve enforcement of existing laws, and a strong public education program to promote awareness and participation in program activities, led by a non-governmental organization. This paper reports on the approach and experience of preparing the initial plans for the five zonas especiales de manejo, ZEMs, located along the mainland's Pacific coast.

The government of Ecuador selected special area management as a technique rather than province-wide or national planning for several important reasons. First, a series of profiles of issues in the four mainland coastal provinces revealed a commonality of themes but a considerable difference in the relative importance of these issues depending on locality. Secondly, the basic ideas of the new program, such as combining resource development and management efforts, and greatly increasing the level of local involvement in planning and implementation, required careful testing on small sections of the coast before applying them province- or nation-wide. Ecuador had virtually no prior experience with resource management and public participation in the coastal zone. Finally, funds were simply not available for successfully mounting a full program in all four provinces. (Mershrod, 1989; Olsen, 1987)

Selection and Characteristics of the Special Area Management Zones

The environmental profiles of the four coastal provinces prepared in 1987 by the Fundacion Pedro Vicente Maldonado were accompanied by a series of workshops in each province aimed not only at obtaining comments on the draft documents, but at discovering what areas within the province were in most trouble and how people wanted to address the key problems and issues. This led to two important results: a manifesto of support for creating a national coastal resources management program in 1988 signed by more than one hundred community leaders, public officials, and resource users (culminating in Executive Decree 375 of 1989) and the identification of four priority areas which were designated Special Area Management Zones. A fifth special area zone was added by the President.

The locations of the five mainland sites are shown in Figure 1. Most sites face similar issues, including poverty, artisanal fisheries development, mangrove and coastal habitat destruction, water pollution and lack of sanitary facilities, tourism development potential, and improper siting of coastal buildings and roads. The relative importance of each issue varies considerably between zones, and as a result, the policies and actions which will be included in each plan are significantly different (Robadue, 1990).

The shoreline between the towns of Atacames and Muisne in Esmeraldas Province is typical of much of the Ecuadoran coast--a mix of fishing villages and tourist beaches catering to a national market separated by stretches of high bluffs and headlands, with small farms and cattle ranches operating inland. Major issues include protecting remaining mangroves and restoring others, as well as better serving the tourism market while controlling the use of beaches and land development. As in all of the ZEMs, the presence of the coordinator is itself a major step forward, since in this area there had not been any consistent effort to deal with community problems.

The coast between Canoa and Bahia de Caraquez in Manabi Province is interupted by the Rio Chone, a rapidly changing estuary which now contains 5,000 hectares of shrimp ponds and which has lost 4,000 hectares of mangrove forest since the 1970s. Development pressures on the resource base include proposals for large, new resort complexes on the long, wide tourist-quality beaches, continued filling of the estuary, which is also receiving sediment from eroding hills in the watershed, and controversy over the construction of dams which will diminish the flow of freshwater to the estuary.

The ZEM from Manglaralto to San Pedro in Guayas Province was selected, in part, because of the presence of unprotected archaeological resources in the coastal zone centering around the pre-Columbian culture of Valdivia. Problems of economic development dominate this zone, which includes fishing communities, agricultural lands, and vacation homes as well as a major mariculture research facility. Unlike the other ZEMs, much of the coastal land along this stretch of the coast is held in tightly organized communes.

The fourth special area management zone is the long open coast between the towns of Playas and Posorja, and the mangrove estuary which contains the small fishing village of Puerto El Morro, also in Guayas Province. The once quiet town of General Villamil, also known as Playas, is now a destination for tens of thousands of lower income people from the city of Guayaquil who arrive primarily during holiday periods for short stays. The facilities to handle these beach goers are completely inadequate. In addition, artisanal fishermen unload, clean, and sell their catch near the most heavily utilized portion of the beach.

An area of coast between the urban area of Machala-Puerto Bolivar and the tourist portion of Isla Jambeli places this ZEM in the midst of a very large mangrove and shrimp mariculture-dominated estuary which receives the drainage water from the vast agricultural zones of the Province of El Oro.

The urban area here is among the fastest growing in the country and the economic activity of this province is producing serious conflicts over coastal land use and water pollution.

Design of the Special Area Management Project

The primary objective is to prepare a coastal resources management and development plan for each zone within the two-year time frame established in Executive Decree 375. The strategy for developing the plan consists of three basic elements: policy design; participation; and plan implementation.

A policy design process began several months before the Executive Decree took effect and included the establishment of offices and coordinators for each zone, who then prepared a profile of the ZEM communities and the major issues faced in the ZEM. Several technical teams were formed, focusing on environmental sanitation, artisanal fisheries, tourism, ecology, coastal geological processes, and mangroves. These teams were responsibile for preparing an analysis and short- and long-term recommendations for action in each ZEM.

The participation and decision-making process depended on the creation of advisory committees, usually consisting of 20 or more local officials, resource users, educators, and businessmen, and executive committees, comprised of representatives of the most important provincial and national agencies. These were established at the end of 1989. The advisory committee is a temporary organization whose life is only two years, in which time the plan must be completed and submitted to the executive committee, which at present is viewed as a permanent entity. However, an important early role of the ZEM coordinators was to help the technical teams work closely with local resource users such as fishermen, hotel associations, farmers, and community leaders.

Once technical reports became available, the expert (technical) teams were required to meet directly with the advisory committee for the latter group's review, comments, and recommendations on the technical reports. Draft chapters of each plan were prepared on the basis of the advisory committee accepting or modifying the technical reports. The advisory committees in each ZEM will review the draft plans in early 1991 and then submit them to the executive committees, which represent many of the implementing agencies, and then to the National Coastal Resources Management Commission, whose approval will mean that the plans become part of the national development program.

Plan implementation is the final, vital component of the ZEM process. There are at least three critical opportunities for getting ideas generated during the planning process into action. Initially, practical exercises were developed and approved through the advisory committee after the technical teams made their initial action proposals. A total of 40 small projects affecting 25 different coastal communities were implemented during the second half of 1990 at a cost of only $20,000. In addition, communities provided nearly 25% of the cost of the projects in cash, as well as a great deal of labor to implement them. Individual members of the advisory committee became personally responsible for implementing the projects under the supervision of the Fundacion Pedro Vicente Maldonado. Secondly, additional implementation funds will be made available once a ZEM plan is approved by the advisory committee during 1991 to carry out additional activities within the plans at the community level.

Finally, many of the policies and actions included in the ZEM plans will require much greater levels of financial support and changes in the policies of national agencies. Coastal Resources Management Project staff in Ecuador and at the University of Rhode Island are working to identify local, national, and international sources of funds to sustain the implementation effort. The Interamerican Development Bank has shown a strong interest in supporting a number of these projects. Of equal importance will be the role of the National Coastal Resources Management Commission plays in encouraging its member ministries to undertake policy reforms and to use their own budgets to carry out existing mandates with a greater vigor and effectiveness, at least in the ZEMs.

The Importance of Experiments in Special Area Planning to Ecuador's National Coastal Resources Management Program

The Ecuador CRMP is searching for ways to foster sustainable economic development as well as create effective mechanisms for protecting and managing tnhe country's natural resource base. The emerging consensus is that this must take place largely at the local level. The special area planning element of the CRMP gives full expression to local needs and preferences while at the same time addressing some rather complex resource use issues of national significance.

For example, one of the "practical exercises" undertaken in 1990 provided funding to develop a mangrove tour by the local high school in Atacames, Esmeraldas Province, which has a curriculum in tourism. As the project was put into action, it became clear to the ZEM Advisory Committee that, in addition to measures to protect the mangroves in the Atacames River, solid waste and water pollution in the river needed attention to provide a good experience for the tourists. A clean up campaign was designed and organized to eliminate trash disposal in the river and the direct discharge into the river of domestic sewage by hotels and residences. The solutions to the environmental sanitation in the ZEM had already been discussed in technical reports and by the advisory committee. But local action to implement some of these measures has been motivated by the desires of both businessmen and residents to insure that the nature tour planned by the high school would be a success.

Not every water pollution and solid waste disposal problem in the five ZEMs can be addressed in a similar fashion, especially since larger urban areas require upgrading or construction of wastewater treatment systems. Wastewater discharge permits must be issued by national agencies for industrial pollution sources. Not all mangrove areas are located close to tourism areas where nature tours can become a financial incentive for mangrove protection. But, by confronting similar issues in different settings, the ZEM programs are providing a constructive channel for creative thinking about solutions.

The next major challenge for the Ecuador CRMP is to reexamine each of the coastal provinces to determine how the approaches and activities which are proving successful in the ZEMs can be applied to other communities and critical ecosystems. National priorities in key issues are currently being examined through the activities of CRMP-sponsored interagency working groups in mariculture, mangroves, water quality, and coastal development. The design of an Interamerican Development Bank project during 1991 will also provide a valuable opportunity for Ecuador to think carefully about national priorities. If approved, the bank project will provide financing for implementing the five original ZEM plans as well as expanding the number of ZEMs. It may be possible to use the ZEM approach to address a limited number of issues, such as environmental sanitation, in a large number of small communities, and reserve the more complex, integrated planning process for critical environmental areas which are facing large-scale development pressures or resource overexploitation.

Public education is viewed as central to motivating action in specific areas of the coast, and the CRMP is placing a major emphasis, through the Fundacion Maldonado, in building its capacity to support local public education campaigns. This education effort raises not only awareness but public expectations for action. The emphasis placed on local participation by the Ecuador CRMP has also demonstrated that these expectations can be quickly channeled into effective local action, greatly multiplying the human resources available to respond to the growing demand for sustainable forms of economic development in the coastal zone.

References

Brown, J.W. 1990. In the U.S. Interest: Resources, Growth, and Security in the Developing World. Boulder Co.: Westview Press.

Brown, L. 1990. State of the World: 1990. New York: W.W. Norton and Company.

Merschrod, K. 1989. In search of a strategy for coastal zone management in the third world: notes from Ecuador. Coastal Management, Volume 17, Number 1.

Olsen, S. 1987. A collaborative effort in developing the integrated coastal resources management project for Ecuador. Coastal Management. Volume 15, Number 1.

Robadue, D. 1990. Development and conservation planning in Ecuador's coastal zone. Maritimes, Volume 34, Number 1. URI Graduate School of Oceanography, Narragansett, R.I.

Tolba, M.K. 1987. Sustainable Development: Constraints and Opportunities. London: Butterworths.

Uphoff, N. 1986. Local Institutional Development: An Analytical Sourcebook With Cases. Kumarian Press: Hartford, Ct.

World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press. New York, N.Y.

World Resources Institute. 1989. The Crucial Decade: The 1990s and the Global Environmental Challenge. Washington, D.C.

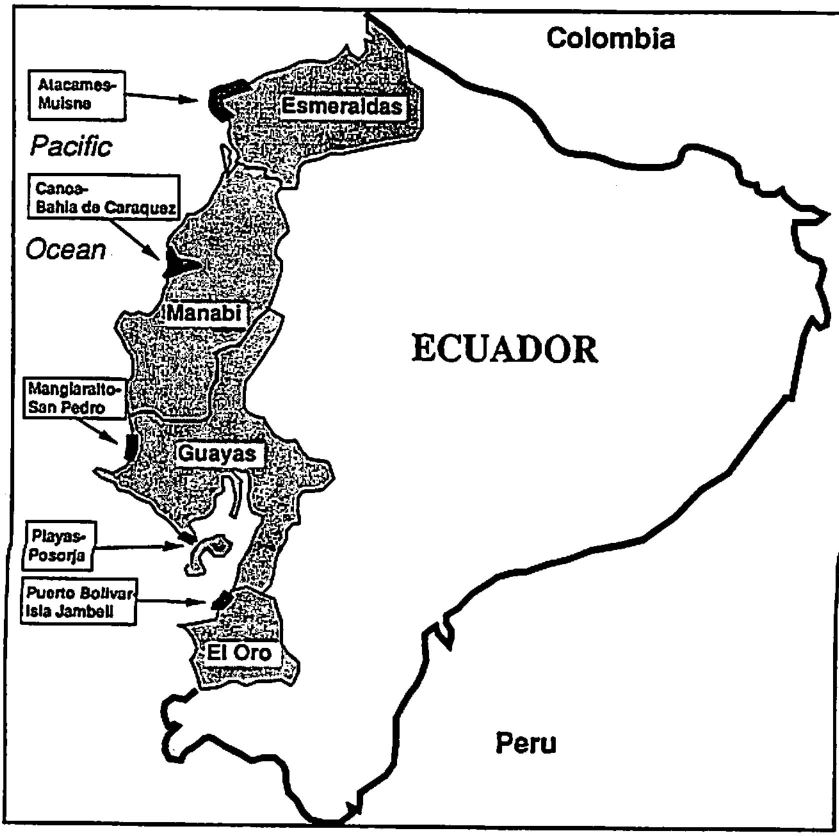

Figure 1

Ecuador's Special Area Management Planning Zones

The Effects of Land Use Restrictions on Housing Prices in Anne Arundel County, Maryland: A Hedonic Analysis

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Introduction

The ever-present tension between expansionary development and preservation of the environment has been steadily increasing in the eastern United States, particularly in the Boston, Massachusetts to Washington, D.C. corridor. As the area has tried to deal with this conflict, there has been a flurry of environmental legislation aimed at reducing point sources of pollution, upgrading combined sewer overflow capacities, and improving waste water treatment. In spite of these and similar actions, non-point sources of pollution have not been addressed as readily, in part because they represent much more nebulous and intangible targets.

This is not to say that efforts have not been made to tackle non-point source pollution; programs have been devised to limit some of the more identifiable non-point sources. Agricultural practices have been modified to reduce erosion, run-off, the excessive use of weed control chemicals, and land use regulations have been established to redirect the degree and type of land use. A prime example of such programs is the Chesapeake Bay Critical Area Program, a program containing land use restrictions explicitly legislated to preserve the ecology and resources of the Chesapeake Bay while reducing point and non-point sources by regulating the density and usage of land.

The fact that little is known about the economic effects of land use restrictions provides the motivation for this paper. Quantification of one aspect of the Chesapeake Bay Critical Area Program's economic effects, provided here, perhaps anticipates a more complete analysis of the impacts of the program. Single-family housing prices are used as the key to quantifying the economic effects of the land use restrictions. This is because the housing prices embody land values and land values, in turn, reflect the characteristics of the land's component parts, including the parts which are regulated. Specifically, this paper discusses the effects of the Critical Area Program's land use restrictions in Maryland's Anne Arundel county, using hedonic regressions to estimate single-family housing prices before (1983) and after (1987) their implementation. With 432 miles of tidal shoreline, approximately 18.3% of the county's entire area came under the Critical Area Program. This translates into 5,133 acres of Intensely Developed Area, 20,929 acres of Limited Development Area, and 22,837 acres of Resource Conservation Area being regulated. The explicit effects of the restrictions on housing prices are determined after controlling for inflation as well as general housing price increases. Although the actual percentage price changes derived here only apply to Anne Arundel County, they serve a much broader purpose by providing a sense of both the magnitude and the locus of the restrictions effects.

The Chesapeake Bay Critical Area Program

The United States Environmental Protection Agency's eight-year characterization of the decline of the Chesapeake Bay, coupled with the social and economic importance of the Chesapeake Bay to Maryland, prompted the Maryland Legislature to set up the Chesapeake Bay Initiative in November, 1983 to protect critical Bay resources and reduce point and non-point source pollution. Within the category of non-point source pollution, the Initiative addresses three broad program areas: management of nontidal wetlands; adoption of agricultural Best Management Practices (BMPs) to control agriculturally introduced nonpoint source pollution; and legislation to protect the natural resources adjacent to the Chesapeake Bay's shoreline.

The legislation protecting the 1000-foot wide strip adjacent to the Chesapeake Bay is known as the Chesapeake Bay Critical Area Program. The main intent of the legislation was to make individuals, particularly developers, more sensitive to the impacts that subdivision, rezoning, variance, or special exception applications have on water quality and natural habitats. More explicitly, the goal of the program was to provide sound environmental planning, better directives for preserving habitat, water quality, resources, and the like, and to accommodate present and future land use development. This was to occur at the same time as the protection of natural resources and irreplaceable physical features.

To achieve the Critical Area Program's goals, eight components of the program were specified, including a land use management component. In April, 1986, the Critical Area Commission, the coordinating group for all local governments within Maryland, provided the local governments with both the criteria and timetable for regulating land use in the Critical Area. Anne Arundel County's then used this information in designing its General Development Plan (GDP) of land use regulations or restrictions, consistent with the Critical Area Program goals to (1) preserve environmentally sensitive areas and open space, (2) preserve and enhance the County's scenic and aesthetic values, (3) promote greater sensitivity to environmental factors through increased coordination and review in the development process, (4) maintain the viability of fish and wildlife habitats, (5) increase public access to the Chesapeake Bay, (6) achieve effective erosion control on construction sites, and (7) improve water quality and promote water resource conservation (Maryland Office of Panning and Zoning, 1988).

The Land Use Management Element of Anne Arundel County's GDP involved first categorizing the types of development in their Critical Area, and then creating policies and regulations for uses of the various types of development in it. The types of development and use in the Critical Area were organized into the three categories of Intensely Developed Areas (IDAs), Limited Development Areas (LDAs), and Resource Conservation Areas (RCAs). Intensely Developed Areas are recognized by not having much in the way of natural habitat and instead having either (1) concentrated industrial, commercial, or institutional use, (2) more than four residential houses per acre, or (3) more than three houses per acre with public sewer and water service. Limited Development Areas have lower density development, contain some degree of natural habitats, and have runoff of unaltered quality. Resource Conservation Areas are dominated by natural environments (open space, surface water, wetlands) and resource using activities such as forestry, fisheries, aquaculture, or agriculture. Development within the Critical Area is required to comply with the regulations corresponding to the particular type of area in question (IDA, LDA, or RCA), so that the goals of the Land Use Management Element can be met.

Land Use Restriction Studies

The effects of land use restrictions (LURSs) on land values are known: with the loss of development potential, undeveloped land values decrease whereas developed land values generally increase. There are, however, four effects exerting both positive and negative pressures on developed land values: (1) scarcity-induced effects (positive); (2) amenity-induced effects (positive); (3) restriction effects (negative); and (4) congestion effects (negative). The coastal land use restrictions do preserve open space and decrease non-point source pollution, thus providing positive amenity effects for individuals in the area, yet the limited amount of housing resulting from the restrictions may introduce a relative scarcity of available single-family housing units. Both the amenity and the scarcity effects will serve to increase single-family housing prices in the Critical Area. On the other hand, the potential for negative impacts on housing prices caused by the restriction and congestion effects introduced by the LURs may mitigate the amenity and scarcity effects. Additionally, if the scarcity effects are strong enough, i.e. if the restrictions really do prevent households from locating in the Critical Area as they otherwise would have, there may be increased demand for alternative, inland housing. The effect of increased inland demand for housing, however, may not cause an increase in housing prices as it did at the coast if it also results in a decrease in amenities such as inland open space.

Hedonic Determination of Property Values

Sherwin Rosen's seminal 1974 article, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition" (Rosen, 1974) provided the theoretical model for understanding hedonic estimation. Rosen described housing as a product, differentiated by the various combinations of its characteristics, whose hedonic prices would reach equilibrium in a competitive market as utility maximizing consumers interacted with cost minimizing providers to reach optimum combinations of characteristics. His connection of implicit prices with econometric results provided a way of revealing the implicit attribute prices from the observed prices and characteristics of products.

Polinsky and Shavell (1976) moved Rosen's model into a purely competitive setting, where consumers had perfect mobility, to show that land values fully reflect the dollar value of their characteristics. Changes in the characteristics prompted the fully informed consumers to readjust their consumption patterns to reflect the new characteristic levels. Subsequently, demand would change for the affected properties, with the result that land prices changed to reflect fully the new bundle of characteristics consumed.

Because many restrictions have been written to prevent deviations from a given level of "quality of life" or available "open space" that a community desires, one category of empirical hedonic studies has looked at how land use restrictions or zoning laws have affected housing prices or land values. Since the preservation of open space or the quality of life is a way of preventing its loss, it can be said that zoning to that effect is a way of preventing the decrease in utility that an area provides vis-a-vis its characteristics or attributes. Thus, relative to other unzoned areas, the utility of that area is increasing. Although studies (Peterson (1974); Courant (1976); Jud (1980)) have been done on the effect of different zoning types (large lot, allowable use, and density zoning), the bulk of the empirical work on the effects of land use restrictions has not concerned itself with this issue. More generally, the use of the hedonic technique to empirically measure the magnitude of utility changes resulting from land use restrictions can loosely fall into one of two categories: (1) cross-sectional studies, those done using various markets, some of which have and some of which do not have land use restrictions; or (2) cross-sectional studies with a "before versus after" aspect, those done analyzing markets, before and after implementation of restrictions. The former type of study utilizes variables to signal whether land is in or out of a zoned area. The latter type of study estimates hedonic price functions for the "before" and "after" situations, allowing comparisons of how the value of the characteristics changed as they embodied the effects of land use restrictions. The majority of the studies done are the second cross-sectional type of study. One can determine how, if at all, prices in regulated areas have deviated from the prices in control areas by using areas which do not implement land use restrictions as controls.

Quantification of Land Use Restrictions' Effects

This study builds on previous empirical work studying the effects of land use restrictions on a coastal area, in the general style of cross-sectional studies with a "before versus after" aspect. Capitalizing on the concept of distinct control areas, the intent of this paper is to detail the magnitude and locus of the affects of the restrictions; hence quantifying the effects of the land use restrictions (LURs) on single-family residential housing prices both at the coast and as one moves inland. To detect the LUR-induced changes, the prices of upland areas (those beyond the reach of the LUR-induced effects) are used as controls. Ideally, there would have been a control area identical to Anne Arundel County in which no land use restrictions had been implemented; however, no such area was found.

