PAPERS

from the Estuarine Management Practices

Baton Rouge, Louisiana

NATIONAL SEA GRANT COLLEGE PROGRAM
NATIONAL MARINE FISHERIES SERVICE

PAPERS

from the

Estuarine Management Practices

Symposium

1985

NOVEMBER 12-13, 1985
PRINCE MURAT INN
BATON ROUGE, LOUISIANA

NATIONAL SEA GRANT COLLEGE PROGRAM
NATIONAL MARINE FISHERIES SERVICE

LOUISIANA
SEA GRANT
COLLEGE PROGRAM
LSU Center for Wetland Resources
Baton Rouge, Louisiana 70803

October 1986

TABLE OF CONTENTS

PROCESS OR PRODUCT?
ETHICAL PRIORITIES IN ENVIRONMENTAL MANAGEMENT

Mark Sagoff
Center for Philosophy and Public Policy
University of Maryland, College Park

"A general philosophical schism," Charles Peterson (1984) writes, "exists among the public and scientists, separating those who believe that nature can be improved by the works of man (the biotechnologists) from those who treasure and seek to preserve the biological and ecological status quo (the bioconservatives)."

Those who believe nature can be improved by technology would transform comparatively wild or natural environments into managed aqua-agricultural systems or develop them for industrial, residential, or recreational purposes, when to do so increases the benefits that nature offers man. Those who seek to preserve ecosystems in a comparatively natural state, on the other hand, would restrict technological interventions into the environment in order to assure the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife.

This essay discusses the values--or, more precisely, the conceptions of value--that underlie these two positions. I shall suggest a framework for reconciling these two approaches in environmental regulation. Although I will draw general conclusions, the essay will focus on particular regulatory problems, specifically, issues that arise in wetland and estuary management.

Two Conceptions of Valuation

The schism in environmental management between the biotechnologists and the bioconservatives corresponds to a distinction philosophers draw between two ways we may love a person or value an object.

First, we may value something (or someone) for the good it (or he or she) does us; i.e., we may value the thing for the wants it satisfies or for the uses to which it may be put. In that case, it is not the <u>object</u> we admire or cherish but its useful <u>characteristics</u> or <u>qualities</u>. We would transfer our love to another object, therefore, if it had more desirable or more useful characteristics, and we would care for the object less if it provided few benefits--fewer goods and services--for our use or enjoyment.

Second, we may value or love a particular object or person <u>per se</u>; we usually think of members of our families, for example, our <u>children</u>, this way. We value the characteristics of a child, of course, but we value them primarily insofar as they are the properties of that person. If a person's qualities change--if a rich friend loses his money--we will not love that person less, in this example because he can no longer pay for dinner. Nor would we transfer our affection to another--a richer person, or a child with more favorable qualities (Vlastos 1973).

We value wetlands, estuaries, and other environments in both of these ways. First, we value the useful and enjoyable products of estuaries, and we might want to preserve or protect those ecosystems for the sake of the goods and services they provide. But if that were our only way of valuing the estuary, we should prefer an aquacultural or an industrial process if it gave us more of the same--or improved--products and services more cheaply. And we should allow a wetland to be converted--to a country club, a liquid highway, a sewer, or a residential development--if, all things considered, that would be more useful or more beneficial to man.

Those who treasure and seek to preserve the biological and ecological status quo, however, value the products and properties of nature in part because they are the products and properties of nature. They cherish the product and the process together and not the evolutionary process simply as one method, which could be replaced by more efficient methods, for obtaining a variety of commodities and services.

This philosophical or ideological difference results, of course, in differences of opinion concerning what is optimal, for example, with respect to fresh water flow, sedimentation, and so on, in estuarine management.

Managers wishing to make the most efficient use of estuaries would define optimal levels as those which greatly increase production of whatever satisfies consumer interests, preferences, or demands over the long run. Those who would preserve the ecological and evolutionary integrity of nature, on the other hand, understand optimal levels of salinity, sediment, or whatever, to be those levels, roughly speaking, that would have existed--or generally have existed--in the absence of large-scale human interventions.

Our problem is to reconcile these two positions in a reasonable environmental policy. I am going to suggest a general framework for doing this. I shall work from the view I have taken, namely, that the two sides differ not simply in values but in the approach they take to valuation and in the object which they consider valuable. I shall argue that we may reconcile these positions if we respect each for what it is and regard neither in itself as a sufficient basis for environmental regulation.

Process or Product?

Many environmental scientists have argued that the schism in estuarine policy, for all intents and purposes, is not as deep as it seems. These scientists point to the deleterious effects of unintended spillovers (e.g., agricultural runoff) on the economically important contributions marshes and estuaries may make, for example, to the maintenance of coastal fisheries (Schubel 1984). These arguments suggest that the best way to increase the productivity of estuaries generally is to restore their biological integrity or to preserve their historical ecological status and character (Nixon 1980, Pope and Gosselink 1973, Shabman and Batie 1980).

Those who believe nature can be improved by the works of man, however, do not deny that accidental technological spillovers often have deleterious effects. They argue that technology, applied skillfully, can repair the damage, and they may substitute efficient artificial systems for fragile and expensive natural processes and environments.