Following Polinsky and Shavell (1976) and Freeman (1979), this study begins with the assumption that the Anne Arundel County single-family housing market is a market in which there is equilibrium and full mobility. Because of Anne Arundel County's complex yet, broadly speaking, urban character, it is plausible to consider the entire county as one market. The county is located on the western shore of the Chesapeake Bay, roughly 35 miles east of Washington, D.C. It is also plausible, however, to consider the issue of sub-markets because of the distinctly different areas within the county which do not easily fit into a homogeneous category of "generally urban." This analysis uses 2,272 single-family homes sold in 1983 and 1987 in the county, excluding those homes within the city limits of Annapolis. The city of Annapolis was excluded because its coast did not fall under the same restrictions as the rest of the Critical Area. Table 1 explains the variables used and provides, at the county level excluding Annapolis, their mean values in 1983 and 1987.

Model

The price, Pj, of a residential single-family house can be represented as a function of its, Sj, structural and site characteristics, its, Nk, neighborhood characteristics, and the, Zm, variables of frontage on, view of, and distance from the coast which are intended to pick up the amenity and scarcity effects likely to be altered by LURs:

$$P_i = P(S_{i1},...,S_{ij},N_{i1},...,N_{ik},\dot{Z}_{i1},...,Z_{im}). \quad (1)$$

The implicit price of a characteristic is the contribution of an additional unit of a characteristic--for example, Zm--t the price of house, Pj, *ceteris paribus*, and is the partial derivative of the price function with respect to Zm:

$$\frac{\delta P_i}{\delta Z_{im}} \quad (2)$$

The fact that many structural and site characteristics are not independent and do exhibit diminishing marginal utility made consideration of a linear model somewhat unrealistic, while logarithmic functions at least implied that the implicit prices of some characteristics were both dependent on the levels of the other characteristics and not constant. Additionally, logarithmic functions permitted a model reflecting the hypothesis that, as distance from the coast increased, the effects of the LURs fell off in a nonlinear fashion. Because the semilogarithmic form of the model did poorly statistically, the double log form was chosen. The form of Equation 1 actually considered is:

$$P_i = \exp\left\{\alpha + \underline{\beta X_i} + \eta \text{Frontage}_i + \mu \text{View}_i + \sigma[\ln(\text{Distance}_i)]\right\} \quad (3)$$

where Pj is the price of house i in 1983 dollars, Xj is a vector of its structural, site, and neighborhood characteristics, and is a vector of coefficients on the $\underline{X}$ characteristics. Frontage, View, and Distance are the variables intended to pick up the LUR-induced effects and, respectively, denote whether a house has water frontage, whether a house has a view of the water, and how far the house is located from the water. The η, μ, & σ are the respective coefficients for these LUR variables. Because the hedonic regression was estimated using data from 1983 and 1987 combined, the estimated form of Equation 3 is:

$$P_{hi} = \exp\left\{\alpha_h + \underline{\beta_h X_i} + \eta_h \text{Frontage}_i + \mu_h \text{View}_i + \sigma_h[\ln(\text{Distance}_i)]\right\} \quad (4)$$

where h = 1983 or 1987. Assuming that the implicit prices, for the site, structural, and neighborhood characteristics had not changed in the four year period, i.e., that the real housing price difference between 1983 and 1987 would be attributable to the land use restrictions and would be picked up by the LUR variables of frontage, view and distance, resulted in consideration of a constrained version of the model:

$$P_{hi} = \exp\{\alpha_{83} + \alpha_{87} + \underline{\beta X_i} + \eta_{83}\text{Frontage\_83} + \eta_{87}\text{Frontage\_87} + \mu_{83}\text{View\_83} + \mu_{87}\text{View\_87} + \sigma_{83}\ln(\text{Distance\_83}) + \sigma_{87}\ln(\text{Distance\_87})\} \quad (5)$$

The real price change calculation includes a term that controls for general increases in real housing prices, meaning that the calculated percent price changes are solely due to land use restrictions:

$$P = \left\{\left[\exp\{(\alpha_{87} - \alpha_{83}) + (\eta_{87} - \eta_{83})\text{Frontage} + (\mu_{87} - \mu_{83})\text{View} + (\sigma_{87} - \sigma_{83})\ln(\text{Distance})\} - 1\right] * 100\right\} - \text{Control} \quad (6)$$

Results

Combining the regression results found in Table 2 with Equation 6, the real percent price change of a single-family house solely due to land use restrictions was calculated (Table 3, second column). Subtracting the control increase in housing prices (11.1%) leaves the percent change in housing prices solely due to the land use restrictions presented in the fourth column of Table

3. The fifth and sixth columns of Table 3 show the cash effects of the restriction-associated price change on the average 1983 house's value ($88,670). The fifth column takes the restriction-associated percent change and monetizes it for the value of a mean 1983 house in the distance categories of 0-1, 1-2, 2-3, 3-4, 4-5, 5-6, and 6-7 miles from the coast. It is important to note that the data set consists largely of houses near the shore. There are only 15 houses located 3 or more miles from the coast in the 1983 data set and 26 in the 1987 data set. Thus, the regression really focuses on estimating the price changes for those homes within 3 miles of the coast.

Although View is not particularly sensitive to LURs, Frontage is extremely affected by the LURs. Thirteen percent of the LUR-induced price increase for a single-family house on the water is due to its having frontage. Figure 1 highlights how these effects occur primarily at the coast and drop off as distance from the coast increases, implying that the effects of the land use restrictions are rather limited in their locus and only large right near the Critical Area. This applies especially to those houses having frontage and, thus, within the Critical Area. If one takes into account the more expensive homes near the water (average price for a single-family house located from O to 1 miles from the water was $91,679 in 1983), the increase solely due to LURs was roughly $11,000 without frontage or view, nearly $12,000 with a view, and nearly $23,000 with frontage and a view.

These county-wide restricted regression results do show some impact on housing prices beyond the three mile distance category; however, while the house at distance of zero miles having frontage and view experienced price changes of 27.2% the price change due to LURs was only 5.1% at 6 miles. Thus, acceptance of this county as a single market and the use of the restricted regression leads to the conclusion that the LUR-induced price changes largely impact those houses in and near the Critical Area. Although the issues of correct market hedonic functional form and market definition are not definitively solved, the results do provide an idea of where the effects of the LURs are occurring.

Additional analysis involving four submarkets within the county supported the conclusion that the impact of the restrictions on housing prices drops off as one moves inland. In spite of the data limitations and the need to understand each character of the market, the market segmentation results vividly point out how the impact of the land use restrictions on housing prices is really limited to a fairly narrow band along the coastline. The impacts do not seem to move inland.

Implications of Results

This study has provided specific quantification of how land use restrictions in Anne Arundel County, Maryland affect housing prices not only at the coast and inland, but rather at the coast and as one moves inland. Accepting the assumption that the site, structural, and neighborhood characteristics' implicit prices did not change significantly over the four-year period, the results show that the land use restrictions implemented as a result of the Critical Area Program have an impact largely at the coast and that this impact rapidly decreases with distance from the coast. The potential for both amenity and scarcity effects (to increase housing prices) exists; however, the lack of large price changes inland implies that the scarcity effects are either mitigated by increased inland levels of disamenities or are themselves not overwhelming. If the inland aspect of the scarcity effects was mitigated by decreased inland amenities, such as increased crowding, one would anticipate a larger contribution at the coast. Because the LUR-induced price change dropped off rather rapidly (presumably, in part, due to amenity improvements), it does not seem likely that there was a large scarcity component to the price changes. If this assumption of unchanging implicit prices is not accepted, a similar tale still unfolds: the majority of the impact of the LURs occurs at the coast. There prices jumped roughly 14% more for houses with frontage and a view than for houses without these in-the-Critical Area indicators; without frontage or view the price increases varied by less than 2% as one moves inland for 7 miles.

These results are only as strong as the validity of the assumptions used when generating them. One must keep in mind, therefore, that it was assumed that the individuals are fully free and able to move from one location to another. It may be that the movement of the population towards the coast will result in the assumption of full mobility being invalid for studies done in the not-so-distant future. Additionally, it was assumed that the portion of Anne Arundel County affected by the land use restrictions is relatively small, that the bundles of characteristics contributing to the value of a house are completely and easily interchangeable, and that individuals' preferences did not change over the four years.

If regulations aimed at protecting coastal open space and pollution are implemented in a community, it is useful to have information such as provided by this study regarding the efficiency of the policies of choice. Knowledge about the impacts of policy choices can provide decision-makers with insights into the results of their decisions. These results can be used to identify who gains and who loses after the implementation of land use restrictions. Because the results of this study are presented on a house-by-house basis, they can be used for comparison with either other studies done at the individual home level, or, by summing the results for the population in question, at the county level.

The importance of empirical studies such as this rests not only on the study's technical correctness, but also on the degree of its applicability and comparability to other works. Hopefully, by more explicitly defining the locus and magnitude of the amenity- and scarcity-induced changes in housing prices due to the Critical Area Program Land Use Restrictions implemented in one county, policy makers in other areas will be more able to make their decisions.

References

Anne Arundel County, Maryland Office of Planning and Zoning. 1988. Critical Area Proaram: Anne Arundel Countv.

Bajic, Vladimir. 1985. Housing-Market Segmentation and Demand for Housing Attributes: Some Empirical Findings. AREUEA Journal 10(1):58-75.

Beaton, W. Patrick. 1988. The Cost of Government Requlations Volume in: A Baseline study for the Chesapeake Bay Critical Area. Center for Urban Policy Research, Rutgers University, N.J.

Brookshire, David S., Mark A. Thayer, William D. Schulze, and Ralph C. d'Arge. 1982. Valuing Public Goods: A Comparison of Survey and Hedonic Approaches. The American Economic Review 72(1):165-177.

Courant, Paul N. 1976. On the Effect of Fiscal Zoning on Land and Housing Values. Journal of Urban Economics 3:88-94.

Frech, H.E. 111 and Ronald N. Lafferty. 1984. The Effect of the California Coastal Commission on Housing Prices. Journal of Urban Economics 16:105-123.

Freeman, A. Myrick, 111. 1979. A Hedonic Price Approach to Measuring Demand for Neighborhood Characteristics, in David Segal, ed., The Economics of the Neiqhborhood. New York: Academic Press, Inc. pp. 191-21 7.

Jud, G. Donald. 1980. The Effects of Zoning on Single-Family Residential Property Values: Charlotte, North Carolina. Land Economics 56(2):142-154.

Katz, Lawrence and Kenneth T. Rosen. 1987. The Interjurisdictional Effects of Growth Controls on Housing Prices. Journal of Law and Economics 30:149-160.

Kneisel, Robert. 1979. The Impact of the California Coastal Zone Conservation Commission on the Local Housing Market: A Study of the South Coast Regional Commission. Ph.D. dissertation, University of California, Riverside.

Peterson, George. 1974. The Influence of Zoning Regulations on Land and Housing Prices. Prepared for: The Urban Institute, Washington, D.C. 20037.

Polinsky, A. Mitchell and Steven Shavell. 1976. Amenities and Property Values in a Model of an Urban Area. Journal of public Economics 5:119-126.

Rosen, Sherwin. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. Journal of Political Economy 82:34-55.

Schwartz, Seymour 1., David E. Hansen and Richard Green. 1981. Suburban Growth Controls and the Price of New Housing. Journal of Environmental Economics and Management 8:303-320.

Zorn, Peter M., David E. Hansen, and Seymour 1. Schwartz. 1986. Mitigating the Price Effects of Growth Control: A Case Study of Davis, California. Land Economics 62(1):46-57.

Figure 1 Effects of Land Use Restrictions on Single Family Housing Prices in Anne Arundel County, Md.

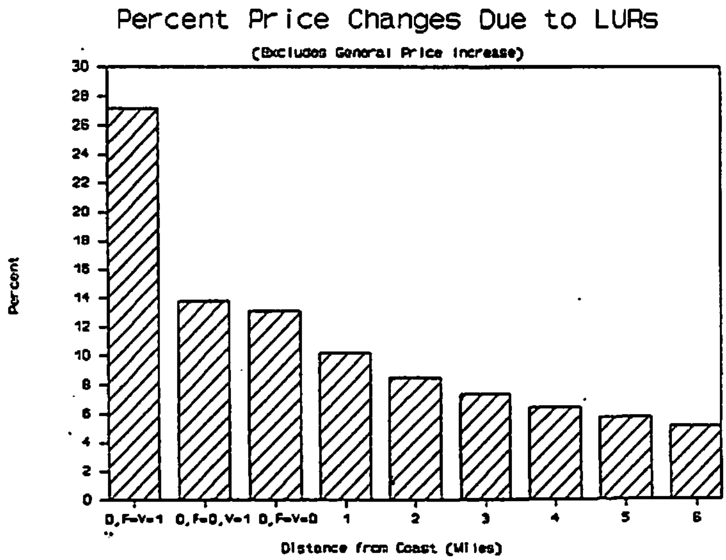

Table 1 Regression Variables and Mean Values: County-wide, excluding Annapolis

Variable	Description	1983	1987
PRICE	Market price of a house	88,670	124,886
BD	Number of bedrooms	3.26	3.21
BATH	Number of bathrooms	1.74	1.28
DINED	Dummy variable (1=formal dining room)	0.39	0.53
BASED	Dummy variable (1=full basement)	0.37	0.35
AGE	Age of house (years)	15.51	15.57
GARAGE	Dummy variable (1=garage or carport)	0.40	0.38
AIRCON	Dummy variable (1 = central air)	0.59	0.60
FRPL	Dummy variable (1 = fireplace)	0.51	0.45
SF	Interior area of house (ft^2)	1662	1717
LOTSIZ	Area of lot (ft^2)	21,526	19,145
MONTH	Month house was sold (1=January, 12=December)	6.5	6.6
DIST83, DIST87	Linear distance to the nearest point on the Bay or tributary	0.68	0.68
DISTCBD	Distance (miles) to closest central business district (Glen Burnie or Annapolis)	4.97	5.23
FRONT83 FRONT87	Dummy variable (1=water frontage)	0.08	0.07
VIEW83, VIEW87	Dummy variable (1 = water view)	0.12	0.13
EDUCTN	Percentage of blockgroup over 18 yrs or ≥ 4 yrs high school	48.8	47.9
PCTNWN	Percent of blockgroup classified as non-white	6.5	6.6
HHINC	Median household income of blockgroup	26,358	26,870

Table 2 County-wide Constrained Regression Results

Variable	Coefficient	T-statistic
INTERCEPT_83	3.32204	15.28
INTERCEPT_87	3.53854	16.21
Ln(BD)	0.08147	3.84
Ln(BATH)	0.01891	3.49
DINED	0.02813	3.14
BASED	0.00667	0.74
Ln(AGE)	-0.07398	-17.92
GARAGE	0.09292	9.28
AIRCON	-0.00152	-0.15
FRPL	0.05036	5.16
Ln(SF)	0.42205	24.39
Ln(LOTSIZ)	0.13888	24.97
Ln(SETMON)	0.03555	5.62
Ln(DIST_83)	-0.00654	-0.36
Ln(DIST_87)	-0.04043	-2.22
Ln(DISTCBD)	-0.02957	-4.43
FRONT_83	0.40268	16.86
FRONT_87	0.50437	17.24
VIEW_83	0.05982	2.96
VIEW_87	0.06573	2.86
Ln(EDUCTN)	-0.00668	-1.60
Ln(PCTNWN)	0.01026	2.45
Ln(HHINC)	0.34573	15.92
F-statistic	336,279.2	
Observations	2,272	

Table 3 Breakdown of Real Housing Price Changes[1]

Miles from Coast (Dist)	Total Real Change (%)	Level Change (%)	Price Change due to LUR (%)	Effect on Avg 1983 House	Effect on Avg Mileage Group
------	------	------	27.2	24,100	-------
0,F=V=1	38.3	11.1	13.8	12,244	23,077
0, F=0,	24.9	11.1			11,725
V=1			13.1	11,592	
0,F=V=0	24.2	11.1	10.2	9,036	11,099
1	21.3	11.1	8.5	7,568	7,749
2	19.6	11.1	7.4	6,539	6,093
3	18.5	11.1	6.5	5,747	8,463
4	17.6	11.1	5.8	5,105	8,336
5	16.9	11.1	5.1	4,565	(no obs)
6	16.2	11.1			5,092

[1] F and V are the frontage and view dummy variables, respectively; when the dummy variable equals 1, the condition (of having frontage and/or view) exists.

The Gulf of Maine Program: an Ecosystem Approach to Ocean and Coastal Management

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Overview

The bane of life for most natural resource managers is the need to combat a constant series of "brushfires" rather than to give thought to the larger question of the future health of a particular resource. Certainly, this has been the case in the management of coastal resources. The steady demands of localized problems, coupled with permit review duties, distract coastal resource managers from consideration of the long-term demands and problems that will face their marine water body. Only after the repeated closing of hundreds of acres of shellfish beds and popular swimming beaches, or in the aftermath of a catastrophic environmental accident, can coastal managers focus on the sustainable health of the coastal environment. In the United States, it is usually at that point that the federal government steps in with remediation programs, such as EPA's National Estuary Program, to "fix" the degradation that is so evident.

The Gulf of Maine Program differs markedly from this pattern. The two provinces and three states that border on the Gulf (Nova Scotia, New Brunswick, Maine, New Hampshire, and Massachusetts) have made a bold attempt to forestall declines in the health and productivity of the Gulf of Maine. Through cooperative efforts, a regional marine environmental quality monitoring program and a ten-year Gulf of Maine Action Plan are being developed to help guide the actions of the five jurisdictions over the next decade. Through these and other efforts, it is hoped that the states and provinces themselves can sustain the Gulf of Maine, upon which their economies and quality of life depend.

The Gulf of Maine

The Gulf of Maine is one of the world's most productive water bodies. Its marine resources supported Native American and European settlers for centuries. The bathymetry of the Gulf makes it a semi-enclosed sea, almost entirely separated from the Atlantic Ocean by underwater banks. The only major avenue through which deep ocean waters enter the Gulf is the 761-foot deep Northeast Channel. The Gulf's reputation as a rich fishing ground stems from a high primary productivity that results from the vigorous vertical mixing of surface and bottom waters in various sections of the Gulf. Vertical mixing also occurs in coastal estuaries and in certain offshore areas, such as off the southwestern coast of Nova Scotia. The more than 250 billion gallons of freshwater from the region's rivers that enter the Gulf each year bring nutrients and, of course, a spectrum of land-based pollutants to the Gulf.

The Gulf of Maine supports nearly 20,000 state and provincial fishermen, and an almost equal number of people within the fish processing and shipping sector. Many more work building or repairing vessels or selling fuel and supplies. Within some Nova Scotian communities, approximately 75% of the population relies on commercial fishing for a living.

The Gulf of Maine coast is extremely popular as a region in which to live or to vacation. The figures in Table 1 show that population growth during the last two decades has been steady, and in some counties, explosive. This growth and its consequent by-products, combined with the overutilization of the Gulf's numerous living resources, has produced distinct signs of change within the Gulf ecosystem.

Stresses on the Gulf

The extent of wetlands within the region has been greatly diminished during the more than 400 years of settlement. In the Canadian Maritime Provinces, approximately 65% of the tidal marshes and flats have been lost or altered since the arrival of European settlers. Much of the acreage was drained for agricultural use by Acadian farmers during the 17th-Century. Currently, 49,000 (20,000 hectares) of wetlands are estimated to remain in Nova Scotia, New Brunswick and Prince Edward Island. Enormous acreages of wetlands have also been lost in the three states due to dredging and filling operations, aimed at harbor development or, more recently, commercial and residential projects.

Increasing population and related changes in land use have had far-reaching implications for the Gulf's environmental quality. From 1950 to 1980, huge swaths of agricultural and forested lands disappeared throughout the coastal region. In Rockport, Maine, for example, developed land within town borders increased by 300% while on Cape Cod, Barnstable County saw a 255% increase in developed lands within the county. As Table 2 indicates, population growth in the United States section of the region will continue to be steady. The constant increase in year-round population, coupled with the current ten million visitors to the region each summer (in 1988, over 4.5 million people visited Acadia National Park alone), suggests inevitable impacts upon the Gulf's environmental quality.

Pollution

Non-point source pollution has become a cause for concern in both the provinces and the states. Runoff from malfunctioning septic systems or sewer system overflow has lead to closure of thousand of acres of shellfish flats. Agricultural runoff may also be introducing harmful chemicals to the rivers that enter the Gulf.

Highway runoff from roads contains a plethora of pollutants. Coastal roads, such as heavily travelled Route 1 in New England, contribute large volumes of runoff containing petroleum hydrocarbons and various heavy metals to the Gulf. A National Marine Fisheries Service study of Boothbay Harbor in 1982 revealed lead levels in crabs as high as those found in organisms from New York City and Philadelphia. Research into historic activities within the town showed that no industrial activities had taken place that could account for the lead. Nor was the effluent from the municipal sewage treatment plant the culprit. The conclusion was that automobile exhausts and oil drippings, from the 5000 cars per day that pass through Boothbay Harbor during the summer, might account for the lead levels. In addition, paint chips and sandblasting waste from local boatyards may have contributed to the lead load.

Point source discharges are also a growing pollution problem. Industrial discharges from many of the paper, pulp, and fish processing plants in the two provinces ultimately empty into the Gulf. In the states, tanneries, textile mills, metal fabrication and finishing operations, and myriad other manufacturing enterprises legally discharge a variety of toxics. The cumulative effects of this mix of chemicals upon the marine environment has not yet been assessed. Sewage treatment in large metropolitan areas presents another source of pollution. Many of the cities in the two provinces have sewage collection systems that provide little or no treatment. Sewage may be treated with chlorine, a chemical with potential toxic effects on marine organisms.