There is a lot to be said for the biotechnological approach. Whether in the corn fields of Nebraska or the feedlots of Texas, the salmon ranches of Washington or the chicken farms of Maryland, America depends upon science and technology to increase the productivity and profitability of natural resources. Genetic engineering takes the next step in freeing aquaculture and agriculture from the uncontrollable and often unpredictable forces of nature, and so the computer is poised to replace the tiller and the plow (Cochrane 1979, Doyle 1985, Kalter 1985).

Consider salmon. The time between birth and harvest (three years for a large salmon) is one reason fish farming has not become as efficient as poultry production. Scientists in British Columbia, however, have doubled the growth rate of salmon by treating them with a recombinant hormone taken from chickens. These scientists, by breeding only females and sterilizing them, have produced a <u>better</u> salmon, one not discolored by sexual maturation, and one that can be mass produced and marketed all year. "Further, in the wild, breeding fish die shortly after mating; sterile fish do not mate, so they live longer and grow larger than their normal counterparts" (Klausner 1985).

Similar aquacultural breakthroughs, many involving genetic engineering (Avault 1983), are reported for scallops, shrimp, oysters, striped bass, grouper, trout, and on and on (Lovell 1979). If we can apply industrial methods of production to chickens why not to fish?

How long can we expect to preserve estuaries and wetlands as the last frontier for hunting and gathering--the last major resource that functions inefficiently as a commons? If we have profit, production, and efficiency in mind, we may have to replace the slow, random processes of evolution with the up-to-date technologies of bioindustry and bioengineering.

If the Chesapeake Bay is to be an efficient producer of seafood, for example, technological methods of aquacultural production may have to replace wild or natural systems in its waters, just as, on its shores, Frank Perdue's factory farms have replaced whatever methods nature originally introduced to grow chickens. Frank Krantz, director of tidal fisheries for the state of Maryland, has expressed the view that the Chesapeake Bay "should be run more like a farm than a wilderness." Krantz, according to a newspaper report, believes that "watermen must earn the right to fish the bay. 'You don't think Frank Perdue lets just anyone grow his chickens?'" (<u>Washington Post</u> 1984).

Maryland's new Center for Marine Biotechnology will promote an aquacultural approach to fisheries by genetically manipulating species to enhance disease resistance, increase growth, lower oxygen needs, hasten maturity, and so on (Colwell 1984). Projects planned for the center "include cloning genes into striped bass and winter flounder to make these species survive better in the bay."

In the past, the major emphasis in Chesapeake Bay management has been bioconservative, i.e., to clean up the area and to restore natural conditions so that native species can thrive. New technologies now enable us to work in the opposite direction. We may be able to restructure species to thrive in high levels of sediment and salinity. This policy may be far less costly and far more efficient than present attempts to reduce or eliminate various pollutants.

Aquaculturists in Norway and Scotland, where fjords are privately owned and separated by dams and nets from the sea, report great success in exploiting effluents and in harvesting from polluted waters. The production of sole in water discharged from nuclear power plants, moreover, demonstrates how thermal pollution can help production by shortening the growth cycle of fish (Devik 1976).

Reports describing the prospects of bioengineering suggest that many useful commodities, or improved versions of substitutes, may be produced more cheaply and more efficiently by artificial or technological processes than by natural ecological systems (Yoxen 1983). Insofar as this is true, we may concede the general proposition that the way to increase the long run economic return on estuaries and other ecosystems might be to develop them for agricultural, aquacultural, recreational, and other commercial purposes.

Both the biotechnologist and bioconservative approaches to environmental policy have strong support in our society. We value estuaries and other ecosystems for the economic goods and services they provide; we wish to increase the long-term benefits they offer man. Yet we also value many ecosystems intrinsically because of their historical and evolutionary relationship to our lives. This gives us a moral reason to preserve and protect estuaries even if that policy, to some extent, inhibits efficiency in the allocation of resources (Siry 1984).

A wise use of biotechnology will respect both attitudes, both ways of valuing the natural environment. The question is not whether to introduce biotechnology into evolutionary ecosystems but how to do this wisely and in a way that avoids what could be unhappy social, cultural, and political consequences.

What would constitute a wise use of biotechnology in an estuary like the Chesapeake? To approach this question, I will tell a story, first, about what could happen if biotechnology were introduced thoughtlessly and without regard to social, cultural, and economic realities. This story presents a "worst case" sketch; it describes a situation we can and should avoid.

Second, I will briefly challenge the idea that allocatory efficiency provides an appropriate normative framework in which to think about environmental regulation. I will explain what I take to be the correct use of economic analysis in determining priorities in environmental policy and management.

Finally, I will use estuarine and wetland policy as an example to discuss how we may strike a balance between commercial and ethical concerns in environmental regulation.

Hybrid Corn: An Analogy

Corn (Zea mays), a native American species, accounts for a third of the acreage planted in grain in the United States. Corn production in the United States, which had been declining steadily since 1870, surged in the 1930s as a result of the introduction of hybrid varieties. In 1930, American farmers, most of whom had not yet adopted hybrids, produced about 20.5 bushels of corn per acre and 1.8 billion bushels in all. In 1980, American corn farmers using hybrids increased their yield per acre to 90.8 bushels. They produced close to 6.5 billion bushels on many million fewer acres than they had planted fifty years before (Kloppenburg 1984, Cochrane 1979).

The hybridization of corn not only vastly increased the efficiency and productivity of the farmer but also ended his autonomy and independence. First, since hybrids revert, farmers cannot grow but must buy seed, for which they pay nearly two billion dollars a year (Davenport 1980, Harvard Business School 1978). Second, hybrids require specific management systems, involving mechanization and the application of agrochemicals. As a result, today only about 10 percent of the total value of finished agricultural products results from on-farm production processes. Commercial items (seed, fertilizer, machinery, pesticides) account for 40 percent, and post-farm processing contributes the remaining 50 percent of the value of the final product (Lewontin 1982).

Historians of agriculture commonly refer to a technological treadmill: "the vicious cycle of innovation/increased production/depressed prices/ further innovation" (Kloppenburg 1984). Farmers at the leading edge "who survived each cycle of the technological treadmill absorbed their failed neighbors and found that the growing scale and technological complexity of their operation compelled them to specialize" (Kloppenburg 1984). As a result, the number of farms has been cut by two-thirds since 1935, the size of the average farm has tripled, and 10 percent of farms account for 60 percent of farm production (McDonald and Coffman 1980).

Market conditions may compel the fisherman, as they have the farmer, to adopt technologies that undermine his independence and autonomy; tie him to his suppliers, consultants, computers, and machines; and force him to sell out or to expand and specialize his operation (Webber 1984). He may also leverage himself up to his ears as he creates the surpluses that cause the prices he receives (but not those he pays) continually to fall. The history of agribusiness, in other words, may repeat itself in "aquabusiness."

The possibility of "conveyor-belt" fish production, moreover, suggests an analogy to the poultry and egg industry, where after a few especially rapid cycles of the technological treadmill, 50 or 60 plants, each housing more than one million chickens, account for 90 percent of the national output of eggs (Howard 1985). It is reasonable to speculate that as industrial processes have supplanted farming so, too, they may supplant fishing as methods of food production (U.S. Department of Agriculture 1981).

Commercial fishermen in Maryland, for example, fearing competition, may lobby legislators to prohibit private leasing of bay waters and otherwise to discourage aquacultural production. But aquaculture in Virginia and elsewhere could then undercut prices, and the legislature might allow residents to lease small areas for aquacultural use. But these may not compete with large operations elsewhere; interest rates rise, prices fall, and owners buy up or sell out to their neighbors. Local firms (not national corporations), encouraged by loan guarantees, are invited in to establish the Chesapeake at the forefront of aquabusiness.

Research completed at Maryland's Center for Marine Biotechnology then might discover disease-resistant strains which, with antibiotics, allow 1 million striped bass to mature together in a relatively small pond at a cost of 25 cents a pound, and likewise for other species. Ciba-Geigy and Union Carbide, which could combine to run aquacultural operations in Virginia, may buy this technology from the Virginia Institute for Marine Sciences, which had altered it slightly and filed for a patent, precipitating a long and expensive legal battle.

The Maryland firms, facing falling prices, fail; the state government, confronting a fiscal crisis, achieves an economic bail-out by paying Weyerhaeuser $25 million to assume its liability and take over management of aquaculture and fisheries in the bay.

Meanwhile the Maryland fishing communities break up, and the watermen do the best they can. Some migrate to the city and find jobs in the canneries. Others take computer courses and learn to produce fish the modern way. But this solution does not last: competition from South America threatens American mariculture. After struggling for a few years, Weyerhaeuser moves its entire operation to Equador, and the bay is allowed to silt in.

The reason I have invented this "worst case" outline is not to argue that biotechnology is evil and should be kept out of evolutionary and ecological systems. Rather, I have intended only to suggest that biotechnology, like any important and powerful new technology, must be used in ways that make social, cultural, and ethical sense. Otherwise, political opposition will thwart its development. To be sure, biotechnology promises to replace conventional technology with much more efficient methods of production. As we shall now see, however, efficiency is not the goal--surely not the only goal--we seek to achieve.

Why Efficiency?

Managers of natural resources are familiar with the argument that various resources, since they are unowned, are not properly priced by markets, and therefore their value must be recognized and protected by regulation. Accordingly, manager frequently rely on cost-benefit analyses that set "shadow" prices for such unowned ecological services (Shabman and Batie 1980). Attempts are therefore made "to assign monetary values" to various unpriced benefits," e.g., the role of salt marshes in nurturing commercially important species....." (Reinhold et al. 1980).

Behind these attempts to incorporate outward features lies the assumption that an efficient market, one in which all resources are fully owned and traded by informed individuals without transaction costs or bargaining problems, will allocate resources in an optimal way. When markets--because of third-party costs, free rider problems, unowned goods, etc.--fail to allocate resources efficiently, the government may "correct" this failure by itself allocating resources as an efficient market would have done.

Why should we accept this framework for resource management? Why should we consider an efficient allocation, all things being equal, to be a desirable or responsible allocation of resources? I am not suggesting that we should weigh efficiency against other values, such as equity, in the allocation of resources. I am asking why we think efficiency has any worth or merit that may be weighed against ethical concerns including equity and justice.