The Gulf of Maine Program

Recognition of the growing stresses upon the Gulf of Maine and concern for the Gulf's future prompted the creation of the Gulf of Maine Program by the two provinces and three states. The five jurisdictions recognized that, although their individual management plans for Gulf resources differed, they would share mutual benefits from the sustained health and long-term productivity of the Gulf. Consequently, the Gulf of Maine Working Group was formed in June, 1988.

Composed of agency representatives with non-voting federal agency observers, the Working Group spent six months in informal discussions to identify and agree upon the major issues facing the Gulf of Maine. They decided to undertake three immediate tasks to provide a common base of knowledge about the status of the Gulf: produce a nontechnical report on the environmental character and stresses of the Gulf; develop a long-term regional marine environmental quality monitoring program; and convene an international conference to explore joint issues and to devise specific goals for future action by the states and provinces. The three states successfully applied to the U.S. National Oceanic and Atmospheric Agency for funding to complete these tasks. Additional personnel support was provided by the state and provincial agencies represented in the Working Group.

In late 1989, the Working Group published **The Gulf of Maine: Sustaining Our Common Heritage**, a nontechnical report summarizing the health of the Gulf environment. In December of that year, a group of Canadian and United States firms were hired to design a regional marine environmental quality monitoring program for the Gulf. Also during that month, the Working Group hosted an international conference on the Gulf of Maine, attended by over 250 scientists, fishermen, bureaucrats, academicians and citizens attended. At the close of the conference, the **Agreement on the Conservation of the Marine Environment of the Gulf of Maine** (Agreement) was signed by the Governors and Premiers of the states and provinces.

The Agreement makes clear the intent of the states and provinces with regard to future use of the Gulf: "..the Parties to this agreement recognize a shared duty to protect and conserve the renewable and non-renewable resources of the Gulf for the use, benefit and enjoyment of all their citizens, including generations yet to come.." With this language, the Governors and Premiers echoed the call for use of the principle of sustainable development to guide development of the world's natural resources, as stated in the United Nations Brundtland Report (UN, 1987). The findings of the Agreement also revealed an acknowledgement that the Gulf in its present state is, for the most part, healthy. It is the future use of the Gulf and its surrounding lands without consolidated and cooperative protection efforts by the state and provinces that will result in harm to the ecosystem and consequent economic loss to surrounding communities. It is this preventative rather than remedial approach that distinguishes the Gulf of Maine Program from other coastal water body management programs in the United States and Canada.

The Council on the Marine Environment (Council), established as a result of the Agreement, is composed of two representatives from each state and province, appointed by the Governors and Premiers. The Council is responsible for developing the marine environmental monitoring program and for creating a Gulf of Maine Action Plan by June, 1991. In June, 1990, it held its first meeting in Halifax, where operating bylaws, budgetary items, and establishment of a Secretariat office were agreed upon.

The developing Gulf Action Plan grows from the professional papers presented at the Gulf Conference in 1989 and from identified critical issues which were consensually established at that time. The geographic scope of the region and the contrasting regulatory and management programs of the states and the provinces make creation of this regional plan a complex undertaking. However, by using the issues that all can agree upon (such as growing population and the cumulative environmental impacts of pollution inputs) as a foundation, the Action Plan will build a sound blueprint of the priorities for public and private action during the next decade.

The Action Plan is divided into five major issue sections: Coastal and Marine Pollution; Monitoring and Research; Wildlife, Fish and Habitat Protection; Protection of Public Health; and Public Education and Participation. Within each section are stated objectives and particular actions that will be taken to achieve the goals. Determining specific costs and appropriate timelines for the actions will be undertaken in cooperation with specific lead agencies in the states and provinces.

The goals and objectives of the Marine Environmental Quality Monitoring Program are included within the Action Plan. The Monitoring Program focuses on identifying risks to ecosystem and to human health and on the critical need to provide consistent and timely data to environmental managers within the region. Well-coordinated efforts through the Monitoring Program will be crucial to its future success; therefore, to test the Program, a pilot "Mussel Watch" project will be initiated in 1991. A joint US-Canadian subcommittee will oversee implementation of the pilot project.

The volatile nature of such international issues as Canadian and United States fisheries management and enforcement procedures has generated a great deal of public attention. Nonetheless, the international Council on the Marine Environment is likely to be the best avenue for long-term cooperation among the states and provinces on a spectrum of marine environmental issues. Development of the Action Plan and initiation of a regional Monitoring Program are just two of the examples of the Council's initiatives within the Gulf of Maine Program. Efforts to develop a regional consciousness around the Gulf find expression in a variety of public educational materials, collaborative data management projects, and fruitful professional workshops. Clearly the strength of the Gulf Program comes from the fact that it reflects the indigenous concerns of the states and provinces. Historically, the Gulf of Maine has served as the physical and economic link between the three states and two provinces. In practice, this geo-political link has proved to be a strong and productive one, as the Gulf of Maine Working Group has shown. Although it is too early to predict the outcome of the Gulf Program, the congenial relations among the Working Group, the Gulf Council, and the governors and premiers holds great promise for improved stewardship of this fertile, but fragile, marine water body.

TABLE 1. POPULATION FIGURES BY COUNTY, GULF OF MAINE PERIMETER

County	1971	1981	71-81 %change	1986	81-86 %change
Nova Scotia					
Yarmth	24,682	26,290	6.5	27,073	3.0
Digby	20,349	21,689	6.5	21,852	0.8
Annpls	21,841	22,522	3.1	23,589	4.7
Kings	44,975	49,739	10.5	53,275	7.1
Hants	28,935	33,121	14.4	36,548	10.3
Colchst	37,735	43,224	14.5	45,093	4.3
Cmbland	35,160	35,231	0.2	34,819	-1.2
N. Brunswick					
Albert	16,307	23,632	44.9	24,832	5.1
St.John	92,162	86,161	-6.5	82,460	-4.3
Chrlotte	24,551	26,571	8.2	26,525	-0.2

County	1970	1980	70-80 %change	1988 est.	80-88 %change
Maine					
Cumb.	192,528	215,789	12.0	235,500	9.1
Hanc.	34,590	41,781	32.4	45,800	9.6
Linc.	20,537	25,691	25.0	29,500	14.9
Sagah.	23,452	28,795	22.7	33,100	14.8
Waldo	23,328	28,414	21.8	31,300	10.2
Wash.	29,859	34.963	17.0	34,900	-0.3
York	111,576	139,739	25.2	166,000	18.8
N. Hampshire					
Rock.	138,951	190,345	36.9	235,700	23.8
Straf.	70,431	85,408	21.2	98,700	15.6
Massachusetts					
Barnst.	96,656	147,925	53.0	178,800	20.8
Essex	637,887	633,688	0.6	654,200	3.2
Norfolk	604,854	606,587	0.2	610,200	0.6
Plymth	333,314	405,437	21.6	430,900	6.3
Suffolk	735,190	650,142	-11.5	666,700	2.6

Sources: US Dept. of Commerce, Bureau of the Census, Northeast 1988 Population estimates for Counties and Incorporated Places, March, 1990; Colgan, Charles, "Economic Growth Trends on the Gulf of Maine Littoral," 1989; Statistics Canada, Census Office, Population and Dwelling Counts, 1971 and 1986

TABLE 2. ESTIMATED POPULATION & DENSITY, COASTAL COUNTIES OF MAINE, NEW HAMPSHIRE AND MASSACHUSETTS

	1970	1980	1990 est.	2000 est.
Maine	686,000	795,000	879,000	953,000
	(57)	(66)	(72)	(79)
			density/squ.mile	
NH	209,000	276,000	353,000	414,000
	(196)	(258)	(331)	(388)
			density/squ.mile	
Mass.	4,260,000	4,299,000	4,496,000	4,784,000
	(1205)	(1216)	(1272)	(1353)
			density/squ.mile	

Source: NOAA, 50 Years of Population Change along the Nation's Coasts, 1989.

An Environmental Policy for the Future

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On 29 August 1989, the National Marine Fisheries Service's Northeast Region approved an "Environmental Policy" that promises to revamp habitat programs from Maine through Virginia. This paper summarizes the policy and its intentions, provides examples of new initiatives, and forecasts the inevitable challenges.

The Policy

This policy was developed out of frustration. With habitat losses mounting, many fish stocks dwindling, and applied habitat research budgets directed to other priorities, NMFS decided to test a different approach to habitat conservation. The policy statement captures that intent:

> "To minimize adverse impacts of human activities on estuarine and marine habitats by using the fishery management process and interagency arrangements; to use the best scientific information available to evaluate environmental threats and provide technical advice and recommendations to decision makers."

Essentially, the NMFS Northeast Region has embarked on a grand experiment to fulfill its trustee mandates. The new approach has generated heightened enthusiasm.

In resource management and environmental decisions, the Region is shifting greater (though not exclusive) emphasis to its fishery management mandates rather than the traditional advisory roles afforded through permit review and comment. For example, if NMFS reviewers collaborate with state and federal fishery management bodies that have been granted special consideration in environmental decision-making [via Magnuson Fishery Conservation and Management Act amendments of 1986; 16 U.S.C. Section 1852(i)], our habitat concerns will automatically receive greater consideration than historical advice. In research, the policy confirms an agency commitment to focus additional resources on those species and habitats most affected by human activities. That shift will include directed environmental research programs, a larger role in coastal waters, and regular collaboration with resource managers to meet evolving needs. In combination, NMFS hopes that new information and a new approach will generate more convincing arguments in favor of habitat conservation. NMFS realizes that successful implementation of the new policy depends greatly on its colleagues in research, management, and decision-making. Although this policy directly affects only one regional office of NMFS, its success hinges on broad inter-agency cooperation. NMFS cannot, in good conscience, reduce its technical advisory role without knowledge that its partners will assume the burden. Similarly, we cannot hope to succeed without commitments from regulatory agencies that they will accept our new role and new products.

Policy implementation rests with the recently-formed Environmental Council, a four-member executive board that recommends specific actions to the Regional Director. Because most habitat threats and information needs are shared with other trustees, one Environmental Council mandate is to cooperate early and regularly with state and federal agencies, industry, academia, and special interest groups. That coordination will prove vital as the Northeast Region develops scientific positions and management information to meet the needs of decision makers.

Early Initiatives

After one year, the Environmental Council has finished background planning documents on nine potential areas of primary interest:

1) consider NMFS Northeast Region's role in special estuarine or coastal research and management programs;

2) revise habitat sections in fishery management plans;

3) assess the need for directed research on biotoxins;

4) quantify the extent and implications of resource losses due to habitat degradation;

5) improve cooperation with other NOAA offices, especially those involved in prediction, modeling, and trends analyses;

6) conduct habitat-related research related to fishery management mandates;

7) integrate NMFS programs into EPA's Environmental Monitoring and Assessment Program (EMAP);

8) develop a new bio-environmental research team to meet the needs of habitat managers; and

9) construct a computer directory of state and federal environmental programs in the Northeast.

Based on further discussions, it appears that the Northeast Region of NMFS will concentrate its efforts on #4, with secondary efforts in other initiatives that can be handled quickly or within existing staff capabilities, e.g., #1 and #2.

While we are testing a new way of influencing environmental decision-making and habitat conservation, this policy and these nine initiatives fit comfortably into the NMFS Habitat Conservation Policy (48 Federal Register 228:53142-53147; 25 November 1983). The intent is also a natural extension of the harvest allocation role performed by regional fishery management councils established under the Magnuson Fishery Conservation and Management Act and interstate councils operating within the Atlantic States Marine Fisheries Commission. Indeed, the Mid-Atlantic Fishery Management Council has already used its authorities under the 1986 Magnuson Act amendments and the intent of the NMFS/Northeast Region policy to challenge individual waterway permit decisions and national wetland policies.

On key initiatives, the Environmental Council will consider holding special workshops to gather best-available information, develop consensus, prioritize research needs, coordinate programs, etc. The first workshop will likely be in early 1991, with one or two to follow each year held throughout the Northeast.

Challenges on the Horizon

Our enthusiastic hopes for administrative and environmental success are tempered by many obstacles and challenges. Our greatest fear is that well-established protocols, both within NOAA/NMFS and in inter-agency circles, will not adapt to this new role. Without the support and trust of all participants, it is doubtful that the Environmental Policy and its hopes to utilize fishery management to improve habitat management will succeed.

Before NMFS can hope for inter-agency support, we must integrate our own research and management programs. In those nearshore areas where habitat threats are greatest, NMFS has largely leftresearch to states or other federal agencies. Not unexpectedly, those other entities do not always meet NMFS habitat management needs. During implementation, it is imperative that NMFS research programs coordinate closely to ensure that management programs and decision-makers are thoroughly supported. For their part, managers must clearly convey their needs and work with scientists on planning and implementation.

Similar challenges await the policy in the arena of inter-agency relationships. Environmental Council activities and workshops will generate reports intended to sway decision-makers. The U.S. Corps of Engineers, which normally receives permit-specific advice, must accept more generic Environmental Council reports and apply them with equal consideration to its public interest reviews. Decision-makers must also recognize the important role of fishery management councils in environmental decisions, including the long-term benefits of living marine resources and viable commercial and recreational fishing industries. Without that cooperation, this experiment could collapse swiftly. Still, the prospects of filling the long-recognized information needs of environmental managers is an invigorating prospect.

If this experiment succeeds in the Northeast Region, perhaps other NMFS regions and other agencies would consider similar efforts elsewhere. The entire sphere of environmental decision-making would improve greatly if agencies moved beyond general (and often redundant) advice into a customized approach crafted for each agency, its mandates, and its staff.

The Fourth Migration: A Scenario for Coastal Planning in the 21st Century Northeastern U.S.?

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Introduction

An elusive, but oft-quoted, demographic projection is that by the end of the present Century over 80% of the Nation's population will live within 50 miles of the coast. While this forecast has been used to project environmental degradation and excesses resulting from coastal development, e.g. Houck (1988), others, e.g. Culliton et al. (1990), Edwards (1989), West (1987), and Spangler (1972), have convincingly shown that since about 1940 the Nation's coastal population has remained relatively constant at a level of about 60% or less of the total United States population. While the threatened expansion of the coastal population has not occurred, both the absolute numbers of people living in the coastal area has increased and the nature of their utilization of coastal lands has profoundly changed. The scenario presented here, for the Northeastern states, is speculation built upon sound demography and unashamedly based upon thoughts of the visionary planner Louis Mumford in a 1925 paper entitled, "The Fourth Migration."

The Fourth Migration

Over half a century ago, Louis Mumford (1925) wrote of a "fourth migration" to come. He had defined the first migration as that of "the land pioneer"--those who cleared the land and led the way west of the Alleghenies. His second migration was that of "the industrial pioneer"--those hardy souls who created the network of "blighted industrial towns" which characterized the 19th-Century. The third migration was the flow of people and materials into the financial centers of the country "...where buildings and profits leap upward in riotous pyramids." This migration was a product of the evolution of the industrial system from one of "productive effort" to a phase of "financial direction" in the period of the late 19th- and early 20th-Centuries. Mumford characterized these migrations in terms of goals: the first sought land; the second, industrial production; and the third, financial direction and culture. These, he posited, would be followed by a fourth migration, one which would give to the whole continent a stable, well-balanced, and settled cultivated life. Made possible by technological developments in transportation, such as automobility, and in communications, such as electronics, the Fourth Migration would produce a more environmentally satisfactory setting for the Nation's people.

For most of the Nation's history, the proportion of its population on the coast has been decreasing. At first, its population was entirely coastal for

European colonizers settled there, seldom penetrating far into the wilderness. As westward migration commenced, the coastal population as a proportion of the total national count began to decrease. The Nation's earliest cities were its seaports which were organized around overseas trade of agricultural products, the dominant sector of the developing economy. Communities formed to support agriculture and became nodes on the developing national transportation system. Advancing transportation technology allowed for ever greater diffusion of population, causing smaller communities to decline in the face of growing employment opportunities in more urban areas. This movement of people from the rural agricultural economy to the cities and the manufacturing economy was the Second Migration and established a demographic pattern which was to continue through the late 18th- and 19th-Centuries (Long, 1981). Through these social, economic, and technologic operatives, the urban pattern of the United States was established as early as the late 1800's. Because the evolving national transportation system tended to follow precedent technologies, linking existing nodes of population, population concentrations continued to be greatest around the seaports of Baltimore, Boston, Buffalo, Chicago, New York, Philadelphia, San Francisco, and Seattle. Their dominance in size was heightened by the waves of immigration to the U.S. between 1880 and 1930.

The twentieth century has been characterized by the movement of population from the central city to adjacent areas. Technologies of rail transport (trolley and railroad) initiated the process of suburbanization, but the advent of the automobile put it into full flower. But, it was not until after World War II that the great suburban boom was in full stride with important impacts upon tidal wetlands and other coastal resources. The large scale movement of population from rural areas to the cities and the decentralization of the core city to the suburbs has been the dominant factor in American demography for most of the 20th-century. Metropolitan populations were increasing faster than that of the nation as a whole as rural-to-city migration continued. But, at the same time, the national population center was shifting towards the west and city centers were losing population to their rapidly growing suburbs.

Manufacturing was decreasing as a major employer in many cities, but a new component of the economy was rapidly growing--the financial and information service sector. Made possible by the revolutionary transformation of communications, centers of financial management and their supporting enterprises began to arise. Because the seaports had, in their earliest forms, required a strong financial and communications infrastructure, they were well poised to become, if they were not already, the nation's financial/information service centers. These changes set the stage for the commencement of the Fourth Migration.

It was, therefore, with great excitement that demographers noted a "turnaround" when, in about the mid-1960's, established patterns were broken. The South's traditional outmigration ceased and certain non-metropolitan areas began, after decades of decline, to show population increase; the rural-to-urban flow was replaced by an urban-to-nonmetropolitan tide. Between 1970 and 1980 about 33% of the U.S. counties were showing turnarounds in pattern of population movement. Long (1981) notes that this is an exceptionally large change for what had become a very stable pattern of population movement.

Because the shift to an urban-to-nonmetropolitan movement countered many generally accepted notions of U.S. population distribution, the new trend became the subject of considerable speculation. Increasing numbers of retirements, shifts in the energy industries, and various short-term economic scenarios were all put forward as explanations for the new pattern of growth. As Kasarda (1980) has suggested, however, many of the trends in deconcentration can be attributed to technological innovations in communications and transportation. Accepting this view, one could identify the 1965 "turnaround"--the commencement of a pattern of deconcentration of U.S. population--as the beginning of the Fourth Migration. Indeed, Long (1981) postulated that "Spatial distribution patterns can be viewed as resulting from the need at any given level of a nation's social and economic development to obtain a required level of productive social interaction while reducing the amount of counterproductive social interaction." Hawley (1972) identified the danger of crowding and congestion that occur with high levels of social interaction, but audio and visual communications, computer networks, satellite communications and other electronic devices obviate the face-to-face intercourse (e.g. Hawley, 1978; Richmond, 1969) and facilitate deconcentration.

The effects of the "turnaround" were not evenly distributed about the country but varied from region to region. The Northeast, particularly in the suburban portions of the Boston-Washington megalopolis, the Appalachian Southeast, the Mountain States, and the northern tier of counties in the Mid-West displayed the effect best. In his analysis of the "turnaround," Long (1981) points out that, despite the declining rate of national population growth, the nation's nonmetropolitan areas showed a substantial rise in their population. But, the deconcentration movement of the 1960's and 1970's seemed to halt in the mid-1980's with a return to migration from rural-to-city settings (Engels, 1987). Halt, that is, in every part of the country but the Northeast, where decentralization continued (Engels, 1987).

Mumford's useful shorthand scenario of the development of our nation may or may not be stalled at the third phase: one in which a rush seaward and a concentration of humankind in the coastal financial and commercial centers of the country remains in progress. This is of course a highly literal application of his conceptual framework but such an application provides a point of departure for a discussion of the phenomena of coastal growth of which we have all been made aware.

The Third Migration in the Northeastern States

It is no accident that the Third Migration centers defined by Mumford are also the port cities of the nation--that's history. Initially commercial hubs, then financial centers, the port cities have evolved, with communications technology, into today's financial and information service centers. Coincident with the rural-to-city migration came enormous growth of the cities and subsequent expansion of suburbs. The concurrent movement of large numbers of persons from rural to coastal urban locations is reflected in coastal demography. The Northeastern states, among the first settled, have the highest density of both total and coastal populations with about 63% of the region's population located in coastal counties. But population growth in the Northeastern states has been lower than the national average for nearly three decades and the ratio of coastal to non-coastal population, constant for that same period of time, is projected to continue to be about equal or to diminish. As the rest of the Nation catches up with the Northeast, coastal population densities of Northeastern urban areas have been surpassed. Los Angeles County now has a higher coastal population density than New York County (Manhattan) (Culliton et al., 1990).

As late as 1950, over 70% of the Nation's manufacturing jobs were in the Northeast and Mid-West, concentrated in the largest cities. Today, manufacturing is progressively moving out of and away from the port cities, driven by many factors, including high land values. Nowhere is this trend better displayed than in New England. Earliest to develop, these states are the most densely populated and are simultaneously experiencing both an aging population and changing employment patterns. In 1990, the Northeastern states (with the exception of Maine and Vermont) were lowest in the job creation rankings (New York Times, 25 April 1990). And the Port of New York and New Jersey, once the regional economic engine, dropped from its traditional spot as the Nation's number one port to second, after Los Angeles. Preliminary census data suggest that, had it not been for strong immigration to New York City, its population would have shown a decline.

As manufacturing employment declined in the Northeast, the information processing industries have grown. New York City and Boston have seen sharp increases in employment in these industries: 45% and 53% respectively, of their employment is in industries where executives, managers, professionals, and clerical workers predominate. The information processing industries employ workers with higher educational levels and, in general, pay better than manufacturing jobs. Between 1970 and 1984, New York City lost 500,000 jobs in industries requiring less than a high school education. Between 1959 and 1984, however, it gained 518,000 jobs requiring more than a high school diploma (Kasarda, 1987).

In the Northeastern coastal region, population growth is, with certain exceptions, stable. Langstaff (in press) has shown, for example, that the population of Connecticut's coastal town's, as a percentage of the State's population, has decreased steadily since 1940. Even coastal county populations have remained relatively constant over that period, measured the same way. Culliton et al. (1990) project 11 Northeastern counties, of the 15 listed, to lead in coastal population growth, in absolute numbers, between 1988 and 2010. But only 5 of the 15 are included as leading counties in projected rate of change of population. Absolute population growth of Northeastern states over the next 20 years is projected to be significantly below the National average.

A Scenario

The Northeastern states are experiencing lessened population growth and that growth being experienced is, in general, distributed statewide rather than being concentrated in the coastal region. These states are also experiencing a profound change in character of employment from manufacturing towards the financial and information service industries for which the supporting technology is in place. For these reasons, we might conclude that the Fourth Migration has commenced in this region. If we hypothesize that:

1) national policy should shift from one of seeking to attract manufacturing industries to Northeastern cities and instead stimulate the movement of potential workers for those industries from the inner cities to where manufacturing has relocated (e.g. Kasarda, 1985);

2) national energy policy results in higher costs for privately operated transportation systems;

3) no unforeseen national policy results in a marked reversal of present population trends

then, the character of the Northeastern states coastal region might dramatically alter.

Because their population is dispersing evenly throughout the region, the pressures on coastal resources of the Northeastern states, other than those of accessibility, should not increase. Cities might experience a renaissance at cost to suburban surrounds as a consequence of high land values, congestion, and energy policy in the latter, but inmigration would be exceeded by outmigration in response to policies stimulating movement of those seeking manufacturing jobs. The financial and information sector positions which would remain would provide greater tax revenues and lesser social costs, allowing the cities to expend more municipal funds on environmental rehabilitation. Alternatively, should the financial and information sectors also pack up and move, the urban centers of the Northeast might experience a sharp population decline among younger cohorts of their population and see, for the first time, a decreasing population density.

These scenarios offer opportunities for the Northeastern states to view their coastal resources from a new perspective. Rather than accepting incremental and continuing environmental degradation, coastal recreation congestion, and skyrocketing land values, the opportunity to achieve many of the goals of environmentalists might be presented. Among such goals might be the restoration of coastal habitats previously lost, together with the enhancement of fish and wildlife populations; achievement of a coastal water quality commensurate with the expectations of recreationists; and improved access to coastal resources by a larger segment of the region's population. These opportunities are in marked contrast to most present day management strategies oriented towards "holding the line." As the potential for the kinds of coastal demographic change hypothesized is enhanced, there is also need for the academic community to review its educational offerings to prepare the next generation of coastal environmental managers for a refreshingly new set of challenges.

Conclusion

The concept of a Fourth Migration, in the form postulated by Mumford or in some other, suggests that coming decades could be characterized by important changes in the configuration of the coastal region, cities, and port complexes of the Northeastern states. Physical and biological alterations to those urban/coastal environments, presently considered largely negative in impact, may be rectified as pressures on the coastal region for new housing, recreational facilities, and waste disposal facility are alleviated. Made or reclaimed coastal land could become the locus for restored shoreline habitats to which wildlife, freed from excessive human contact, industrial turmoil, and pollution, return. Coastal sprawl might be contained--or enhanced--by reduced property values and rational energy policy. Improved access to coastal recreational assets should have positive effects on public expenditures for improving quality. While the Fourth Migration should be viewed only as a means of expressing the dynamics of the national demography, it provides a useful speculative framework from which to view current events. Demographic trends should not be taken as permanent fixtures, but should always be viewed as potential departure points for yet another national movement. The "rush to the coast" viewed with alarm in the 1970's may, at least in one segment of the United States, be history.

References

Culliton, T.J., et al, 1990. 50 years of population change along the nation's coasts. 1960-2010. The second report of a coastal trends series. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Oceanography and Marine Assessment, Ocean Assessments Division, Strategic Assessment Branch. Rockville, MD. 41 pp.

Edwards, S.F. 1989. Estimates of future demographic changes in the coastal zone. Coastal Management, Vol. 17, pp. 229-240.

Engels, R.A. 1987. Testimony in Internal Migration--population changes in the United States to the 21st. Hearing Before the Subcommittee on Economic Resources, Competitiveness, and Security Economics of the Joint Economic Committee. Congress of the United States, Ninety-Ninth Congress, Second Session. September 18, 1986. pp. 2-15.

Hawley, A.H. 1972. Population, density and the city. Demography, Vol. 9, No. 4, November, 1972. pp. 521-530.

______ 1978. Urbanization as a process. In D. Street et al. (eds.) Handbook of Contemporary Urban Life. Jossey-Bass Publishers, San Francisco, CA. pp. 3-26.

Houck, O.A. 1988. America's mad dash to the sea. The Amicus Journal. Summer, 1988. pp. 21-36.

Kasarda, J.D. 1980. The implications of contemporary redistribution trends for National Urban Policy. Social Science Quarterly, December, 1980

______. 1985. Urban change and minority opportunities" in P.K. Peterson, ed. The New Urban Reality. The Brookings Institution, Washington, D.C..

______. 1987. Contemporary U.S. migration and urban demographic--Job opportunity mismatches. Testimony in Internal Migration--population changes in the United States to the 21st Century. Hearing Before the Subcommittee on Economic Resources, Competitiveness, and Security Economics of the Joint Economic Committee. Congress of the United States, Ninety-Ninth Congress, Second Session. September 18, 1986. pp. 58-81.

Langstaff, L.M. in press, Demographic and land use trends in the Long Island Sound region. U.S. Environmental Protection Agency, Region I, Technical Report. 31 pp.

Long, J.F. 1981. Population deconcentration in the United States. U.S. Department of Commerce, Bureau of the Census, Special Demographic

Analyses CDS 81-5. November, 1981. 105 pp.

Mumford, L. 1925. The fourth migration. The Survey, Vol. 54, No. 3, pp. 130-133. May 1, 1925, Survey Association, Inc.

Richmond, A. H. 1969. Sociology of migration in industrial and post-industrial societies. In J.A. Jackson (ed.) Migration. University Press, Cambridge MA. pp. 238-281.

Spangler, M.B. 1972. Projections of socio-economic trends in the coastal zone. Marine Technology Society Journal. vol. 6, pp. 21- 24.

West, N. 1987. Population changes in coastal jurisdictions with barrier beaches: 1960-1980. In R.H. Platt et al (eds.) Cities on the Beach: Management Issues of Developed Coastal Barriers. Research Paper, University of Chicago, Department of Geography, No. pp. 55-63.

Federal Coastal Legislation--A Comparison of Recent Trends with the Past Two Decades

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Introduction

The time of birth of Federal environmental law is generally cited as the late 1960's and the 1970's, a period during which a plethora of legislation was enacted. This paper initially describes the concepts common to these statutes. The remaining sections focus on coastal legislation enacted during the final hours of the 101st Congress. A comparison of the more recent trends with earlier statutory approaches concludes the paper.

Common Trends in Federal Environmental Statutes

A comprehensive review of natural resource legislation would reveal that the basis for certain statutes was established as early as the first two decades of the 20th-Century. For example, the genesis for certain water quality legislation was derived from public health and sanitation legislation passed during the middle of the 20th-Century. However, given the commonly-accepted view that environmental law is the product of the 1960's and 1970's, the appended list of environmental legislation by subject category will be utilized as the basis for determining common themes.

Several common themes can be discerned by reviewing the appended list of federal environmental statutes:

(l) It is generally true that some of the earliest environmental legislation is not bound to a specific time period; e.g. the Migratory Bird Treaty Act and the Fish and Wildlife Coordination Act. During the 1960's and the 1970's, in particular, the authority to implement a large percentage of the newly-enacted legislation was restricted to a specific time period which ranged from two to five years. The limited time period forced the House and Senate committees of jurisdiction to review the effectiveness of specific programs, the degree to which mandates were achieved, and, accordingly, to make any necessary adjustments in programs, timetables, or means to achieve a desired end.

It should be noted, however, that the failure to reauthorize expiring authorities does not necessarily result in an automatic decommissioning of related programmatic activities. As an example, activities to implement the Endangered Species Act and the Clean Air Act continued after their respective expiration deadlines had passed. The Clean Air Act provides a particularly useful example since it was not reauthorized for approximately two decades until October of 1990 (P.L. 101-549).

(2) Perhaps the most common characteristic of the past two decades of environmental legislation is what can be referred to as the "command and control" regulatory strategy for achieving desired ends. The best examples of this approach are the Clean Water and Clean Air statutes, the Ocean Dumping Act, the Magnuson Fisheries Conservation and Management Act, and the Outer Continental Shelf Lands Act. Based on each of these statutes, restrictions have been enacted at either the federal or state level to regulate activities which adversely impact the natural environment, e.g., permits to discharge polluting effluent under the Clean Water Act's National Pollutant Discharge Elimination System. The basic assumption is that a specific objective, e.g. "fishable, swimmable waters," can be achieved by regulatory action which sanctions, denies, or conditions the polluting activity.

(3) Another common trend is the reliance on biological criteria as the threshold standard for federal regulatory decisions. As an example, the Magnuson Fishery Conservation and Management Act employs the terms "maximum sustainable yield" (MSY) and "optimum sustainable yield" (OSY). The first term is a biological criterion. The second term, "optimum sustainable yield," modifies this criterion to consider other factors such as economic factors in determining allowable harvests via fishery management plans or Governing International Fishery Agreements. The Marine Mammal Protection Act similarly uses the terms "depleted" and "non-depleted" as the criteria for deciding whether the general moratorium on harvesting can be suspended or lifted for various purposes.

(4) The concept of federal environmental standards as minimum standards is an approach which is also contained in the Clean Water and Clean Air statutes. Both statutes authorize EPA to promulgate air and water quality criteria for various categories of pollutants. In adopting related state air and water quality standards, each state must adopt the federal criterion as a minimum; however, states retain the option to promulgate a more stringent standard for protection purposes.

(5) A trend which serves as the converse of the previous point is the lack of "state pre-emption" in Federal regulatory statutes. This concept means that, irrespective of a federal minimum criterion, a state retains the option of issuing a more stringent standard. Although widely accepted in Federal environmental legislation, the issue of state pre-emption was an especially contentious issue in enacting the Oil Pollution Act of 1990 (P.L. 101-380) after two decades of stalemate. The Conference Report adopted during the summer of 1990 precluded pre-emption of state authority to establish more stringent liability limits for oil spills or removal activities.

(6) An emphasis on "process" rather than "substance" has also been

a principal theme of environmental statutes. The National Environmental Policy Act (NEPA) is perhaps the best example of this emphasis since it mandates a process to be followed in preparing an environmental impact statement (EIS) as opposed to dictating substance to be contained in an EIS. Litigation regarding NEPA has generally supported this point; most court decisions have been solely concerned with the process followed in completing the EIS. It can also be argued that the Coastal Zone Management Act (CZMA) is principally a procedural statute in defining procedures to be followed in approving and evaluating a state coastal zone management plan as well as the three framework options which a state can select for devising its plan, including a "networking" option.

(7) The "polluter pays" concept is also a hallmark of CERCLA and the Oil Pollution Act of 1990 which apply to spills of hazardous and oil substances, respectively. Both statutes rely on "funds" financed by hazardous waste producers and vessel owners for response, clean-up, compensation, and restoration in the event that litigation does not result in a successful suit against a liable party or the liable party cannot be identified.

(8) A final trend consists of the "risk transfer" concept which was incorporated in the 1982 Coastal Barrier Resources Act (CBRA). This relatively simple concept is based on the acknowledgement that coastal barrier islands are hazardous places to inhabit. If the Federal Government terminates its support for development in these fragile areas (e.g. federal flood insurance), the risk of developing these areas is transferred to the developer or landowner. Remaining sections of this paper will further describe the concepts and success of this statute.

Two Decades of Coastal Legislation

In certain respects, coastal statutes enacted from the late 1960's to the current time have been experimental. One feature which has been variable is the geographic scope of the statutes. As indicated by its title, the 1968 Estuary Protection Act is restricted to estuaries. The CZMA, which followed four years later, broadened the area of concern to generally include three miles offshore of each state and areas inland determined by the state to impact the coastal zone.

A significant time gap occurred between enactment of the CZMA and the 1987 reauthorization of the Clean Water Act which established the National Estuary Program. Again, a specific focus was given to estuaries. Two sessions later, however, the Congress reauthorized the CZMA and broadened the geographic area of focus to include watershed areas for planning and permitting purposes. This approach is most evident in the newly-enacted non-point source pollution program. The reauthorized statute requires each coastal state to prepare a non-point source pollution plan and to integrate this plan with the state's coastal water quality program.

The 101st Congress

With the start of the Bush Administration, greater dialogue regarding environmental legislation has developed between the Executive Branch and the Congress. As an indication, the Administration conveyed legislative proposals to Congress to reauthorize the Clean Air Act, enact an oil spill liability bill, and reauthorize and amend the CZMA.

Three notable pieces of legislation were enacted during the waning hours of the 101st session. These included: (l) the Coastal Barrier Improvement Act of 1990; (2) the Coastal Wetlands Planning, Protection and Restoration Act; and (3) the Coastal Zone Act Reauthorization Amendments of 1990. Although the Coastal Defense Initiative of 1990 was not enacted, it will be briefly mentioned due to its likely consideration in the 102nd Congress.

Coastal Barrier Resources Improvement Act of 1990

The Coastal Barrier Improvement Act of 1990 extended the original "risk transfer" concept contained in the 1982 statute to a much larger portion of the coast -- both in terms of acreage and geographic location. Concerns had originally been expressed that amendments to add new acreage to the Coastal Barrier Resources Act would confront the risk of losing acreage originally included in 1982. This did not occur, however.

The Coastal Barrier Improvement Act of 1990 more than doubled the amount of acreage included in 1982. The Coastal Barrier Resources System now contains 1,271,395 areas; the major portion of the new acreage is wetlands or the "aquatic habitat" associated with the barrier. New geographic areas include units along the Great Lakes, the Florida Keys, the Virgin Islands, and Puerto Rico. Other noteworthy features include new mapping responsibilities for the Pacific Coast and a process for including lands which are publicly-owned or owned and managed by nonprofit conservation organizations.

The concepts contained in this statute have tremendous political appeal. Coastal barrier islands are hazardous areas to live or invest in and are also ecosystems with important natural resource value. It is argued, consequently, that development in such areas will not occur in the absence of federal development monies, especially federal flood insurance. Termination of such monies transfers this risk from the federal taxpayer to the landowner or developer who chooses to live on or develop the area. The lack of any federal involvement is particularly appealing to critics of federal regulatory programs.

The concepts in this statute are also appealing to conservative fiscal views. Studies have indicated a savings of approximately $830 million in federal monies during the six and-a-half year period since the statute was passed in 1982. This is based on the acreage included in the system in 1982 and the fact that 100,934 acres of fastland were included. Similarly, it has been estimated that $997 million would be saved over a twenty year period based on the new acreage. This savings would increase to $2.08 billion for both development assistance and post-disaster redevelopment assistance for these areas. Financial savings are derived not only from terminating federal flood insurance subsidies, but also from precluding the construction of bridges, highways, wastewater treatment facilities, and other infrastructure.

Statistics also indicate that the statute has been successful since areas included in the system in 1982 generally have not been developed. These statistics reveal that only 10 of the 186 units included in 1982 have undergone significant development since 1982. It is believed that much of this development occurred after passage of the statute in October 1982 and before imposition of the prohibition on federal flood insurance, which became effective in October of 1983.

Coastal Wetlands Planning, Protection, and Restoration Act

The title of this law can be misleading since it primarily concerns Louisiana's coastal wetlands rather than all coastal wetlands. Statistics indicating the alarming rate of loss of Louisiana's marshes served as the impetus for this bill. Federal wetland mapping activities have indicated that, from the early 1950's to the late 1970's, Louisiana lost about 50 square miles of its coastal wetlands.

Although numerous studies have documented the causes of this problem, the lingering issue has been how to finance solutions such as major diversions of the Mississippi River to restore the sediment flow to the marshes. Premised on the fact that OCS oil and gas development is one of several factors contributing to this loss, sponsors of the original Senate measure envisioned earmarking a portion of OCS receipts to finance coastal wetland restoration. This was subsequently altered during the waning hours of the 101st session -- the statutory funding mechanism is, instead, a portion of receipts deposited into the Sportfish Restoration Account, an account administered under the Wallop-Breaux Sportfish Restoration Program.

This bill represents a new era for the U.S. Army Corps of Engineers, who will have lead responsibility for the wetland restoration program. The Corps' former emphasis on flood control and navigation projects will be diminished. Other portions of this bill are also noteworthy. Louisiana is required to develop a coastal wetlands conservation plan to govern permits for development activities in the state's coastal wetlands. The procedures stipulated for this effort are similar to other federal/state planning approaches since several federal agencies will be involved in reviewing, approving, and evaluating the plan.

What is particularly noteworthy is that Louisiana is required, "in addition to existing Federal authority, to achieve a goal of no net loss of wetlands as a result of development activities." The standard for wetland protection in the new statute is more stringent than any related provision in the Coastal Zone Management Act, including the Coastal Zone Act Reauthorization Amendments of 1990. Although the reauthorized CZMA authorizes a coastal zone enhancements grants program, its objective is to "protect, restore or enhance the existing wetland base, or to create new wetlands" --a goal which falls short of the "no net loss" standard.

Coastal Zone Act Reauthorization Amendments of 1990

Enactment of the reauthorization bill as part of the Omnibus Budget Reconciliation Act of 1990 represents a significant feat for several reasons. The first is the substantive change to the federal consistency provisions which provide a new category of federal activities subject to the consistency requirement. The revised section 307(c)(1)(A) of the CZMA now requires that each federal agency activity "within or outside of the coastal zone that affects any land or water use or natural resources 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". The addition of the terms "within" or "outside of the coastal zone" and the use of the term "affect" rather than "directly affecting" has effectively overturned the Supreme Court's 1984 decision in Secretary of the Interior v. California.

Critics of this change may continue to argue that the federal consistency provisions challenge the concept of federal supremacy which is at the heart of intergovernmental relations. Section 307 of the CZMA has been further amended, however, to exempt certain federal activities found to be "inconsistent . . . if the President determines that the activity is in the paramount interest of the United States." The new exemption provision may assist in mitigating concerns regarding the amended consistency language.

The second significant category of amendments concerns the new non-point source pollution program. Non-point source pollution is a major contributor to estuarine and coastal water quality deterioration. During the 99th and 100th sessions of Congress, the House Committee on Merchant Marine and Fisheries conducted nine oversight hearings on the causes, location, and severity of coastal pollution from both point and non-point sources. A summary report, entitled Coastal Waters In Jeopardy: Reversing the Decline and Protecting America's Coastal Resources, was published at the start of 1989. Its message can best be described by referring to one of its many somber findings --

> ". . . from the contaminated sediment of New Bedford Harbor to the closed beaches of Long Island Sound, from the declining shellfish harvests of Chesapeake Bay to the rapidly disappearing wetlands of Louisiana, from the heavily-polluted waters of San Francisco Bay to the Superfund sites in Puget Sound, the signs of damage and loss are persuasive . . ."

The Coastal Defense Initiative of 1990 was subsequently introduced as the major legislative mechanism to address water quality deterioration by accelerating the issuance of federal water quality criteria and state issuance of water quality standards. Although this bill was not enacted during the 101st session, some of its concerns were addressed in the coastal zone management reauthorization bill.

Specifically, the new Coastal Nonpoint Pollution Control Program requires each state to develop a non-point pollution control program as part of the CZMA planning process and pursuant to provisions contained in the Clean Water Act. Adopting this component may result in management plans which adopt a watershed approach to coastal planning -- a broader approach than that contained in the traditional CZMA planning areas. Among the components to be included in a state's program is a proposal to modify the boundaries of a state's coastal zone as necessary to implement the non-point source program.

Common Themes of Coastal Statutes

Based on the earlier review of common trends in environmental legislation, the following similar themes are apparent:

(l) The five-year period for the CZMA reflects the typical reauthorization time span for recent legislation, thus requiring oversight and review after a specified time period. Although the funding for the Louisiana Coastal wetland restoration bill is limited to a five-year period, the revenues to fund the bill are permanently appropriated for this period of time. The new coastal barriers statute does not impose any timetable on the provisions which terminate federal development monies for lands within the Coastal Barrier Resources System.

(2) The reauthorized CZMA continues the concept of federal environmental standards as minimum standards. Coastal zone management plans must meet certain national standards in order to be federally-approved. However, state standards in developing and implementing programs for consistency may be more protective than those which would be imposed at a

national review level.

(3) The CBRA remains the best example at the federal level of the "risk transfer" concept. Other federal conservation statutes (e.g. the Swampbuster provisions in the 1990 Farm Bill) seek to protect natural resources -- in this case, wetlands -- by denying crop subsidies to landowners who convert wetlands. Although both statutes rely on negative economic incentives, the scope of the coastal barrier approach is much broader in terms of potential federal savings and types of federal development monies denied.

Conclusion

The real impact of the recently-enacted legislation is contingent not only on its mandates but also the reality of appropriated funds to implement and enforce the mandates. Similarly, the success of any statute is contingent on litigation undertaken to accelerate or prevent implementation. Finally, political sensitivities involved in implementing natural resource statutes are a very real factor within the Executive Branch in terms of implementation and within the Legislative Branch in terms of oversight. Having realized that the majority of our environmental legislation is only two decades old, we can continue to assess its concepts while anticipating its successes or shortcomings.