Managers may believe that a more efficient allocation (all things being equal) is better, somehow, than a less efficient allocation of resources. But how? No one has ever explained why efficiency in the allocation of resources is a good thing or what better may mean in this context.

Sometimes we think, incorrectly, that efficiency (all else being equal) is a good thing because free markets are good things and free markets produce efficient allocations under certain rather abstract conditions. But this argument is inappropriate. Free markets may be desirable institutions for many reasons other than that they lead, theoretically, to efficiency in the allocation of resources.

Free markets are desirable because they are neutral and voluntary; they encourage autonomy and make the individual, rather than the government, responsible for the outcome of personal choice. Markets that have all these virtues (efficient markets) have nevertheless allocated resources in the most inhumane ways.

Efficient markets, markets in which all transactions are voluntary and costs are not extended to third parties, have led, for example, to child labor and the 80-hour work week. Accordingly, we may want free, informed markets to function in spite of, rather than because of, the allocations, however efficient, that are likely to result.

Why is efficiency desirable in the allocation of resources? One might answer that an efficient allocation, by definition, increases the satisfaction of preferences over the long run. Why is this good? Because the satisfaction of preferences, again by definition, increases welfare or utility. The concepts of welfare and utility, however, are defined tautologously in terms of the satisfaction of preferences. When used in this way, they have no demonstrable connection, logical or empirical, with any substantive conception of the good, such as well-being or happiness.

There is no logical or empirical connection, for example, between satisfying a preference (that is, meeting or filling it) and providing satisfaction (that is, pleasure or happiness). Conceptually, the connection between satisfaction in the satisfaction of preference and satisfaction in the sense of happiness amounts to little more than a pun. Empirically, wealth--and with it, the satisfaction of desire--often leads to disillusionment, frustration, and additional desire. Wealth, in other words, does not buy happiness. Not the satisfaction but the discipline or education of preference increases satisfaction in the sense of happiness, after basic needs are met (Scitovsky 1976).

Sophisticated analysts, therefore, do not try to connect efficiency with the idea of increasing pleasure or happiness. They acknowledge that efficiency concerns "what people are willing to pay for something rather than the happiness they would derive from having it" (Posner 1983).

Some people suppose that allocatory efficiency promotes economic prosperity, but this is a mistake. Economic prosperity, regional or national, is a macroeconomic goal that has no demonstrated connection, conceptual or empirical, with a microeconomic approach to resource policy cast in terms of efficiency in the allocation of resources. One might argue, indeed, that one macroeconomic result of market efficiency may be to bring prices down to or below costs, and then no one can make any money. This may be the reason that agriculture, our most efficient industry, is also our most depressed (Shepard et al. 1983).

I have argued so far that the bag of concepts that include allocatory efficiency, preference satisfaction, consumer surplus, willingness to pay, and welfare--all of which are defined in terms of one another--lacks a normative basis. To show otherwise, to argue that efficiency and related goals have a normative dimension, one must describe a relevant connection between them and a substantive conception of the right or good. And this has never been done.

Laws that govern resource management, particularly of wetland and coastal resources, like pollution control laws and health and safety legislation, stand in the tradition of child labor laws, food and drug laws, gambling statutes, and so on, in that they restrict efficiency in market transactions in order to preserve or promote the shared values and aspirations that we identify through the legislative process. Accordingly, resource managers who use allocatory efficiency as a regulatory standard may work against the spirit and sometimes the letter of environmental legislation.

Managers, however, may use the concept of an efficient market to achieve national aspirations in cost-effective ways and to adjust their regulatory agendas to economic, technological, and political realities. I will now try to suggest a general framework in which this might be done.

Dignity and Price

Public officials who manage the Chesapeake Bay concern themselves primarily with a few species, notably, striped bass, oysters, and crabs. Why are these species important? The obvious economic answer may be deceptive. There is not much of a market for oysters, but there seems to be a good market for oyster research. Why?

Two explanations come to mind. First, we care about the welfare of the fishing communities that depend upon the ecological functioning of the estuary. Second, we care about the health, integrity, and well-being of the estuary itself, and we tend to select commercially important species as indices of estuarine health. "The idea, or the hope, is that what's good for the species of interest will be good for the whole estuary" (Hendrix 1984).

A wise use of biotechnology in an estuary like the Chesapeake, then, would attempt first to find ways to protect the estuary from anthropogenic stress, for example, by providing better methods to treat wastes. Biotechnology, ironically, may then help to restore an estuary to an antedeluvian ecological state.

Second, since biotechnological advances in aquaculture are all but inevitable, fish farming should be introduced into the Chesapeake and other estuaries, insofar as possible, in ways that do not compete with but support capture fisheries. These programs may be less efficient than those that establish lease or property rights to bay waters, but they would be consistent with our overall objectives. These goals, once again, are to preserve the estuary and the fishing communities, not to ruin both in the process of piling an aquacultural Pelion on an agricultural Ossa.

Eventually, aquacultural production may become so efficient that it renders commercial capture fisheries uncompetitive. At that time, our wetlands and estuaries, if we have restored and protected them, will appear to us as the national treasures they are, objects of love not simply objects of use. Then we shall say that they--and we ourselves--have a dignity not simply a price.