CATEGORICAL LISTING OF FEDERAL ENVIRONMENTAL STATUTES

Water Quality

Estuary Protection Act
Federal Water Pollution Control Act
Emergency Wetlands Resources Act
Food Security Act
Marine Protection, Research and Sanctuaries Act
National Ocean Pollution Planning Act

Living Resources

Marine Mammal Protection Act
Magnuson Fishery Conservation and Management Act
Endangered Species Act

Coastal Zone Management and Land Use

Coastal Zone Management Act
Coastal Barrier Resources Act
Estuary Protection Act

Outer Continental Shelf Development

Coastal Zone Management Act
Outer Continental Shelf Lands Act

Air Quality

Clean Air Act

Oil Spills and Hazardous Waste

Oil Pollution Act of 1990
Comprehensive Emergency Response,
Compensation and Liability Act

General Environmental Policy

National Environmental Policy Act

Growth Along the Nation's Coasts: A Preview of NOAA's Upcoming Report on Coastal Development

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This paper summarizes residential and non-residential development in U.S. coastal counties during the 1980's. It provides an assessment of coastal development levels, examines regional trends, and targets "hot spots" of growth in coastal areas.

The paper is a preview of an upcoming report from the National Oceanic and Atmospheric Administration's (NOAA) Coastal Trends Report Series. The series, initiated in 1989 as part of NOAA's program of strategic assessments, presents information on current and future development trends and their direct and indirect effects upon our national coastal resource base. The reports are a basis for identifying patterns in resource use and environmental quality concerns in the Nation's coastal areas.

Background

Coastal counties are among the most heavily developed areas in the Nation; about half of all housing units permitted for construction in the U.S. between 1980 and 1989 were in coastal areas. The most dramatic growth occurred in coastal Florida and California, where an estimated 3.1 million new housing units were built during this period.

Public concern over the impacts of coastal development has never been greater. For years, the coastal environment seemed resilient to the effects of human activities. However, as the population grew and coastal areas were forced to accommodate ever-increasing residential, industrial, commercial, and recreational uses, land and water resources diminished in quality and quantity.

The management of residential and non-residential growth has become an environmental focal point in coastal areas near Chesapeake Bay, eastern and southwestern Florida, southern California, San Francisco Bay, and Puget Sound. The construction of single-family homes, apartments, offices, and stores is a sign of healthy economic growth. But the dilemma of balancing this growth with sound environmental management is becoming a greater national concern. Many coastal communities, for example, have grown in developments that have "sprawled" across the landscape. Barrier islands have become a mecca for retirees and vacation home owners. Coastal wetlands have been filled for housing developments and their waters have been directed into canals. The natural processes of coastal ecosystems have been disrupted by poorly planned or inefficient development patterns. Consequently, the ecological and economic values of coastal areas are threatened as coastal development increases.

Definition of Coastal Areas

The paper includes information for 30 coastal states (including those bordering the Great Lakes) and 451 coastal counties. This total includes the District of Columbia, 23 boroughs or census areas in Alaska, and 42 independent cities in Virginia and Maryland that are "county equivalents." Coastal counties are those identified by either NOAA's Coastal Zone Management Program or by individual state coastal management programs.

The coastal U.S. was divided into six regions (North Atlantic, Middle Atlantic, South Atlantic, Gulf of Mexico, Pacific, and Great Lakes) to examine the spatial variations in development. NOAA uses these regions in its coastal assessment activities, including its National Estuarine Inventory Program and Coastal Trends Report Series.

Data Sources

The data used in this report were collected from the U.S. Bureau of the Census. Information on residential and non-residential building permits is included and used as an indicator of new residential and non-residential construction. Data from the 1980 Census of Population and Housing also are included. An estimated housing count for 1989 was calculated by adding the number of new units (minus demolitions) permitted between 1980 and 1989 to the total number of housing units calculated in the 1980 Census. In this report, it is assumed that a housing unit is constructed (completed) in the year it receives a permit.

The data on building permits were derived from the Bureau of Census' place-level permit data base. This data base includes the number of permits reported or estimated for 17,000 permit-issuing places in the U.S. The data selected for this report: 1) provide annual statistics between 1980 and 1989; 2) include residential and non-residential information; 3) were developed in a consistent format for the entire Nation; and 4) can be aggregated to the county level. No similar source is available within the federal government. Several private economic research firms were contacted but either do not have complete national coverage, have data for only a few years, or do not have a consistent framework for collecting data on a national level.

A housing unit consists of a room or group of rooms intended for occupancy as separate living quarters. In a large, multi-unit building, such as an apartment complex, each apartment represents one housing unit (Bureau of the Census, 1990). The number of buildings or structures is used for non-residential categories.

Limitations of the Data

The building-permit data set has several limitations. First, the geographic coverage is incomplete; about 5% of all privately-owned housing units are constructed in areas not requiring building permits (Bureau of the Census, 1990). Second, the data excludes mobile homes and conversions of non-residential units to residential units (and vice versa). Third, about 3% of all homes are built in permit-issuing places without a building permit (Construction Statistics Division, 1989). A small number of housing units receiving permits are never completed.

Changes in the geographic boundaries of a permit-issuing place (due to annexations, new incorporations, etc.) also may result in problems in comparing statistics for that place over time (Bureau of the Census, 1989). In spite of these limiting factors, the permit data are still useful indicators of residential and non-residential construction trends.

Residential Development

The Nation's coastal counties contain approximately 46 million housing units, almost half of all U.S. housing. During the 1980's, an estimated 6.7 million new residential housing units were constructed in these counties. This building represents an average increase of about 1,800 units per day. Coastal areas in Florida, South Carolina, and Virginia had the highest growth rates between 1980 and 1989 (Figure 1).

The peak year for development was 1986, when about 834,000 units were permitted for construction in coastal counties. Trends show single-family unit development was relatively stable during the 1980's and non single-family housing development slowed in the late 1980's from mid-decade peaks. Figure 2 presents the number of new housing units (by unit type) authorized by permit between 1980 and 1989.

The decade of greatest housing development in the United States occurred in the 1950's, when the residential stock increased by 35%. Housing increases declined in the 1960's to 20% and rebounded to an average growth rate of 25% in the 1970's. During the 1980's, the estimated rate of change averaged about 16%. Coastal areas of Florida, Washington, and Texas have had the most rapid growth rates over the past four decades.

Housing density

The level of development in coastal counties is increasing rapidly every year. In 1989, the estimated housing density in these areas (excluding Alaska) was 142 housing units/mi^2, more than four times the national average of 34 housing units/mi^2 (Figure 3). Housing densities have increased substantially over time. In 1950, coastal counties in all states (excluding Alaska) and the District of Columbia contained 19.6 million housing units, averaging 61/mi^2. This average had increased to 82 units/mi^2 in 1960 to 98/mi^2 in 1970, and to 123/mi^2 in 1980.

Coastal county housing densities are highest in Illinois (1,601 units/mi^2), Pennsylvania (702 units/mi^2), and Massachusetts (527 units/mi^2). However, the most rapid growth rates in housing density during the 1980s occurred in the coastal portions of Florida (34%), South Carolina (33%), and Virginia (29%). Housing increases in Florida, the most rapidly growing state, have translated into an additional 31 housing units for every square mile of land.

Trends by unit type

Between 43 and 45% of all new single-family development in the U.S. during the 1980's occurred in coastal counties. Approximately 313,000 units received permits in 1980; this figure declined to 238,000 in 1982. The number of units receiving permits peaked in 1986 at 479,000 units, declining to 420,000 in 1989 (Figure 2). The single-family house category includes all detached one-family houses and attached one-family houses, such as townhomes.

The number of new units in buildings containing between two and four housing units has declined each year since the mid-1980's (Figure 2). The greatest number of new units was permitted in 1983 (60,000) and 1984 (61,000). In contrast, only 35,000 units were authorized for construction in coastal counties in 1989. More than half of all two to four-family units in the U.S. have been constructed in coastal counties since 1986.

Between 1980 and 1989, an estimated 2.3 million units were permitted for construction in buildings with five or more units (multi-unit dwellings). The largest number of such units (317,000) was permitted in 1985 (Figure 2). Although the number of multi- unit dwellings has declined in recent years, the percentage of multi-unit development along the Nation's coast has increased. Between 52-59% of multi-unit development since 1986 occurred in coastal counties.

Non-Residential Development

Non-residential buildings include offices, banks, stores, hotels, and factories. Development in coastal counties accounted for almost 2.3 million new non-residential buildings between 1980 and 1989, about 48% of all non-residential construction in the Nation in the past decade. The percentage of all U.S. non-residential construction in coastal counties for 11 major categories is shown in Figure 4.

Industrial buildings include plants that produce, process, or assemble goods and materials, such as factories, machine shops, paper mills, beverage plants, manufacturing plants, and printing plants. During the 1980's, these buildings were constructed in large numbers along the Southern California coast and in the San Francisco Bay area. Coastal California accounted for more than 22,000 new industrial buildings, over 8,000 more than were built in Florida, the second highest state.

Office buildings include offices, banks, professional buildings, financial institutions, administration buildings, and medical office buildings. About 41% of all coastal office building construction during the 1980's occurred in Florida and California. Coastal areas with low levels of office building construction include Minnesota, New Hampshire, Indiana, Mississippi, Alaska, and Hawaii.

Indoor recreational facilities, including theaters, athletic and social clubs, arenas, bowling alleys, skating rinks, bathhouses, and gymnasiums also are constructed in large numbers in the Nation's coastal areas. During the 1980's, more than 24,000 indoor recreational facilities, accounting for 48% of the U.S. total, were permitted for construction in coastal areas. Florida and California accounted for almost half the indoor recreational development.

Outdoor recreational and port facilities, the leading non-residential category, includes structures such as outdoor swimming pools, marinas, outdoor stadiums, outdoor theaters, boardwalks, wharfs, and docks. Almost 60% of these structures permitted for construction in the 1980's were located in coastal counties. More than half of all new non-residential construction in the Nation's coastal areas occurred in coastal Florida (33%) and California (28%). Large numbers of recreational structures and port facilities also have been constructed in Hawaii and portions of New York, New Jersey, and Massachusetts.

Hotel buildings were constructed in greatest numbers in resort and commercial centers. Areas surrounding Los Angeles, Houston, Chicago, and Washington, D.C. led in coastal hotel construction. Counties containing vacation centers such as Atlantic City, NJ, Myrtle Beach, SC, and Virginia Beach, VA had large growth in this category.

Parking garages, service stations, and repair garages saw the greatest development in California and Texas, and to a lesser extent, in Florida. About 24,000 structures in these categories were constructed in U.S. coastal counties during the 1980's.

Public works and utilities buildings, school buildings, and hospitals and institutional buildings are categories responding most directly to population change and, therefore, reflect overall residential housing trends. Coastal counties accounted for 36-37% of all U.S. construction in these categories during the decade.

Stores and customer services include stores, restaurants, taverns, night clubs, bakeries, laundry and dry cleaning shops, and beauty and barber shops. Over 155,000 stores were permitted for construction in coastal areas in the 1980's, the second highest category of non-residential development. Florida had almost twice as many new buildings permitted for construction as California, the next highest state.

Analysis by Region

North Atlantic

This region currently includes about 2.4 million housing units, the lowest of the six coastal regions. This figure is based on an estimated 291,000 new housing units authorized by permit between 1980 and 1989. The major growth centers in the North Atlantic region during the 1980's were in Massachusetts, primarily in the Boston metropolitan area and on Cape Cod. Most of the residential growth (66%) has been single-family development. Only about 25% of new residential construction was in multi-unit development. Residential construction peaked in 1986 (46,000 units permitted for construction), declining to 22,000 units in 1989.

Non-residential construction remained stable during the mid-to late-1980's. The North Atlantic accounts for only 4% of non-residential development in U.S. coastal counties. However, the region's 21 coastal counties accounted for the new construction of 57,000 outdoor recreation structures, 5,600 stores, 4,600 industrial buildings, and 3,700 office buildings during the decade.

Middle Atlantic

This region had the second largest increase in residential units (1.5 million permitted for construction) during the 1980's. It currently has more units (13.6 million) and the highest density (391 housing units/mi^2) of any coastal region. About 30% of the Nation's housing is found in Middle Atlantic coastal counties. The major growth centers were in the New York and Washington, D.C. metropolitan areas and along the New Jersey coast.

About 68% of all residential growth in the Middle Atlantic region has been in single-family development, the highest of any region. Residential development peaked in 1986 at 206,000 units, declining to 138,000 units in

1989. Growth has been most rapid in Virginia, where six counties had estimated housing increases of more than 50% between 1980 and 1989.

Non-residential development growth in this region has been concentrated in New Jersey, Virginia, New York, and Maryland. In the 1980's, the region accounted for about 22%, 21%, and 20% of coastal county construction for indoor recreational facilities, stores and customer service buildings, and office buildings respectively. Coastal Virginia had the highest levels of any state in new office and hotel construction in the North Atlantic region. New York and New Jersey accounted for about half of all new industrial facilities.

South Atlantic

This is the most rapidly developing coastal region in the Nation. The region's housing increased by one-third between 1980 and 1989. The most dramatic growth occurred in Florida, where an average of 1,900 housing units were constructed each week. The South Atlantic currently has about 4.2 million housing units, based on an estimated 1.2 million new units permitted for construction. Communities along the Florida coast from Jacksonville to Miami had growth rates among the highest in the Nation. Development in eastern Florida has spread along a narrow coastal strip in a series of suburban, second-home, and resort developments. Outside of Florida, the largest residential growth in the South Atlantic region occurred in those counties in which Charleston and Myrtle Beach, SC are located.

Much of the region's growth has been in multi-unit construction. Florida's Dade, Broward, and Palm Beach counties, rank fourth, fifth, and eighth, respectively, in multi-unit development. About 37% of all residential construction in the South Atlantic (the second highest regional percentage) is multi-unit dwellings. South Atlantic non-residential development also is concentrated in Florida. The region accounted for almost 20% of coastal construction for public works buildings during the 1980s. The region also accounted for about 19% and 18% of coastal development for indoor recreational facilities and outdoor recreational and port facilities, respectively.

Gulf of Mexico

The 99 coastal counties in the Gulf region currently include 6.2 million housing units, averaging 79 housing units/mi^2, the second lowest regional density. The residential housing stock in this region increased by about 25% during the 1980's. The region's major growth centers have been southwestern Florida from Tampa/St. Petersburg to Fort Myers, along the western Florida panhandle, and the Houston metropolitan area. Although the region had the third highest number of new residential units, regional growth has been driven primarily by intense development in Florida and early-1980's development in coastal Louisiana and Texas.

Fifty-eight percent of all new residential units built in Gulf coastal areas during the 1980s were single-family homes. Gulf of Mexico multi-unit construction is concentrated in the region's commercial and retirement centers. Three of the Nation's eleven leading coastal counties in multi-unit construction were located in this region: Harris County, TX, and Hillsborough and Pinellas counties, FL. Unlike other regions, coastal development in the Gulf of Mexico peaked early in the decade (1983) and has since declined. The number of units permitted in 1989 (87,000) was more than 60,000 units lower than in 1980. These data reflect the decline in housing development in the mid-to-late 1980's in coastal areas of Louisiana and Texas. In coastal Louisiana, for example, the number of new single-family homes decreased from a peak of 13,000 in 1983 to about 4,000 in 1989.

Non-residential development in the Gulf of Mexico region has also declined since 1984. However, because of development in the early 1980's, and continued growth in Florida, this region ranked high in recreational and industrial building starts. The Gulf accounts for more than one-fourth of all U.S. coastal development of stores and customer services, office buildings, schools, and hospitals.

Pacific

The largest increase in housing units (1.9 million permitted for construction) since 1980 occurred in the Pacific. This region currently contains an estimated 11.4 million housing units, averaging about 133 housing units/mi^2 (excluding Alaska). The major growth centers are in Southern California and the San Francisco Bay area. Coastal counties in California accounted for 21% of the Nation's coastal housing growth between 1980 and 1989.

Forty-three percent of residential development in this region has been multi-unit structures, the highest of any region. Los Angeles, San Diego, and Orange counties in southern California ranked first, third, and sixth, respectively, in new multi-unit construction in the Nation's coastal counties. Residential development in this region peaked in 1986 (267,000 units) and remained stable through 1989. The construction of new single-family homes has increased steadily throughout the 1980s.

The Pacific region accounted for over one-third of coastal development for outdoor recreational facilities, industrial buildings, and hotels nationwide. Counties in southern California (Los Angeles, Orange, and San Diego) and the San Francisco Bay area (Santa Clara, Alameda, and Sacramento) had large industrial and recreational development. While California led the Pacific in every non-residential category, Washington showed major growth in store and office development. Hotel and outdoor recreational facility construction were high in Hawaii because of its resort-oriented economy.

Great Lakes

Coastal counties in the Great Lakes region contain about 7.8 million housing units, the third highest regional total. The 517,000 new housing units built during the 1980's was the lowest regional total, after the North Atlantic region. The largest growth in the region occurred in Monroe County, NY, where Rochester is located; Macomb County, MI, a suburban county of Detroit; and Cook and Lake counties, IL, which contain Chicago and its suburbs.

Sixty percent of all residential growth was in single-family development, 32% in multi-unit (five or more) construction. Residential development in the region's coastal counties from 1980 to 1984 averaged 36,000 housing units per year, lower than any region except the North Atlantic. Growth peaked in 1986 at 74,000 units, declining to 70,000 units by the end of the decade.

Non-residential growth in the Great Lakes region is concentrated in Michigan, Illinois, Wisconsin, and Ohio. The region accounted for 27%, 18%, and 16% of coastal county construction for parking garages, service stations and repair garages, and public works and utilities buildings, respectively. Michigan led the region in most non-residential categories.

"Hot Spots" of Growth

Figure 6 lists the coastal counties in three categories: 1) those estimated to have the highest housing densities; 2) those with the greatest increase in single-family development; and 3) those with the highest growth rate between 1980 and 1989. Coastal counties with the highest housing densities are concentrated in the Middle Atlantic region. New York (Manhattan), Kings (Brooklyn), and Bronx counties are heavily populated areas that together contain over five million people. High-density counties such as Alexandria, Arlington, and Fairfax, VA are immediate suburbs of Washington, D.C.

Counties with large increases in single-family houses represent major growth centers. Los Angeles County, CA and Harris County, TX, the two largest, are well known for their sprawling development. Together, they account for an average of over 26,000 new single-family houses each year. The Chesapeake Bay area, southeastern Florida, southern California, and the San Francisco Bay area account for 8 of the 15 counties on the list.

Several of the Nation's most rapidly growing coastal counties are along Florida's east coast, in the Jacksonville-Orlando corridor. Counties with high growth rates along Florida's Gulf coast (Hernando, Collier, and Charlotte) are concentrated near Tampa/St. Petersburg and the retirement- and resort-oriented counties along the southwestern coast of the state. Virginia's Spotsylvania, Stafford, and Prince William counties are commuter suburbs of Washington, D.C.

Summary

The Nation's coastal housing grew by almost 20% during the 1980's. As many coastal areas grow more crowded, the short-comings of management decisions and actions that focus on site-by-site and permit-by-permit decisions, but fail to address the more pervasive problems of growth and development, become more obvious. As we move into the next century, comprehensive and effective management initiatives are required by both public and private interests to ensure the economic growth and environmental well-being of coastal areas.

References

Bureau of the Census. 1957. **County and city data book, 1956.** U.S. Department of Commerce. Washington, DC: U.S. Government Printing Office. 565 p. + appendices.

_______. 1973. **County and city data book, 1972.** U.S. Department of Commerce. Washington, DC: U.S. Government Printing Office. 1020 p. + appendices.

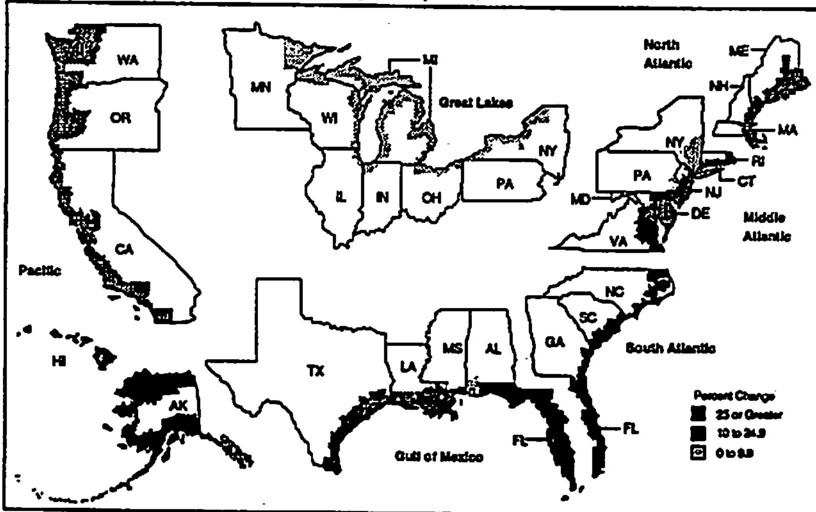
_______. 1988. **County and city data book, 1988.** U.S. Department of Commerce. Washington, DC: U.S. Government Printing Office. 797 p. + appendices.

_______. 1989. **Housing units authorized by building permits:** Annual 1988. Current construction reports, C40-88-13. Construction Statistics Division. Bureau of the Census, U.S. Department of Commerce. Washington, DC: U.S. Government Printing Office. 327 p.

_______. 1990. **Housing units authorized by building permits:** December 1989. Current construction reports, C40-8912. Construction Statistics Division. Bureau of the Census, U.S. Department of Commerce. Washington, DC: U.S. Government Printing Office. 93 p.

_______. 1990a. **Place-level permits,** 1980-1989 (data base). Construction Statistics Division. Bureau of the Census, U.S. Department of Commerce. Washington, D.C., U.S. Government Printing Office.

Figure 1. *Percent Change in Coastal Housing Units by State, 1980-1989*



The 1989 estimate is based on the number of residential units authorized by building permit.

Figure 2. *Annual Residential Construction, 1980-1989*

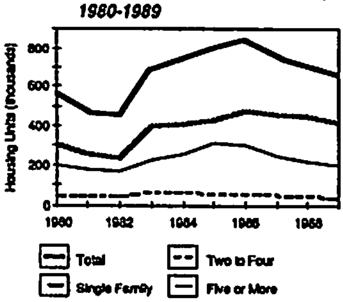
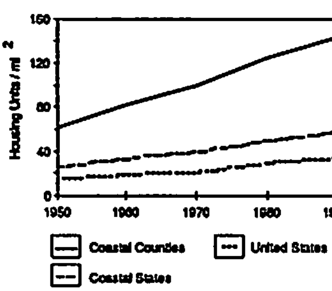
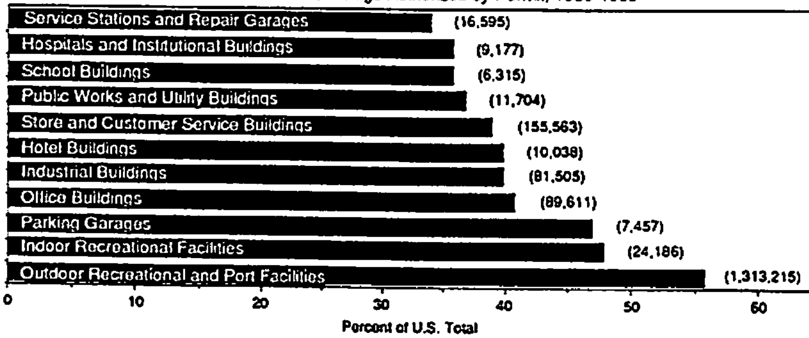


Figure 3. *Housing Density, 1950-1990*



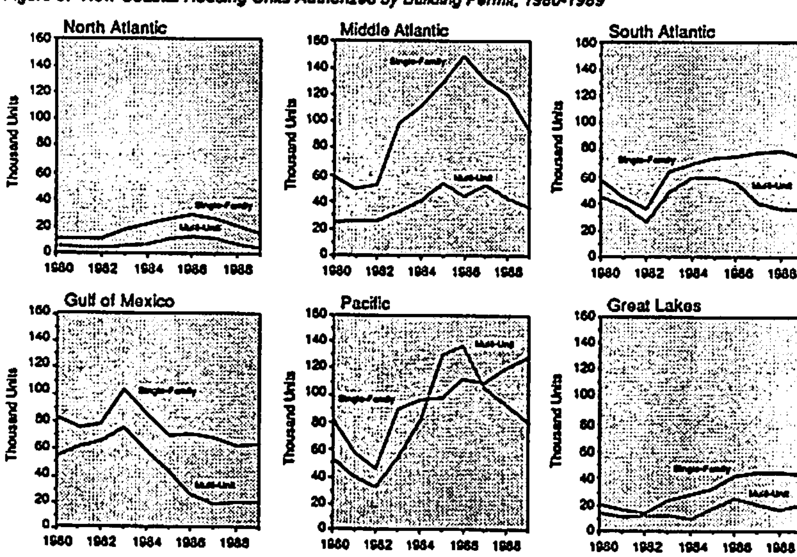
Data based on the number of units authorized by building permit. Density figure does not include Alaska.

Figure 4. *New Coastal Non-Residential Buildings Authorized by Permit, 1980-1989*



Data based on the number of buildings or structures authorized by building permit.
Absolute number of buildings or structures in parentheses.

Figure 5. *New Coastal Housing Units Authorized by Building Permit, 1980-1989*



No data shown for two- to four-family units.

Figure 6. *Leading Coastal Counties*

County	Housing Units per Square Mile, 1989	County	Single-Family Houses, 1980-1989	County	Percent Change in Housing Units, 1980-1989
New York, NY	35,983	Los Angeles, CA	135,200	Flagler, FL	142
Kings, NY	12,749	Harris, TX	131,366	Osceola, FL	104
Bronx, NY	10,847	San Diego, CA	107,820	Hernando, FL	101
San Francisco, CA	7,196	Palm Beach, FL	100,771	Collier, FL	92
Queens, NY	6,949	Orange, CA	78,879	Spotsylvania, VA	85
Philadelphia, PA	5,148	Fairfax, VA	75,347	Charlotte, FL	84
Suffolk, MA	5,103	Sacramento, CA	61,561	Camden, GA	83
Hudson, NJ	5,048	Dade, FL	60,628	St. Lucie, FL	80
District of Columbia	4,511	King, WA	58,869	James City, VA	80
Alexandria, VA	3,886	Orange, FL	57,239	Seminole, FL	78
Baltimore City, MD	3,877	Hillsborough, FL	57,156	St. Johns, FL	75
Arlington, VA	3,280	Broward, FL	53,555	Chesterfield, VA	67
Essex, NJ	2,552	Cook, IL	53,256	Stafford, VA	66
Richmond, NY	2,467	Suffolk, NY	48,733	Prince William, VA	65

Data based on the number of new residential units authorized by building permit.

The Gulf of Mexico Program

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Abstract

The Gulf of Mexico serves as one of America's most valuable natural resources. Due to increasing signs of deteriorating environmental quality, and increasing conflicts among the varied users of the resource, the U.S. Environmental Protection Agency has initiated an effort called the Gulf of Mexico Program to provide a mechanism for addressing complex problems in the Gulf that cross state, federal, and international boundaries. The institutional structure of the program will provide better coordination among the scientists, managers, user groups, educational institutions, and the general public in the development of a long-term management plan for the Gulf of Mexico. This paper describes the current strategy, goals, and organizational structure of the Gulf of Mexico Program.

Introduction

The Gulf of Mexico is an extremely valuable natural resource. Some might say it is the nation's most important marine and estuarine resource. The Gulf of Mexico yields more finfish, shrimp, and shellfish than the South and Mid-Atlantic, Chesapeake, and New England regions combined (National Marine Fisheries Service, 1989). It contains 50% of the Nation's coastal wetlands (Basta, personal communication) and provides critical habitat for 75% of the migratory waterfowl traversing the United States.

More than 72% of the oil and 97% of the gas produced from offshore U.S. waters has come from the Gulf. Between 1956 and 1984, more than $76 billion in federal revenues were generated as a result of Outer Continental Shelf (OCS) oil and gas development in the Gulf.

OCS leasing is second only to the federal income tax as a revenue source for the U.S. Treasury (LA Liberte and Harris, 1986). The Gulf is also vital to the nation's trade interests. Approximately 45% of the U.S. export/import tonnage passes through Gulf ports. The five Gulf coast states accounted for 35% of the U.S. population growth between 1980 and 1985, supporting 1/6 of the country's population (U.S. Bureau of the Census, 1986). These states share approximately 1600 miles of Gulf coastline, which contains 207 estuaries. The Gulf coastline is longer than the Pacific coast of California, Oregon and Washington, and is equivalent to the distance from Providence, Rhode Island to Miami, Florida along the Atlantic coast. The Gulf has usually been viewed as one of the least altered and most healthy of our coastal marine environments, but signs of deteriorating environmental quality are increasing across the Gulf. Serious conflicts are emerging among the users of the Gulf, its coastal environments, and its resources.

Oxygen depletion is an increasing problem for many Gulf estuaries. Severe oxygen depletion has been recently documented in over 3,000 mi^2 of continental shelf bottom water off Louisiana and Texas (Turner et al., 1986). Critical habitat is being lost through the alteration and destruction of marshes, mangroves, and seagrass beds all along the Gulf coast. In Louisiana, the estimated rate of coastal wetland loss is approximately 50 mi^2/yr, about 80% of the total national coastal wetland loss rate (Louisiana Wetland Protection Panel, 1987). The Gulf of Mexico produces over one-half of the U.S. oyster harvest (National Marine Fisheries Service, 1986). Over 50% of classified Gulf shellfish growing areas have been voluntarily, conditionally, or permanently closed as a precaution to minimize the risk of illness from eating contaminated shellfish (NOAA, 1988).

The Gulf of Mexico is also affected by activities conducted throughout much of the rest of the nation. Over 66% of the contiguous U.S. drains into the Gulf (NOAA, 1985). Society's nutrients, wastes, pesticides, and soils that are washed from Helena, Atlanta, Albuquerque, Pittsburgh, Chicago, and Tampa eventually end up in the Gulf.

In response, the U.S. Environmental Protection Agency (EPA) Region 4 proposed a Gulf-wide strategy termed "The Gulf Initiative" to identify Gulf-wide problems and set goals and research needs, while developing a strategy in response to those problems. During an initial Gulf Initiative workshop held in Gulf Shores, Alabama on 04-06 August 1986, fifty-nine persons, representing a broad spectrum of organizations concerned with marine pollution, identified critical issues and activities causing problems in the Gulf, made recommendations for a program management structure, and provided a strong consensus that such a program was needed (Buff and Turner, 1987).

With authorization and financial support from EPA Headquarters, EPA Regions 4 and 6 have begun to establish a program to reach the goals of the initiative. The Gulf of Mexico Program is an interagency, interdisciplinary effort to develop and implement a comprehensive strategy for managing and protecting the resources of the Gulf. The Program will use management models and experience gained from previous regional efforts such as the Great Lakes and Chesapeake Bay programs.

Because the environmental problems of the Gulf of Mexico are the result of multi-state and international activities, effective solutions will require Gulf-wide coordination and cooperation. Over the past three years, numerous experts have identified problems of the Gulf that fall into the following major categories: toxics and pesticides; habitat degradation; nutrient enrichment; public health; and freshwater diversion. While the effects of environmental degradation in the Gulf may be manifested locally, these problems result from sources and activities that are regional in nature. There are numerous state, local, and federal agencies working on their own legislative directives that are generally independent of each other. These agencies, recognizing the need for coordination, supported development of a Gulf of Mexico Program to prevent further degradation of the Gulf. Such a program could improve communication among participants and build coalitions to achieve more effective protection of coastal resources.

Overall Strategy

The long-term strategy of the Gulf Program is to protect, restore, and maintain the Gulf waters to protect human health and sustain living resources; to take actions to further control pollution of these waters; and to ensure that alternative uses and economic growth are managed in an environmentally-sound manner. Certain basic principles direct these efforts:

- the Gulf of Mexico Program will be oriented towards protecting and restoring uses.

- the Gulf of Mexico will be treated as a system, taking into account system-wide concerns and cumulative effects.

- site-specific problems and issues will not be ignored but will be viewed within the context of Gulf-wide priorities.

- problems will be viewed within the context of biogeochemical boundaries or other appropriate subregional units.

Because of the complexity of the institutional structures that exist, anything less than a systematically constructed approach cannot be expected to succeed. Therefore, a principal strategy element of the Gulf of Mexico Program is the development of an institutional structure that will:

- provide a mechanism for addressing complex problems in the Gulf that cross federal, state, or international jurisdictional lines.

- provide better coordination among federal, state, and local programs affecting the Gulf, which will increase the effectiveness and efficiency of the long-term effort to manage and protect the resources of the Gulf.

-provide a regional perspective to identify information needs for managing and protecting Gulf resources with subsequent direction to research efforts.

-provide a forum for affected user groups, public and private educational institutions, and the general public to participate in the "solution" process.

Two principal programmatic goals and their objectives have been identified for the Gulf of Mexico Program.

Goal I: Establish an effective infrastructure for resolving complex environmental problems associated with man's use of the Gulf of Mexico.

Objective 1: Establish and provide support to a Gulf of Mexico Program Office.

Objective 2: Establish and implement a Gulf of Mexico Program committee structure.

Objective 3: Establish a public education network that includes information transfer, educational outreach, and participation activities.

Goal II: Establish a framework-for-action for implementing management options for pollution controls, for remedial and restoration measures for environmental losses, and for research direction and environmental monitoring protocol.

Objective 1: Prepare environmental characterizations.

Objective 2: Prepare environmental assessments.

Objective 3: Develop an interactive data management system.

Objective 4: Develop predictive assessments.

Objective 5: Develop and implement a Gulf of Mexico Environmental Action Plan.

Objective 6: Develop and implement a Gulf of Mexico Monitoring Plan.

During the first year of the Gulf Program, a significant effort was focused on forming an effective infrastructure and informing participants about potential roles and responsibilities. A Gulf of Mexico Program Office was established in August, 1988 at the John C. Stennis Space Center, Mississippi and Dr. Douglas Lipka was selected as Director. The three committees making up the principal infrastructure components, the Policy Review Board, the Technical Steering Committee, and the Citizens Advisory Committee, were convened by December, 1988.

The Policy Review Board consists of senior representatives from state and federal agencies across the Gulf and representatives from the Technical and Citizens Committees. This board, chaired by the EPA Regional Administrators, guides and reviews the overall activities of the Gulf of Mexico Program. The board approves program goals and objectives and establishes priorities and direction for the program. The Policy Review Board provides broad-based support for the program in all policy and political matters while leaving operational duties to the other working committees.

The Technical Steering Committee consists of state and federal agencies, academia, and private and public sectors. The chairman of the Technical Steering Committee is the Program Director of the Gulf of Mexico Program Office. The Technical Steering Committee's principal responsibility is to provide technical support to the Policy Review Board in the form of development and evaluation of environmental issues and regulatory strategies and development of program options. The committee provides advice and guidance related to research, data management, modeling, and sampling and monitoring efforts that affect the scientific adequacy of the program. The committee conducts peer review of studies, reports on the status and trends in the Gulf, and alerts the Policy Review Board to emerging environmental issues.

The Technical Steering Committee may create work groups or standing subcommittees. Presently, seven issue specific subcommittees have been established covering the areas of habitat degradation, nutrient enrichment, toxic substances and pesticides, marine debris, freshwater inflow, coastal and shoreline erosion, and public health. In addition, two subcommittees have been formed to address dissemination of information, information and data transfer, and public education and outreach. Each subcommittee has state and federal co-chairmen. The federal co-chairmen have lead responsibilities and each co-chairman serves in that capacity for one year.

The subcommittees are charged with developing action plans identifying specific tasks for accomplishing the following key activities and with presenting recommendations to the broader Technical Steering Committee:

o definition of environmental issues
o characterization of identified issues
o assessment of information for corrective actions
o development of predictive measures
o implementation of corrective actions

Additional duties of the technical subcommittees include review and evaluation of proposals assigned by the Program Office.

The Citizens Advisory Committee consists of representatives of five sectors (environment, agriculture, business/industry, development/tourism, and fisheries) from each of the five Gulf coastal states. Each citizen representative was selected by the governor of his/her respective state. This committee provides a mechanism for structured citizen input into the Gulf Program from respective regions and areas of interest and assists in disseminating information relevant to the goals and results of the program.

To implement correction actions for Gulf problems (Goal II), an understanding of the natural processes operating in the Gulf of Mexico is necessary. The ability to minimize adverse impacts of human activity on the resources of the Gulf of Mexico is directly dependent on our knowledge and understanding of these processes. To properly manage Gulf resources, we must be able to predict the results of management decisions in the context of the full dynamic range of these natural processes.

Based on our understanding of environmental processes and knowledge of sources of pollution, critical pathways can be identified and options for control and remedial action can be developed. Critical to the development of this framework-for-action is a system designed for the interaction of presently available and future scientific databases. Through this interplay of environmental and resource information, more focused analyses can be performed and appropriate predictive assessments can be developed. In turn, regulatory controls can be assessed and further research directed to support these decisions.

To enhance information flow between Gulf Program participants and interested parties, the Program has established an electronic bulletin board system. This system allows users to denote specific information needs, to send and receive electronic mail messages, and to share long narrative documents. In a companion project, an automated catalog of coastal and marine pollution data and information sources for Gulf of Mexico regions and an automated directory of environmental scientists, government officials, legislators, and environmentalists working in this region are being developed. These intergrated electronic catalogs can be accessed and searched via the bulletin board.

A demonstration of this intergovernmental exchange of information has been initiated in a Mobile Bay project. By assembling existing but disparate data and information on coastal wetlands into a single information management system, we can utilize a more systematic, consistent, and beneficial process for management of wetlands. Soil survey maps, National Wetlands Inventory maps, U.S. Army Corps of Engineers permit application/permit issuance data, and other information on the wetlands surrounding Mobile Bay, Alabama, are being entered into a single geographical information system. This will provide comprehensive information on historical wetlands changes for use by environmental managers and regulators. This prototype system can later be expanded to include a larger geographic area as well as other environmental issues.

In conjunction with implementation of management options, a Gulf-wide monitoring program will be established to serve as a verification mechanism and to determine environmental quality modifications. The physical and biological processes of the Gulf of Mexico must be thoroughly characterized to separate natural events from those induced by human activity. Key processes include the fate and effects of land-derived nutrients, the fate and effects of toxic substances and pesticides introduced into the surface water and subsurface water, and the fate and effects of human pathogens introduced into the biota through the estuarine ecocystem.

The final phase of the program will involve implementation of the identified management options. These could include regulatory control, restoration measures, various public involvement activities, and monitoring programs.

Each of us, as citizens and taxpayers perceive new government initiatives with varying degrees of scepticism. Clearly, with the present economic realities which face government at every level, clearly continuous evaluation of how we are managing this nation's resources is necessary. Environmental and resource management programs must be measured against how they address several fundamental questions and often perceived ills.

o Is our environment deteriorating? Are our efforts leading to management decisions and corrective actions?

o Are existing data or projects being effectively utilized or is poor database management, coordination, or communication resulting in waste and duplication of effort?

o Is the public being informed of the value of natural resources to the economy and quality of their life, the threats to those natural resources, and the range of solutions available?

o Does the public have a real and effective role in the resource management decisions affecting them?

Effective management means taking the steps necessary to maintain and restore environmental systems prior to the onset of the catastrophic problems which seem to demand so much of our attention and increasingly limited financial resources. We must learn the costly lessons of Boston Harbor, the Great Lakes, the Chesapeake Bay, and the Superfund toxic waste clean-ups and increasingly expend our energies on prevention through waste minimization, pretreatment, coastal zone planning, best management practices, etc.

The Gulf of Mexico Program strives to identify and highlight those problems we must collectively repair and those areas needing increased protection through improved cooperation and communication between federal, state, and local governments and concerned citizens across the Gulf.

The EPA has provided seed-money and leadership to start the Gulf Program. Without the active participation of all appropriate agencies, the long-term goals of the Gulf of Mexico Program will not be achieved. Because of the overall budgetary constraints, this approach is a logical way of maximizing limited resources to maintain the environmental integrity of the Gulf for future generations.

References

Basta, D. 1987. Personal Communication. Ocean Assessment Division, National Oceanic and Atmospheric Administration.

Buff, V. and S. Turner. 1987. The Gulf Initiative. Pages 784- 792. In: Proceedings of the Fifth Symposium on Coastal and Ocean Management., O.T. Mangood et al. (eds.): American Society of of Civil Engineers. New York, NY.

Center for Environmental Education. 1988. Texas Coastal Cleanup Report. Marine Debris on the Texas Coast April 1987, September 1987, April 1988 with Summary Data from other Coastal States Recommendations and Updates. Austin, Texas.

La Liberte, P. and W. Harris. 1986. Federal Offshore Statistics: 1984. MMS 86-0067.

Louisiana Wetland Protection Panel. 1987. Saving Louisiana's Coastal Wetlands. The Need for a Long-Term Plan of Action. EPA- 230-02-87-026.

National Marine Fisheries Service. 1989. Fisheries of the United States, 1989. Current Fisheries Statistics No. 8900. National Fishery Statistics Program, U.S. Department of Commerce, Washington, D.C.

National Oceanic and Atmospheric Administration. 1988. The Quality of Shellfish Growing Waters in the Gulf of Mexico. Oceanic Assessments Division. U.S. Department of Commerce. Rockville, Maryland.

National Oceanic and Atmospheric Administration. 1985. Gulf of Mexico: Coastal and Ocean Zones Strategic Assessment Data Atlas. Office of Oceanography and Marine Assessments, U.S. Department of Commerce, Washington, D.C.

Turner, R.E., N.N. Rabalais, D.F. Boesch, and R. Kaswadji. 1987. Long-term changes in the Mississippi River water quality and its relationship to hypoxic continental shelf waters. In: Proceedings of Tenth National Conference, the Coastal Society, October 12-15, 1986. New Orleans, Louisiana.

U.S. Bureau of the Census. 1986. Statistical Abstract of the United States, 1987. 107th ed. Washington, D.C.

The Spanish Shores Act of 1988 - A New Approach to Coastal Management Problems

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Introduction

The situation of the Spanish coast in July of 1988 was as described below. This situation necessitated the enactment of legislation to improve the situation, or, at least, to prevent it from further damage. The Spanish Shores Act (the Act), therefore, describes a way of managing the coast, and includes the necesary rules that lead the management activity as well as the priorities and instruments to implement it. This paper begins by describing the situation of the Spanish coast and afterwards describes the content of the Act, ordered as it has been approved, except when a different order turns out to be more comprehensible.

Thirty-five percent of the Spanish population is concentrated in a coastal strip five kilometers wide--an area constituting only 7% of Spanish territory. To this indigenous coastal population concentration must be added the tourist population, important in Spain for its size, of which 82% is concentrated on the coast. The agglomeration of people, the lack of parking space, the absence of smooth circulation of vehicle traffic; in short, the ever-decreasing possibility of enjoying the peace which should be an inherent part of the coast makes urgent action necessary in the area of coastal regulations.