The distinction between dignity and price embodies the difference I described earlier between valuing objects for their intrinsic merit or worth and valuing them for the wants they satisfy or the interests they serve. This is roughly the distinction between moral and aesthetic value, on the one hand, and economic utility or consumer surplus, on the other.

When we value objects or goals on the basis of their intrinsic merit or worth, we see ourselves in a relationship with them in which we express what we believe in or stand for, in other words, the values we respect as a community or a nation. The National Environmental Policy Act, for example, describes the appropriate relationship with nature as a "productive and enjoyable harmony between man and his environment...which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man."

Environmental managers sometimes confront conflicting goals set forth in legislation. The moral value of providing low income housing, for example, may conflict with zoning intended to protect naturally or historically valuable environments against development. Here two values, both of which appeal to legitimate shared concerns of the community, conflict.

Environmental regulators also often confront conflicts between public values and personal or consumer preferences. This is the kind of conflict that typically arises between the aspirational objectives envisioned by environmental legislation and the economic realities embodied in markets.

We are sometimes able to escape conflicts of this kind by focusing on interests and preferences that are consistent with, or even dependent on, the maintenance of the quality and integrity of the natural environment (Wildavsky 1967). Fishing, sailing, swimming, hiking, and hunting, when they are practiced in a context fairly free of technology, may express a kind of harmony with or participation in nature. We may think of these activities, then, as having a dignity and not simply a price, insofar as they express an authentic relationship to natural history or a willingness to confront nature on her own terms. And we may argue that the satisfaction of these interests and preferences requires a bioconservative approach to the environment.

There are many instances, however, in which an efficient allocation of resources (one that increases the satisfaction of preferences ranked by willingness to pay) will conflict with bioconservative aspirations of the sort typically asserted in environmental statutes. A proposed highway, vacation home development, shopping center, country club, and so on, may present this kind of conflict.

Policymakers must then weigh economic interests or benefits to the public against the values and ideals that same public has set forth in legislation. In the next and last section of this essay, I will describe a framework in which this kind of balancing might be carried out.

Striking a Balance

Environmental policies often must balance ethical, cultural, and aesthetic ideals against economically important interests and preferences. This conflict arises, for example, when a power company wishes to build a plant on an estuary, or when a port authority proposes to deepen a channel to accommodate ocean-going ships. It occurs whenever projects that appeal to consumer preferences conflict with programs that protect the quality of the environment, e.g., when a desired highway, country club, or shopping center enters an environment the historical and ecological integrity of which people revere or respect.

We face similar conflicts in our personal lives. An individual's values--his conception of what is right and wrong, all things considered--may require him, for example, to give to charity. Yet his interests or preferences might lead him to spend the money on a flashier car instead. Consider another example. You may believe that the right thing to do, all things considered, is to play with your children before going off to work. This conception of the right and good, however, is likely to conflict, early in the morning, with your strong preference to let them watch television by themselves so that you can stay in bed.

We do not rely on a theoretical apparatus or analysis to resolve conflicts of this kind. Rather, we usually make general policies which, in some rough way, "halve the difference" between our ideals and our inclinations. We might set aside for charity, for example, an amount which constitutes a "fair share," but we may still indulge ourselves with money we could have spent on African relief. We might dedicate Sunday to spend with the children, but on weekdays at 6 am we let them play by themselves.

The mother who debates with herself whether to join her children at 6 am does not weigh or balance her <u>preferences</u>, e.g., how much she is "willing to pay" to be a good parent <u>against</u> how much she is "willing to pay" to stay in bed. She is not trying to increase her satisfaction but to act within her resources and energies in a way that is appropriate to her responsibilities as a mother. She may decide to stay in bed today and take the kids out tomorrow, or something of that sort, to strike a balance. In this manner, she behaves in a way that is consistent with her being a mother, but she allows herself, to some extent, to live as she likes.

Similarly, a person debating how much to give to African famine relief confronts a moral problem. He or she may rely on a policy which, by setting aside a certain amount for charity, clears his or her conscience to indulge personal preferences as well.

When we weigh moral obligations against personal wants or interests, we strive to determine what is required by our moral commitment, on the one hand, and what goes beyond the call of duty, given our resources and circumstances, on the other. One might become a better father or a more generous person if one makes sacrifices beyond the point at which "it hurts," but one can still measure up to one's ideals and aspirations without behaving in supererogatory ways.

A public official implementing an environmental statute confronts the same sort of problem. The statute typically states a moral ideal, e.g., the maintenance of a balanced, indigenous population of fish, shellfish, and wildlife. Yet the official recognizes opposing economic, technological, and other realities that may make uncompromosing policies supererogatory and also impossible to achieve.

Accordingly, the official may look for a general policy that requires incremental improvements in environmental quality and that seeks to preserve the integrity of the ecosystems that appeal most strongly to our national conscience, while remaining sensitive to costs. Environmental "offsets," mitigation strategies, negotiation, and a ranking of ecosystems according to historical, cultural, biological, and similar criteria will be central to a policy of this kind.

To strike a balance is to act on our ideals, values, and aspirations to an extent that justifies our claiming that they are our ideals, values, and aspirations. The problem of valuation in environmental policy, then, is primarily that of determining which actions are mandatory and which are supererogatory for a society that regards the environment as an object of love and admiration and not simply as an object of exploitation and use.

The official who approaches environmental policy from this perspective will not be surprised to find that environmental legislation, in setting forth public values and community ideals, frequently results in outcomes different from those that an efficient market might reach. He or she will recognize that environmental problems, in general, are not problems in increasing consumer surplus or willingness to pay. Rather, the official will try to determine what is obligatory and what is supererogatory in environmental protection in view of the goals asserted in environmental legislation, the means society must employ, and the costs it must pay to achieve those goals.

Policy analysts have tried to make a cost-benefit or efficiency approach in environmental policy attractive by estimating the economic value of unowned resources, for example, the function of the marsh as a source and as a sink for nutrients. They have also attempted to attach "shadow" prices to public values by estimating how much individuals are willing to pay for policies that are consistent with aspirations of the sort set out in legislation (Randall et al. 1974).

Techniques used to "shadow price" unowned resources and fragile values, however, often turn out to be little more than finagle factors used to make cost-benefit analyses come out "right." The difficulties are sometimes empirical: shadow prices may be assigned to ecological services that either do not exist or are simply contradictory. The problems may also be technical: it is difficult to draw up a survey instrument capable of inducing an interviewee to treat the ideals and aspirations he or she would approve as a citizen as if they were personal preferences he or she must satisfy as a consumer (Hyman 1981). These techniques have failed, however, primarily for logical or conceptual reasons, since public values that are judged on their merits in the political process do not belong in the same category as personal preferences priced at the margin in markets.

Policymakers need not rely on shadow pricing to be responsive to the ideals expressed and the costs involved in implementing environmental statutes. They may do better by judging particular regulatory decisions in the context of other decisions within the general policy goal of increasing environmental protection at the least economic cost. This will require the policymaker to set frankly biological, ethical, aesthetic, and cultural priorities with respect to environmental protection and then to achieve these priorities, for example, by permitting minor environmental damage to be offset by greater gains in environmental quality obtained elsewhere at less cost.

The environmental manager may, then, work within the general policy of preserving the quality and integrity of the natural environment, while avoiding the impracticable and supererogatory path of protection at any cost. He or she will recognize that it is often a conceptual mistake to try to measure the benefits of environmental protection, for ecological systems have a dignity not a price. And yet we may respect the dignity of the environment--and our own dignity in protecting it--while promulgating policies that are responsive to economic constraints.

William Odum remarked in a discussion that he "ran into a problem about price a long time ago in Florida dealing with mangrove swamps." An acre of mangrove swamp in south Florida, Odum notes, can be "worth a half million dollars for economic purposes." The mangrove may also be valued intrinsically, i.e., as an object of appreciation and respect. In that way, it has a dignity, not a price.

Odum comments that, "You simply establish the fact that wetlands are priceless. In other words, they cannot be replaced with anything else. They don't have a price; it cannot be calculated" (Odum 1984).

This seems to me to be pretty good advice.

Acknowledgment

Sagoff's research on philosophical issues in environmental policy is supported by a grant from the National Science Foundation to the Center for Philosophy and Public Policy. The author gratefully acknowledges support for this paper from the Office of Policy, Planning, and Evaluation of the U.S. Environmental Protection Agency and wishes to thank ecologists and others there for ideas, criticisms, and suggestions. The views expressed are those of the author only and not necessarily those of any governmental department or agency. The author also acknowledges the cooperation of the editor of <u>Environmental Ethics</u> <u>8</u> (Summer 1986), where parts of this essay also appear.

References

Avault, J. 1983. Maximizing production and profit: efficient species. Aquaculture Magazine, July-August:42-45.

Clean Water Act. 1976 and 1981. U.S.C. 33, secs. 1251-1276.

Cochrane, W. 1979. The development of American agriculture. University of Minnesota Press, Minneapolis.

Colwell, R. 1984. Biotechnology in the marine sciences. In: R. Colwell, A. Sinskey, and E. Pariser, eds. Biotechnology in the Marine Sciences. Wiley, New York.

Davenport, C. 1980. Sowing the seeds--research, development flourish at DeKalb and Pioneer Hi-Bred. Barron's 61:9-10, 33.

Devik, O., ed. 1976. Harvesting polluted waters: waste heat and nutrient-loaded effluents in the aquaculture. Plenum Press, New York.

Doyle, J. 1985. Biotechnology research and agricultural stability. Issues in Science and Technology 1(2):111-124.

Harvard Business School. 1978. Pioneer Hi-Bred International, Inc. Harbard Business School Case Study. Harvard Business School Services, Boston.

Hendrix, G. 1984. Water management in the Everglades and estuarine productivity. In: B.J. Copeland et al., eds. Research for managing the nation's estuaries. U.S. Sea Grant Publ. UNC-SG-84-08. Raleigh, NC.

Howard, R. 1985. The vanishing land. Villard, New York.

Hyman, E. 1981. The valuation of extramarket benefits and costs in environment impact assessment. Environmental Impact Assessment Review 2:227-258.

Kalter, R. 1985. The new biotech agriculture: unforeseen economic consequences. Issues in Science and Technology 1(2):125-143.

Kant, I. 1959. Foundations of the metaphysics of morals. L. Beck, trans. and ed. Bobbs-Merrill, Indianapolis.