As quantitative data to ratify the aforementioned, we can say that in 1988, 40% of the Spanish coastline was developed; 7% is dedicated to port installations, 3% to industrial installations, and 8% to industrial uses, with only 42% not having clearly defined or irreversible uses.

In order to better understand the situation, we begin with the analysis of the principal causes that have provoked it. In a schematic resume' of the aforementioned causes, taking into account the interaction between them, these causes can be defined in terms of their purely methodological effects:

1. Physical causes:

a) Decrease in the amount of sediment carried by rivers that flow into the sea. This is due to the reduction of common land in the interior of the peninsula, mainly as a result of the process of forestation and urban development.

b) Poorly conceived or designed works of maritime engineering with barriers that block the longshore flow of sediments along the coast, or that augment the power of the waves, have increased erosion rates on the coast.

c) The disappearance of reserves of materials such as dunes along the coast, or the construction of buildings that have prevented the natural seasonal change in the profile perpendicular to the beach.

d) The disappearance of areas such as marshlands, that have not been perceived as being important nuclei for the reproduction of wildlife, to the extent of legally encouraging their draining.

2. Legal causes

The lack of regulation in the use of this public property or the absence of an adjacent buffer zone protecting coastal lands are two legal omissions that may be considered within this framework.

As a consequence of the described situation there is a demand for space on the coast, for people, industry, and agriculture, that, together with an important reserve for leisure activities, exceed the supply under normal conditions. The Shores Act, taking as a starting point these circumstances and respecting legitimately acquired rights, is aimed at reorientating this situation; preserving the zones that are saveable, preventing further deterioration where the situation is already negatively consolidated, and revitalizing, as far as budget limitations permit, situations whose continuation can only provoke an accelerated deterioration of the environment.

<u>The Spanish Shores Act</u>

The Act is based in the constitutional mandate that, in Article 132.2, declares as public property the foreshore, beaches, territorial waters, and the material resources of the economic zone and continental shelf of Spain. The Act gathers the principles of article 45 of the Spanish Constitution with regard to the right of all individuals to enjoy a suitable environment and the duty to conserve it, along with the duty of the public powers to protect and improve the quality of life, applying penal or administrative sanctions against those that infringe these rules of conduct and obliging them to repair damage caused. In the same manner, the Act takes into account the criteria contained in Recomendation 29/1973 of the European Council concerning the protection of coastal zones and in the Shores Chart of 1981 of the European Economic Community, among other plans and programs of this organization.

In describing the Act we will follow, in order, the various titles that make it up, summarizing its contents. For methodological reasons, some of the transition provisions have been included together with the regulation in question.

Preliminary title

The preliminary title establishes the object of the Act and its aims which guide subsequent administrative activity. These aims include:

a) to define the portion of the coast which should be legally considered as public property and ensure its integrity and adequate preservation.

b) to guarantee the public use of the sea, the shores, and the remaining portion of the coastal public property.

c) to regulate the rational use of said areas under terms which suit their nature and purpose and which respect the landscape, environment, and historical heritage.

d) to achieve and maintain an adequate level of water and shores quality.

The Shores Act, therefore, does not regulate and order all aspects that affect the coastline. The distribution of responsibilities that the Spanish Constitution establishes in this respect between the various public administrations gives the responsibility for territorial and urban planning to the regional governments and to town councils.

Title I

A) Defines the precise form of coastal public property, which includes:

1) The seashore, comprised of two zones which are schematically defined as follows:

a) the foreshore--the zone reached by the maximum seasonal waves or maximum tides, including wet and low lying areas such as marshes, swamps, mudflats, fresh water lakes adjoining the sea, etc. This zone also extends along river banks to the head of the tide.

b) beaches--the definition coincides appreciably with the ordinary concept, and includes berms and dunes and all other areas formed by sand transported by the sea, the wind, or any other agent.

2) Territorial waters.

3) The natural resources of the economic zone and the continental shelf.

4) Other aspects of coastal public property, such as land reclaimed from, or invaded by, the sea, vertical cliffs, etc., along with islands in territorial waters or inland waters save where they are already incorporated in an estate.

In the management of the coastline, the seashore is the principal object of protection and the Act focuses on this area almost exclusively.

In case of a possible invasion by the sea of adjoining plots of land, the Act permits, the correct authorization having been obtained, that the owners of threatened lands to build defenses, provided that no negative effects are produced in adjacent properties.

B) Coastal public property having been defined, the Act proclaims its character to be inalienable, imprescriptible, and unimpoundable, and proclaims the incompatibily of these areas with their existence as private property. To this effect it is established that the above-stated definition of property takes preference over the real estate registry records.

C) The Act regulates the administrative procedure called Boundary Delimitation Proceedings that identifies the areas which constitute public property and that basically passes for an Administration proposal to which public and private interested parties have access. A resolution is then passed and the process concluded administratively.

Title II

With the aim of assuring the preservation of public coastal property and its public use, the Act establishes easements and property limitations on neighboring land, whose basic contents are as follows:

a) Protection Easement Zone: this affects a strip of 100 meters inland from the landward limit of the seashore. This width can vary depending on the Transition Provisions. In this zone, agriculture may be carried out without any type of permission. Other types of uses require previous permission from the Administration, although the Act itself lays down a series of uses prohibited in this zone, among which are residential uses or important intercity roads with high traffic levels. At the same time, it indicates uses which will ordinarily be authorized and which, by their nature, should occupy the zone--those that provide services necessary for the use of public coastal property and open air sports installations.

b) Right of Passage Easement: affects a strip between 6 and 20 meters wide in which the passage of pedestrians and surveillance and rescue vehicles must be permitted.

c) Access to the Sea Easement: permits the expropiation of land adjacent to public property in order to provide access where urban planning has not allowed for it, with a maximum separation between accesses in urban and development zones of 200 meters for pedestrians and 500 meters for motor vehicles.

All the limitations established by the Act in this title are minimum limits; the competent planning bodies can increase them by means of the corresponding regulations.

Title III

This title provides for the regulation of the use of coastal public property, principally the seashore as defined in Title I. Especially important is the limitation set down in Article 32 with respect to possible uses of this property: it can only be used for those activities or installations that by their nature cannot be carried out or located elsewhere. In any case, the prohibitions relating to the established uses for the protection easement zone still apply. The use or occupation of public property shall be free with free public access for those activities appropiate to the area.

Other uses or occupations require the existence of any of these titles:

a) Reservation: on behalf of the State Administion for the partial or total use of determined sections of public coastal property for the fulfillment of those goals within the scope of its powers.

b) Allocation: to Regional Governments for new ports or routes of transport.

c) Authorization: for uses that involve special intensity, danger, or profitability without permanent occupation of coastal public property, or that occupy it by means of a construction that can be dismantled. The maximum period of authorization is one year.

Among such authorizations the following merit special attention:

1) Those for seasonal services: These are granted for uses required by the intense demand on the beach in summer. Normally, these authorizations are granted to town councils and are run directly or through a third party. They normally apply to establishments selling refreshments or hiring pedal boats, sunshades, deckchairs, etc.

2) Disposal of liquid or solid waste into the sea which requires authorization from the Administration, and from the Regional Governments in the case of contaminating liquids. The Act lays down severe limitations for the disposal of contaminating materials, allowing this practice only where no alternatives exist and stipulating that rigorous precautions are taken.

3) Dredging and extraction of sand, stones, and gravel, which are subject to an evaluation study as regards coastal public property. The Acts prohibits extraction for construction except for beach creation or regeneration.

d) Concessions: regulating those occupations in coastal public property not previously described i.e. those not subject to reservation or allocation requiring permanent constructions or more than a year of implantation. The Act regulates the procedure for granting concessions, describes the content of the project that serves a base for the works, and the administrative procedures, including public information and the proposed conditions, offered to the applicant. Acceptance is a condition for the granting of the concession. The maximum period for which a concession may be granted is 30 years.

Title IV

The Act establishes that works in coastal public property shall be financed from the State budget, with possible contributions from regional governments, local governments, international organizations, and private parties. All occupation of public property shall be liable to a fee, set at 8% annually, calculated on a base determined by the value for tax purposes in comparable private use and the estimated annual net profits of the activity. Also established is the fee for the authorized disposal of contaminating wastes. This title also stipulates the sureties that petitioners of concessions and authorizations must provide.

Title V

In this title, the Act describes the infringements of coastal legislation, the corresponding sanctions, and the procedure for their determination and execution. These actions are independent of those which may be carried out by the ordinary jurisdiction in the case of their constituting an offense. The sanctions are established by means of sanction proceedings. If a violation is confirmed, a fine is imposed, precisely laid down by the Act in accordance with the type of infringement, and, in all cases, an obligation is imposed to return matters to their previous state. If this is impossible, a sum of compensation is set in accordance with the damage caused.

Title VI

As various Administrations have power in the coastal area, this title determines the responsibilities of each one and establishes the means of coordination.

The State Administration is responsible basically for those duties established by the Act. The Regional Authority is responsible for carrying out those duties relating to planning and zoning on the coast, ports, urban planning, waste disposal, and, in general, those granted in their statutes.

Local governments are responsible for reports on the fixing of boundaries, reservations, allocations, and concessions in public property, and for exploiting seasonal services, maintaining beaches and public places in clean hygienic and healthy condition, and ensuring that the rules and instructions issued by Central Government with regard to safety and saving of human lives are observed.

Of special importance is the interconnection between urban zoning and planning and the protection and management of public property through the reports submitted to the Central Administration prior to the approval of urban plans affecting the coastal zone.

Transition provisions

These deal with accommodating existing situations within the content of the new Act and temporarily regulating some of its content.

<u>Conclusion</u>

With the legal frame of Spanish coastal management set forth, its content is being implemented, which implies both legal and physical actions.

Sometimes, legal rules involve physical actions, as in Section 44 of the Act, which contains guidelines regarding action in the territorial ambit. That section establishes a preferential order of action in order to avoid the problems provoked by the inappropriate works such as those described earlier.

The regeneration of beaches, seafront promenades etc. and the allotment of human resources and materials to the bodies that manage the coastline always contend with economic limitations, since the various needs to be attended by the State encounter a limit in the budget. Such balancing often results in a compromise with respect to the different options of revenue and expenditure, formalized in democratic regimes by the Parliament representing popular opinion.

All these coordinated actions endeavor to achieve those objectives synthesized in the preamble of the Act: to guarantee the public character of coastal public property and conserve its natural characteristics, reconciling the necessities of progress with the imperatives of protection.

The Texas Coastal Management Plan: A State Initiative for Coastal Resource Management

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In early 1990, the State of Texas began developing a Coastal Management Plan for public lands. The effort is being led by the Texas General Land Office at the direction of the State Legislature. An earlier effort by the state in the late 1970's that was planned using federal funds and was aimed at qualifying for ongoing federal support never became part of the federal Coastal Zone Management Program. The current state-level initiative has a broad base of public support, represents a wide range of expert opinion, and balances many competing interest groups.

<u>Texas and the Federal Coastal Zone Management Program</u>

Texas took advantage of the opportunity--and the grant money--offered by the federal government under the Coastal Zone Management Act of 1972 to develop a coastal zone management program. The planning effort was coordinated by the Texas General Land Office, which succeeded in assembling representatives of traditionally competitive interest groups to discuss coastal problems and debate courses of action for improved management of coastal resources. It was an auspicious start.

But the Texas coastal management plan, first submitted to Governor Dolph Briscoe in 1976, was destined to fail despite valiant attempts to reshape it both to meet federal demands for a stronger program and to appease state interest groups that objected to any increase in government regulation or bureaucratic red tape. This proved to be an impossible balancing act.

The rising tide of environmentalism that led to the passage of the Coastal Zone Management Act was not strong enough in Texas to sustain the state's efforts to secure a federally-approved program. Furthermore, the robust health of the oil and gas industry at that time reduced the appeal of federal financial assistance promised to states with approved coastal management programs.

Opponents of the program within the state were more concerned about preventing federal interference than they were about winning federal assistance; they ultimately decided that they wanted to be free to manage their own affairs under the existing system. The state's proposed program lost ground at the federal level when an Attorney General's opinion concluded that the state had little or no authority over activities on private property adjacent to public lands.

Governor Briscoe left office in 1979 without forwarding the state's coastal management plan to the federal Office of Coastal Zone Management (OCZM), giving as his reason the absence of adequate support for the plan within the state. He also took the task of plan development out of the hands of the Texas General Land Office and made the Governor's Office directly responsible for coordinating Texas' coastal planning effort with the federal government.

Governor Bill Clements, reluctant to give up federal funding, appointed a task force to evaluate and revise the program document. In the summer of 1979, he submitted a revised plan to the federal government. This simplified version eliminated the complex "activity assessment routine" of the earlier plan and proposed in its place a network of memoranda of understanding among state agencies with coastal management responsibilities. It was received as a satisfactory compromise by many within the state, but federal reviewers saw it as a weak plan favoring industry and lacking firm support from environmental interest groups.

The state tried to satisfy federal conditions for program approval, turning development of the program over to the Texas Energy and Natural Resources Advisory Council (TENRAC), a coordinating body that included representatives of natural resource agencies. TENRAC's revised program document was submitted to the Governor in October, 1980.

In April, 1981, Governor Clements declined to forward this draft plan to OCZM, thereby ending the state's efforts to develop a federally-approved coastal management program. By this time, federal budget cuts had removed much of the incentive for Texas's participation in the program, and it was apparent that the Texas Legislature would not appropriate state funds for coastal management.

The Coastal Planning Effort Revived

Interest in a comprehensive coastal management program for Texas did not die with the demise of the state's effort to enter the federal program. Legislation signed by Governor Clements in June, 1989, S.B. 1571, made the Texas General Land Office the lead agency for development of a long-range management plan for the state's coastal public lands.

There are several explanations for the success of S.B. 1571 and for the widespread endorsement of the program development effort now under way. The program is confined to coastal public lands and therefore poses no threat to private landowners. Most importantly, this time the call for a comprehensive coastal management program came from the coastal communities, not from the state or federal government.

The coastal management legislation resulted from a grass-roots campaign conducted by coastal officials, environmentalists, and other interests aware of their need for help in solving large-scale problems of coastwide concern. Chief among these was shoreline erosion--an issue that unites coastal Texans of every stripe, from conservationist to industrialist. City and county officials all along the coast launched a letter-writing campaign urging state legislators to pass the coastal management bill; after the bill was passed, they launched a second campaign to persuade the Governor to sign it.

The State Program

S.B. 1571 directs the General Land Office to coordinate development of the state's coastal management plan with other state agencies that have responsibilities in the coastal area: the Texas Parks and Wildlife Department; the Attorney General's office; the Texas Water Commission; the Texas Water Development Board; the State Department of Highways and Public Transportation; and the Railroad Commission of Texas.

Land Commissioner Garry Mauro appointed representatives from these agencies and from the Bureau of Economic Geology at the University of Texas to a state agency task force for the plan. Representatives of the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Geological Survey, the U.S. Soil Conservation Service, and the Federal Emergency Management Agency serve on a federal agency task force.

As authorized by the Act, Commissioner Mauro also appointed a citizens advisory committee composed of coastal residents and persons with expertise in coastal matters. Its 70 members represent local government, the scientific community, and a broad range of interests, including commercial and recreational fishing, conservation, real estate development, and industry.

As a first step toward plan development, the General Land Office prepared briefing papers on nine issues of coastwide concern: non-point source pollution; oil spills; hazardous waste generation and disposal; habitat and wetland loss; freshwater inflow; coastal erosion; beach access; dune protection; and marine debris. These issue papers became the basis for discussion at public meetings held by the General Land Office in Beaumont, Galveston, Corpus Christi, Port Lavaca, and Brownsville during February, March, and April, 1990.

Participants in the public meetings identified shoreline erosion, wetland and habitat loss, and public access to beaches as the issues that should be the focus of the state's initial planning efforts. A computer-assisted workshop technique, the "Alternative Futures Assessment Process," is being used to develop a consensus among technical experts, concerned citizens, and public officials on appropriate management strategies for each of the three primary issues.

The Alternative Futures Assessment Process

Conventional planning approaches to resource management tend to stress teams of experts pooling their knowledge to produce a blueprint for change. The General Land Office sought a technique that would not only employ expert knowledge, but would also build the broadest possible base of support for the plan among those most directly affected by it--coastal residents.

The Office for Strategic Studies in Resource Policy at Texas A&M University submitted a proposal to use the Alternative Futures Assessment Process to lay the groundwork for development of the coastal management plan. This process, designed by Tom Bonnicksen of Texas A&M, is a phased approach that spans several months and involves representatives of a wide range of interest groups.

The Texas Legislature appropriated no funds for development of the coastal plan. The Texas Water Development Board provided partial support for implementation of the Alternative Futures Assessment Process from its research appropriation. Texas A&M University and the General Land Office shared the balance of the costs of the $65,000 project. The three groups which participated in the alternate futures process were:

- Subject matter experts
- Interest groups and their representatives
- Office holders and their representatives

Three types of workshops were used to develop an overall futures assessment (Figure A). First, three foundation workshops were held, one each in the upper, middle, and lower portions of the Texas coast. Each of these treated all three broad issues--shoreline erosion, wetlands, and beach access--so that representatives from each geographic region of the coast could define the "variables" that most accurately characterize these issues in their area. As many as 100 variables were developed as the database from which the most critical variables could be derived.

A strategy workshop for each of the three issues then analyzed the top 30 variables related to a topic and refined them using a variety of processes and tools. A typical list of variables for shoreline erosion is shown in Figure B. One tool for using the experience, preferences, and knowledge of the group was the construction of a cross impact matrix showing whether there is a positive, negative, or nonexistent relationship between two variables.

During the two-day strategy workshops, many different operations were performed on the different variables or issues. Participants were asked for their opinions on the possible range of outcomes, (i.e., what is the maximum likely amount that research dollars will go up) and for their preferences concerning the degree of change for any given variable (e.g., tourist visitation).

These opinions and preferences were processed using a computer program called "E Z Impact." The program software is limited to a maximum of fifteen inputs. Hence, the number of participants had to be pared to fifteen, who worked with several of their counterparts to reach a consensus on how to vote their 1/15th of the strategy-setting process. Figure C shows stakeholder groups, individual participant names, and the organizations or interests which they represented in the shoreline erosion/dune protection workshop.

In some activities, participants provided expertise; in others they voted the preferences of their organizations. In some cases, they voted in a way that maximized their group's objectives, and in other situations they predicted outcomes of issues.

The capstone workshops--one for each issue--were the third and final stage of the process. Their purpose was to refine and improve the major findings developed in the strategy workshops. Figure E shows the agenda for the one-day session. One of the first steps was to get group agreement on how much of a given variable is caused by external impacts. Figure B illustrates the external impact (in the right-hand column) for the thirty variables. During the capstone workshop, all aspects of the top five variables that had an impact on the main issue (shoreline erosion in this case) were considered.

Outputs of the Process

As an example of the kinds of results the process yields, the most critical single issue on wetlands derived through the alternate futures process was wetland loss. According to the U.S. Fish and Wildlife Service, approximately 35% of Texas coastal marshes were lost between the mid 1950's and 1979. Participants in the workshops defined the five most important support strategies that could address wetland loss as follows:

1. Reduce wetland degradation

a. Address the sources and effects of overall runoff pollution containing excess nutrients, pesticides, and other harmful contaminants.

b. Adopt a goal of no net loss of wetlands that is appropropriate to Texas and that provides for compensatory mitigation and monitoring of results.

2. Improve interagency coordination

a. Promote a networked approach that divides responsibilities and sets decision-making roles.

b. Set water quality standards that will protect wetlands.

3. Promote education on the value of wetlands

a. Land acquisition for flood storage, fisheries enhancement, and wildlife habitat has definite positive benefits in flood insurance rates, fish catch, and tourism.

b. The magnitude of loss and the benefits of restoration are key points for learning.

4. Wetland enhancement/restoration

a. Much current mitigation is fragmented and ineffective.

b. Texas can set an administrative system for promoting restoration and giving credits to landholders who are protecting the resource.

5. State appropriations of funds

a. The proposed Heritage Trust Fund and the Land and Water Conservation Funds are important steps toward acquisition.

b. Valuation of wetlands, basin-wide plans, inventories of private holdings, and regional strategies based on types of ecosystems are candidates for funding by state appropriations.

Conclusion

Several characteristics of the Alternate Futures Assessment Process made it work well for formulating strategies for the three coastal management issues.

o Plenty of experts and office holders presenting their points helped to make expectations more realistic and attainable.

o A large amount of information exchange and learning took place during the process. As an example, a geological concept such as the sand budget is explained by a scientist as the sources of accretion and erosion from rivers, currents, storm events, etc. This information goes to representatives of office holders and interest groups and advances the chances of workable policies.

o Because the workshops were phased over several weeks with analyses and revised documents distributed to participants between meetings, there was time for reflection and review on what would work in a coastal plan.

o The use of a skilled facilitator who did not take sides on an issue helped to achieve consensus on questions such as how much of bay shore erosion is caused by external impacts.

o The use of computer programs to record and revise assessments was very helpful in finding errors. After major exercises were complete, the computer program quickly translated the groups' decisions to various tables and reports for further review.

The principal virtue of the Alternative Futures Assessment Process is that it compels adversary groups to concentrate on areas of agreement. This is vital to the success of the coastal planning effort. The failure of the first attempt to develop a comprehensive coastal management plan for Texas was largely due to persistent dissension among interest groups.

The final results of the Alternate Futures Assessment Process will become the basis for proposals submitted to the Texas Legislature under the overall Coastal Management Plan.