Klausner, A. 1985. Food from the sea. Bio/Technology 3(1):32.

Kloppenburg, J. 1984. The social impacts of biogenetic technology in agriculture: past and future. pp. 291-321 in: G. Berardi and C. Geisler, eds. The social consequences and challenges of new agricultural technologies. Westview Press, Boulder, Colorado.

Lewontin, R. 1982. Agricultural research and the penetration of capital. Science for the People, January/February:12-17.

Lovell, R.T. 1979. Fish culture in the United States. Science 206:1356-1371.

McDonald, T. and G. Coffman. 1980. Fewer and larger farms by year 2000--and some consequences. Agriculture Information Bulletin No. 439, USDA, Washington, D.C.

Nixon, S. 1980. Between coastal marshes and coastal waters: a review of 20 years of speculation and research on the role of salt marshes in estuarine productivity and water chemistry. pp. 437-525 in: P. Hamilton and K. MacDonald, eds. Estuarine and Wetland Processes. Plenum Press, New York.

Odum, W. 1984. Remark in: B.J. Copeland et al., eds. Research for managing the nation's estuaries. U.S. Sea Grant Publ. UNC-SG-84-08. Raleigh, NC.

Peterson, C.H. 1984. Biological consequences of manipulating sediment delivery to the estuary: a blueprint for research. In: B.J. Copeland et al., eds. Research for managing the nation's estuaries. U.S. Sea Grant Publ. UNC-SG-84-08. Raleigh, NC.

Pope, R.M. and J.G. Gosselink. 1973. A tool for use in making land use decisions involving tidal marshland. Coastal Zone Management Journal 1(1):65-74.

Posner, R. 1983. The economics of justice. Harvard University Press, Cambridge, Mass.

Randall, A., B. Ives, and C. Eastman. 1974. Bidding games for valuation of aesthetic improvements. Journal of Environmental and Economic Management 1:132-149.

Reimhold, R., J. Phillips, and M. Hardisky. 1980. Socio-cultural values of wetlands. In: V. Kennedy, ed. Estuarine perspectives. Academic Press, New York.

Schubel, J. 1984. Man's activities and sediment inputs to estuaries. In B.J. Copeland et al., eds. Research for managing the nation's estuaries. U.S. Sea Grant Publ. UNC-SG-84-08. Raleigh, NC.

Scitovsky, T. 1976. The joyless economy. Oxford University Press, New York.

Shabman, L.A. and S.S. Batie. 1980. Estimating the economic value of coastal wetlands: conceptual issues and research needs. pp. 3-15 in: V. Kennedy, ed. Estuarine perspectives. Academic Press, New York.

Shepard, D., J. Turk, and A. Silberston, eds. 1983. Microeconomic efficiency and macroeconomic performance. Philip Alan, Oxford.

Siry, J.S. 1984. Marshes of the ocean shore: development of an ecological ethic. Texas A&M Press, College Station, Texas.

Thurow, L. 1983. Dangerous currents. Random House, New York.

U.S. Department of Agriculture. 1982. Economic indicators of the farm sector: income and balance sheet statistics, 1981. U.S. Government Printing Office, Washington, D.C.

Vlastos, G. 1973. Platonic studies. Princeton University Press, Princeton, NJ.

Washington Post. 26 September 1984. pp. C1, C6.

Webber, H. 1984. Aquabusiness. In: R. Colwell, A. Simskey, and E. Pariser, eds. Biotechnology in the marine sciences. Wiley, New York.

Wildavsky, A. 1967. Aesthetic power or the triumph of the sensitive minority over the vulgar mass: a political analysis of the new economics. Daedalus 96:1115-1127.

Yoxen, E. 1983. The gene business. Harper and Row, New York.

______. 1984. University of Maryland dives into biotechnology. Bio/Technology, March:213.

MANAGEMENT CONSIDERATIONS RELATED TO THE PHYSICAL ALTERATIONS OF ESTUARIES

Sharon H. Lockhart
U.S. Fish and Wildlife Service

The story of the nation's estuaries has been repeated many times: marinas now stand where salt marshes once flourished and houses block the shoreline path. Most of these changes are also irreversible, for once the marsh elevation is changed in relation to available water, the wetlands can rarely revert to its natural condition or function. The pattern of change has included many individual, separate actions which have seemed innocuous but which cumulatively create a new landscape. The direction of these changes has usually been one of increased use by people, diminished habitat for fish and wildlife, and restricted public access to the tidelands.

There are conflicting figures on how many acres of estuarine habitat we once had and how many have been lost. The first national survey of wetlands probably was conducted in 1922. That survey, reported in the 1923 Year Book of Agriculture (Gray et al. 1923), indicated there were 79,312,558 acres of wetlands in the United States; about 6,379,216 were tidal marshes and the remainder were coastal wetlands, inland marshes, and overflow lands. According to a more recent 1983 report, there are now estimated to be approximately 20,210,000 acres of estuarine wetlands (Frayer et al. 1983). The Congressional Office of Technology Assessment (OTA) report (1984) states that the nation has lost approximately 50 percent of its wetland resources; 3 percent of this total loss has been in coastal areas.