Figure A

THE ALTERNATIVE FUTURES ASSESSMENT PROCESS
FOR THE TEXAS GULF COAST

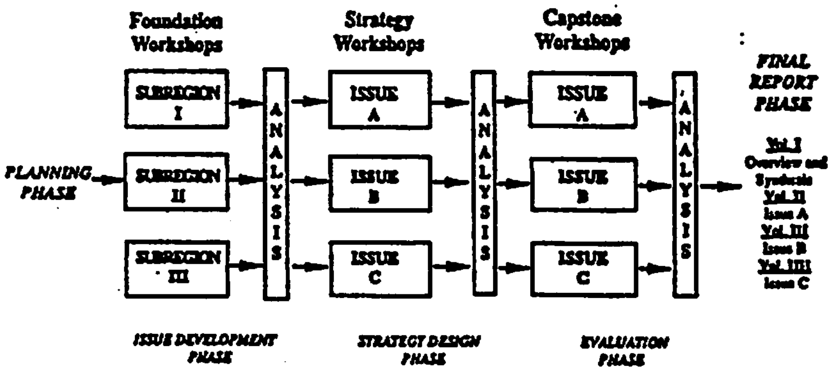

Figure B

SHORELINE EROSION/DUNE PROTECTION

Variable List and Trends

No.	Variable Name	Variable Description	Unit of Measure	Maximum Increase (%)	Expected Change (%)	External Impact (% Exp.)
1	SCI-DAY1	Available Data	Sci Days/Yr	330.0	62.0	10.0
2	RESRCHX2	Gulf Research Funds	Research $/Yr	220.0	34.0	10.0
3	BAY-EROS	Bay Shore Erosion	Ft Lost/Yr	180.0	31.0	70.0
4	BAY-VEG9	Bay Shoreline Veg.	Acs Cov/Shore Mi	151.0	16.0	10.0
5	BEANOUR3	Beach Nourishment .	Cu Yds Add/Mi/Yr	181.0	18.0	10.0
6	BEA-RPS2	Beach Replenishment	Program $/Yr	167.0	17.0	10.0
7	BLKSEDC5	Blk. Coast Sediment	Cu Yds Block/Yr	113.0	26.0	10.0
8	DGREUSE3	Dredge Spoil Reuse	Cu Yds Reused/Yr	281.0	68.0	10.0
9	DUNPROT4	Dunes that Protect	% Protect/Mi/Yr	101.0 -	13.0	10.0
10	DUN-VEG9	Vegetated Dunes	% Covered by Veg	115.0	0.0	10.0
11	ECOINTG4	Ecological Integrity	Acs Undisturb/Mi	75.0 -	13.0	10.0
12	MANAGEX2	Fed/State Mgmt Funds	Manage $/YR	170.0	17.0	10.0
13	GULF-ERS	Gulf Shore Erosion	Ft Lost/Yr	208.0	72.0	60.0
14	HWYLOSS5	Highway Losses	Days Closed/Yr	91.0	51.0	10.0
15	HUMA-ERS	Hum. Induced Erosion	Ft Lost/Yr	256.0	86.0	10.0
16	COMRCE30	Commerce	$ Generated/Yr	236.0	96.0	50.0
17	BLKSEDI5	Blk. Inland Sediment	Cu Yds Block/Yr	145.0	33.0	10.0
18	PLANING1	Implementable Plans	# Plans/Yr	158.0	137.0	10.0
19	PUBEDUC1	Public Education	Hrs Exposure/Yr	338.0	90.0	10.0
20	RIV-SND5	River Supplied Sand	Cu Yds/Yr	181.0 -	28.0	10.0
21	SANDBUD8	Sand Budget	Cu Yds Avail/Yr	25.0 -	22.0	10.0
22	SETBACK1	Set Backs	Ft Mn High Tide	124.0	46.0	10.0
23	SHIPTR70	Ship Traffic	#/Yr	139.0	45.0	50.0
24	STCOORD1	State InterAg Coord.	Eff Joint Act/Yr	296.0	76.0	10.0
25	SUBSIDE5	Subsidence	In/Yr	149.0	22.0	10.0
26	TOURSC30	Tourism Revenue	$ Generated/Yr	246.0	95.0	10.0
27	TRASH 5	Trash	Tons/Mi/Yr	239.0	59.0	10.0
28	VEH-BEA0	Vehicle Beach Use	# on Beach/Yr	156.0	83.0	10.0
29	WETLAND6	Wetlands	Acs/Yr	169.0	46.0	10.0
30	HABLOSS6	Wildlife Hab. Lost	Acs Lost/Yr	326.0	78.0	10.0

Time period is 20 YEARs, beginning 1/ 1991.

Figure C

TEXAS COASTAL MANAGEMENT PLAN

SHORELINE EROSION & DUNE PROTECTION PARTICIPANTS

Stakeholder Group Name	Stakeholder Group Description	Representatives	Organization / Interest
Commerce	Economic Development	Obie O'Brien Pete Pracis	Mitchell Energy & Development Council for South Texas Economic Program
SubsDist	Houston/Galveston Subsidence District	Ron Neighbors Karen O'Neal	Houston/Galveston Subsidence District Houston/Galveston Subsidence District
Academia	Academia	Mary Thorpe, Ph.D.	Geologist, Del Mar College
Environ	Environmental	Sharron Stewart Rex Wahl	Texas Environmental Coalition National Audubon Society
GasPipe	Gas Pipeline	Terry Doyle Mike Speed	Enron Oil and Gas Consulting
Ports	Ports	Richard Gedel Paul Carangelo	Port of Houston Port of Corpus Christi
CityGov	City Government	Robert Pinkerton Robert Lynch	Mayor, South Padre Island Galveston City Council
GalvesCo	Galveston County	Pat Hallesey Frank Frankovich Lou Muller	Galveston County Parks Board Dannenbaum Engineering Park Board of Trustees
JefferCo	Jefferson County	Richard LeBlanc Robert Broder Malon Scogin	Jefferson County Judge Jefferson County Engineer Sea Grant Marine Extension Service
HarrisCo County	Harrison & Chambers Counties	Bob Nailon	Texas A&M Marine Advisory Service
SenatorB	Senator Chet Brooks	Neal Hurt	Senator Chet Brooks
SenatorP	Senator Carl Parker	Marty Conway	Senator Carl Parker
SenatorT	Senator Carlos Truan	Vicki Hines	Senator Carlos Truan
StateAgn	State Agencies	Andy Morgan Sally Davenport Kim McKenna Don Dial C. F. (Dick) Schendel Jeffrey Paine	Texas General Land Office Texas General Land Office Texas General Land Office State Department of Highways & Public Transportation State Soil & Water Conservation Board Bureau of Economic Geology
FedAgn	Federal Agencies	Sidney Tanner Jim LeGrotte B.D. King Dana Barbie David Myers	U.S. Army Corps of Engineers Federal Emergency Management Agency U.S. Fish and Wildlife Service U.S. Geological Service U.S. Soil Conservation Service

North Carolina's Unprecedented Approach to Reviewing Mobil's Plan to Explore for Gas and Oil Off Its Coast

Donna D. Moffitt
North Carolina Department of Administration

Introduction

In the fall of 1988, Mobil Exploration & Producing U.S., Inc. announced that it would submit an exploration plan to conduct exploratory drilling approximately 45 miles northeast of Cape Hatteras, North Carolina. A draft plan has been reviewed by the state and a final plan is currently under review for consistency pursuant to the Coastal Zone Management Act. Although Mobil would like to drill as early as spring of 1991, a new law called the Outer Banks Protection Act, which is part of the Oil Pollution Act of 1990, will prevent the federal government from approving Mobil's drilling plan until October 1991, at the earliest. This effectively prevents Mobil from drilling until spring of 1992 because of weather-related constraints, assuming there are no additional delays due to litigation or administrative appeals.

Mobil proposes to drill a test well on a lease block (9 square miles of ocean bottom) it bought in 1981. The proposed well site is located under 2,700 feet of water and is subject to Gulf Stream currents most of the time. Mobil plans to drill the well with a 534-foot turret-moored drillship held in place by eight 30,000-pound anchors. Mobil estimates it will take approximately 130 to 140 days to complete the drilling to a total depth of 14,000 feet, and that it has a 10% chance of finding natural gas and a 1% chance of finding oil.

Because offshore oil and gas exploration is a new experience for North Carolina, state officials have responded with concern and caution. The state has expended considerable effort to prepare itself for the complex review of Mobil's proposal to drill an exploratory well. This paper will provide a brief background of North Carolina's experience with the OCS oil and gas program and describe the state's unprecedented Memorandum of Understanding (MOU) with Mobil and the Minerals Management Service (MMS) of the Department of the Interior.

Leasing Activity Off the North Carolina Coast

Industry interest in potential deposits of oil and gas off the East Coast of the United States has been erratic. Past and current interest has generally focused on the existence of a buried limestone reef of Jurassic age extending almost the entire length of the Atlantic coast in an area just beyond the edge of the continental shelf. This submerged reef, which contains the same geologic features found in the Gulf of Mexico, exists in water depths ranging from 600 to 6,000 feet. While the precise dimensions of the reef are unknown, researchers believe its location ranges from 25 to 100 miles off the Atlantic coast.

Given the proper organic material, temperature, and pressure during the Triassic period, the Atlantic submerged reef has the potential to be a major trapping structure for oil and gas. The reef is thought to occur off the North Carolina coast in an area known as the Carolina Basin, and is the last major basin not yet explored in the Atlantic Ocean off the United States. The 53 active leases (i.e., continuing to pay annual rental) off the North Carolina coast are concentrated where the limestone reef is believed to lie buried approximately 11,000 feet beneath the seafloor.

Lease Sales

Several lease sales have been held off the North Carolina coast, and two more proposed sales are scheduled over the next three years. At one time, a maximum of 60 blocks were under lease off the North Carolina coast, but only 53 remain active at the present time. Most of the lease blocks are 35 to 45 miles east of Oregon Inlet. The nearest block is approximately 25 miles east of Cape Hatteras and the farthest is approximately 150 miles southeast of Wilmington. The blocks off the North Carolina coast are leased for 10-year terms; however, the terms can be extended by the Interior Department for extended environmental reviews, litigation, or appeals.

Exploration Activities Off the North Carolina Coast

Previous exploration plans

Although 47 exploratory wells have been drilled in the Atlantic Ocean off the United States coast, no oil and gas exploratory wells have been drilled in the ocean off the coast of North Carolina. While some shows of gas were encountered off New Jersey, no commercially viable discoveries have been made in the Atlantic off the United States.

Exploration plans were previously submitted by Chevron and ARCO, approved by MMS, and found consistent by North Carolina in 1982 for exploration on blocks leased in 1981. Neither company requested final drilling permits from MMS after receiving approval of their exploration plans and NPDES discharge permit applications. Necessary plan approvals from MMS and NPDES permits from EPA for both companies have now expired.

Mobil's Exploration Proposal

In August 1988, MMS notified North Carolina that Mobil planned to submit an exploration plan to drill up to up to seven wells in the spring of

1989, with the first well to be located on Block 467, approximately 45 miles northeast of Cape Hatteras. Mobil was to submit the plan as the lead company of a consortium of eight oil companies that intended to submit a plan covering a 21-block exploration unit and seven exploration wells. Mobil and its partners subsequently decided that they would submit a plan to MMS covering one wildcat well on Mobil's Block 467 and, if a discovery was made, another exploration plan covering the remaining six exploratory wells would then be submitted.

The 21-block unit is known as the Manteo Exploration Unit. The eight companies planning to participate in the exploration of the unit are Amerada Hess, Chevron, Conoco, Marathon, Mobil, Occidental, Shell, and Union. Of the 21 blocks, 19 were leased in 1981 and 2 were acquired in 1983. A total of $296,294,000 was paid as bonuses to the federal government for the blocks in this unit. Block 467, the site of Mobil's proposed exploration wildcat well, attracted the most interest in the lease sale held in 1981. A partnership of Mobil, Marathon, and Amerada Hess oil companies paid $103,775,000 for the lease. All of the leases in this unit will expire 10 years from the date of their lease sale unless approved activities are underway by the end of the primary lease term. If hydrocarbons are produced from the blocks in this unit, the companies will pay a royalty of 12.5% to the federal government.

Although all leases off North Carolina were acquired by mid-1983, exploration off the North Carolina coast was postponed by all leaseholders in the mid-1980s when exploration budgets were drastically reduced due to the drop in oil prices. Since the leases in the Manteo unit were nearing the end of their lease terms, all eight oil companies met in early 1988 to discuss the formation of an exploration unit. Block 467 was identified as the most promising site to drill an initial wildcat well to test for the presence of oil or natural gas. As the majority owner of Block 467, Mobil was named operator of the unit and is responsible for submitting an exploration plan and securing necessary approvals and permits.

Site-specific concerns identified by North Carolina

North Carolina is concerned about the unique conditions at the proposed drill site, the importance of the site to recreational and commercial fishing interests, and the lack of adequate environmental and socioeconomic analysis in previous lease sale EISs or the current plan documents. The oceanographic conditions at the site where Mobil plans to drill are extremely dynamic. The unusual ocean current regime could result in operational problems during drilling, unpredictable dispersion patterns and water column suspension of drilling muds, the increased likelihood of being unable to contain or clean up spills, and the increased potential for spills being brought to shore rapidly and at unpredictable locations. Gulf Stream currents fluctuate between 2 and 6 knots, spin-off eddies sweep across the site on the average of every 2 to 10 days, and waves can approach 20 feet in height during northeasters. The sea bottom at the drill site is characterized by extremely rugged conditions, canyons, a continental slope of 15°, and known slope failures nearby.

The site is also biologically rich and diverse because of upwelling currents and other unique conditions created by the separation of the Gulf Stream from the continental shelf. Researchers working in and around the proposed test well site have discovered that it has the highest faunal and floral densities and biomass yet measured on the Atlantic slope and rise, and productivity of the benthic (bottom dwelling) community is unusually high in the drill site area. The biological density measurements are comparable to those of a salt marsh, or wetland, environment.

Block 467 contains an area known locally to North Carolina recreational and commercial fishermen as "The Point," which is one of the most intensely used recreational fishing sites on the East Coast for marlin, wahoo, and dolphin. Large numbers of mackerel and tuna are also caught there and significant commercial fishing activities also occur in the Point area. Whale, porpoise, and sea turtle migration routes pass through this area, which is also an important site of concentrated sea bird activity. No previous lease sale EIS has identified the concentration of diverse biological resources located in and around the Point or properly analyzed impacts that may result from drilling activities in the area.

Because of the lack of site-specific data, the state believes that Mobil is unable to adequately assess impacts from its drilling discharges. This lack of critical information was the basis for the state's decision that it could not concur with Mobil's consistency certification for the proposed NPDES discharge permit from EPA. Mobil appealed the state's decision to the U.S. Department of Commerce, where it is presently under administrative appeal.

State review and comment rights

North Carolina has several statutorily-prescribed procedures and an unprecedented Memorandum of Understanding (MOU) for reviewing and commenting on the Mobil exploration activities. The major statutory authorities are: (1) the Outer Continental Shelf Lands Act (OCSLA), as amended; (2) the Coastal Zone Management Act (CZMA); and (3) the Clean Water Act. The Marine Mammal Protection Act and the Endangered Species Act provide some minimal review and comment rights. The National Environmental Policy Act mandates that certain internal standards be met by MMS, but it does not provide a separate review right to the state or the public for exploration plans.

Memorandum of Understanding signed by North Carolina, Mobil, and MMS

Although MMS had never prepared an EIS for any of the previous 6000 or so exploration plans that had been approved, North Carolina insisted that one be prepared (covering all 21 lease blocks in the unit) to provide an up-to-date review of the potential environmental impacts, to address development and production issues, and to guarantee significant public involvement. The state also sought more than the usual 20 days allotted to the governor for his environmental assessment of Mobil's exploration plan. On 17 July 1989, North Carolina, MMS, and Mobil signed an agreement providing an alternative process to the traditional 30-day environmental review for exploration plans authorized by the OCSLA. The MOU process had the potential to provide the up-to-date information, impact analysis, and public involvement that North Carolina had originally sought through a new EIS. Although the agreement established an environmental review process, it did not commit North Carolina to any particular final position.

In the MOU, MMS agreed to prepare an environmental report that met many of the requirements of, but would not be called, an EIS. Mobil agreed to provide a draft exploration plan for the state's review, something never before required for an OCS exploration plan. MMS and North Carolina negotiated over the process and scope of environmental review. The MOU defined the contents of the environmental report, which went beyond the scope of an EIS to include development and production information, oil spill scenarios, impacts from theoretical pipeline routes, and production and development socioeconomic impacts. The agreement ultimately resulted in MMS preparing a 2-volume draft report, a 3-volume preliminary final report, and a 3-volume final environmental report. Nearly two dozen public meetings were held by MMS and the state in satisfying the terms of the MOU. Mobil received agreement from MMS that the 10-year leases of the 21-block unit would not expire during the review process. MMS has granted Mobil and its partners a suspension of the lease terms and rental payments for all 21 lease blocks while environmental reviews and appeals are underway.

The MOU provided the framework for an environmental review process that North Carolina had sought, but may not have been able to acquire by litigation or congressional action. The scope of the review was greater than would have been provided under a traditional EIS. It was expanded both geographically through coverage of all 21 blocks, rather than the one block where Mobil's test well was to be located, and temporally through coverage of future issues associated with development and production. The environmental report was to focus on the issues and concerns of North Carolina and its citizens, rather than on the potentially more rigid requirement of a formal EIS. Most important, the state relinquished none of the legal rights that it had before entering into the agreement.

In exchange for the environmental report and a minimum five-month review (which ultimately turned out to be one year) of Mobil's draft exploration plan, the state agreed to shorten its formal Coastal Zone Management Act (CZMA) consistency review period to 75 days from the date of receipt of Mobil's final exploration plan by the state Division of Coastal Management, the agency responsible for conducting the CZMA consistency review. By 19 November 1990, the state must determine if it concurs or objects to Mobil's certification that the proposed activities will be consistent with North Carolina's coastal management program.

The draft environmental report was prepared by MMS and submitted to the state on 01 November 1989. North Carolina found the draft report inadequate on the grounds that it failed to include the best available data and lacked sufficient environmental analysis. MMS submitted a preliminary final environmental report on 01 June 1990. While the second document was an improvement, the state was still concerned that critical site-specific data had not been collected and, therefore, the environmental analysis was incomplete. On 31 August, MMS submitted the final environmental report and Mobil's final exploration plan to the state. This action triggered the governor's 20-day OCSLA review and the state's 75-day CZMA consistency review.

The OCSLA requires MMS to act on the exploration plan within 30 days of deeming it complete by either approving it, disapproving it, or returning it to the applicant for modification. MMS has never disapproved an exploration plan. The governor recommended that MMS return the plan to Mobil for modifications consistent with the findings of the Environmental Sciences Review Panel established by the Outer Banks Protection Act. The Outer Banks Protection Act was added to the Oil Pollution Act by Representative Walter Jones of North Carolina. The act contained a legislative finding that neither the draft environmental report nor the preliminary final environmental report had allayed coastal North Carolinians' concerns about offshore drilling.

The new law prohibits MMS from approving Mobil's plan, holding lease sales, or approving development plans until 01 October 1991, and then only if the Secretary of the Interior can certify to Congress that environmental and socioeconomic information is adequate to approve the actions. The Environmental Sciences Review Panel is to assess the adequacy of ecological, oceanographic, and socioeconomic information for OCS activities off the coast of North Carolina. The panel is to report by 18 February 1991.

Change in National OCS Policy

The MOU process was working reasonably well; however, an event in June 1990 caused the governor to publicly oppose Mobil's plan before the completion of the review period. That month, President Bush significantly changed the national policy regarding OCS oil and gas activities in undeveloped areas when he ordered a 10-year delay on oil and gas leasing and development off southwest Florida, Washington, Oregon, the North Atlantic, and 99% of California. The President also asked the Secretary of Interior to establish a process to buy back existing leases off southwest Florida and ordered MMS to conduct additional oceanographic and socioeconomic studies in all these areas.

One implication of the President's order has been for the federal government to push more aggressively for exploration off the North Carolina coast. The current crisis in the Middle East has also bolstered the administration's argument that drilling for domestic energy resources (as opposed to energy conservation) will somehow contribute to national security, even though the United States contains only about 3% of the proven worldwide oil and gas reserves.

The areas that President Bush has put under a 10-year moratorium are estimated to contain 2.54 billion barrels of oil and 24.07 trillion cubic feet of natural gas. The exploration area off the North Carolina coast is estimated to contain only 5 trillion cubic feet of natural gas, yet North Carolina was left out of the 10-year moratorium. Governor Martin reasoned that if the President could put nearly all of the offshore continental United States under a 10-year drilling delay, then new sources of OCS oil and gas must not be that critical. Hence, North Carolina should not be the only state facing risks from offshore exploration and he announced his opposition to Mobil's drilling proposal. The governor stated further that he will reconsider his decision only if the President rescinds his decision or if the nation faces a critical energy shortage.

Conclusion

North Carolina is the only state besides Alaska that is facing frontier exploration for gas and oil. The state, having little experience with the federal offshore oil and gas program, has used the federal regulatory process and side agreements, such as the MOU, to the maximum extent possible to ensure that a full and open environmental review takes place on Mobil's drilling proposal. The extended environmental review process established by the MOU resulted in the most information for, and the most extensive analysis of, a one-well exploration proposal in the history of the OCS program. The state agencies responsible for reviewing the material became better educated about potential impacts from oil and gas activities both at the one-well stage and the production stage. The public has been afforded substantial opportunities to also become educated and to be heard on all facets of the current proposal and possible future activities.

The MOU process was innovative and largely successful, and could serve as a model for how MMS handles other frontier exploration proposals. However, events beyond the control of the three parties to the MOU caused the governor of North Carolina to take a position opposing the drilling proposal prior to the conclusion of the MOU process. Nevertheless, coastal states could benefit from similar agreements with MMS over oil and gas activities off their coasts to increase the amount of time and the scope of the environmental review for exploration proposals in frontier areas.