There is also conflicting information on the rate of loss. In a recent conference proceedings on the status of Louisiana's wetlands, it was reported that this state is losing approximately 10,000 acres of its coastal wetlands annually (Boesch 1982). The OTA (1984) report states that the current annual figure of coastal wetlands lost in the nation is estimated to be about one-half this value or 5,000 acres. This report also states that there has been a net loss of 373,000 acres of saltwater vegetated wetlands from the mid-1950s to the 1970s representing a 7.6 percent reduction is total wetlands of this type. Saltmarsh accounted for 95 percent of that loss; the remaining 5 percent of the loss was forested or shrub-scrub saltwater wetlands. The report noted, however, that actual loss of wetlands was much greater: approximately one-half million acres (figure given was 482,000 acres). The loss of estuarine mudflats is small, about 21,000 acres, and there has actually been a gain, by about 212,000 acres, in the deepwater portions of estuaries (Frayer et al. 1983).

These losses also need to be looked at on a regional or local level. The losses of Louisiana's wetlands have already been noted. The urbanization of the Hudson River estuary, the Chesapeake Bay, the Florida coast, and the California coast have also been well documented. California has the dubious distinction, nationally, of having lost the largest percentage of wetlands. In southern California, this figure is estimated to be between 75 and 90 percent.

The reasons for the loss of coastal wetlands have been well documented. It is estimated that approximately 56 percent of the loss has resulted from dredging for marinas, canals, port developments, and to a lesser extent from shoreline erosion; 22 percent from urbanization; 14 percent from the disposal of dredged material or from creating beaches; 6 percent from natural or man-induced transition of saltwater wetlands to freshwater wetlands; and 2 percent from agriculture (OTA 1984).

Let's look at each of these reasons more closely. All of the reasons listed involve the physical alteration of estuaries. Some form of dredging, filling, or both appears to be responsible for 98 percent of the wetland loss. In the Southeast and Southwest, for example, dredging and filling is the major method used to create waterfront real estate. Wetlands are excavated to construct canals; the dredged material is used to fill the adjacent wetlands for building sites.

Dredging and filling is also used to create our ports. There are 130 ocean ports in the United States; most of which are located in estuaries (Giari 1982). The New York harbor facilities and their activities in the Hudson estuary and the San Diego unified port facilities and their activities in San Diego Bay can be considered typical of other major ports.

Since 1625, the Hudson River estuary has been modified by bulkheading to prevent erosion. Transportation facilities--docks, piers, railroad terminals--were built. Wetlands were filled, and small streams were covered to provide space for industrial and residential development. Channels were dredged for navigation and anchorage areas, and sand and gravel were mixed from the harbor bottom. By 1966, about 20 percent of Manhattan, Brooklyn, the Bronx, and Queens were built on filled lands. By 1966, there were 66 miles of federally authorized channel projects. In addition, there were 32 miles of channels in the harbor entrance area and numerous anchorages for vessels throughout the harbor complex. In all, more than 26 square miles of harbor bottom was involved in channel projects. To maintain the harbor channels the Corps of Engineers (COE) must dredge approximately 2.2 million metric tons each year (Gross 1982).

The story of San Diego Bay is much the same. Since the early 1900s, the dredging and use of spoil disposal as fill has reworked and shifted 129 to 180 million cubic yards of sediments, resulting in a 27 percent reduction in the water area of the bay and approximately doubling in depth 55 percent of the original water area. Only 17 to 18 percent of the original bay area remains undisturbed by dredging or filling (Smith 1976).

Canal construction in coastal Louisiana, Mississippi, and Texas is also accomplished by dredging and filling. Man-made canals are a dominant feature of the Gulf coast. Direct effects are the immediate conversion of wetlands to deepwater canal habitat from the dredging and the creation of spoil banks from the filling. Indirect effects are marsh deterioration from saltwater intrusion, changes in waterflow patterns, and increased erosion (Johnson and Gosselink 1981).

Dredging is also the means used to mine phosphate ore in North Carolina and Florida. The strip mining of phosphates in the Pamlico River estuary, for example, has been carried on since the 1960s (Copeland and Riggs 1985). In the mining operation the overlying sediments are removed and ground water is pumped from the upper aquifers so that the ore can be stripped. The pits are eventually refilled and planted with grass.

Direct impacts associated with dredging and filling are fairly well known. The Corps of Engineers has produced numerous documents and studies during its dredged-material research program. The Fish and Wildlife Service and Environmental Protection Agency have also published several reviews (for example, Allen and Hardy 1980).

Not all impacts to estuaries involve major physical alterations or construction. The agricultural use of wetlands, which accounts for the remaining 2 percent of wetlands loss, may or may not require the construction of levees, the installation of drains, and filling. These practices, while altering the wetland, can be fairly benign in that when farming ceases the lands can be returned to wetlands. This is occurring in San Francisco Bay. The pasturing of animals, especially cattle, generally does not involve major physical alterations of wetlands. Nevertheless, grazing animals can promote their own physical changes to the wetlands by breaking up the turf thus increasing erosion (Reimold 1976). Reductions in primary production, detritus production, and invertebrate population have been noted also in grazed wetlands.

Structural changes outside of the estuary may also result in impacts to this environment. Freshwater withdrawals and diversions can cause major problems. For example, the Bureau of Reclamations Central Valley project and California water project influence San Francisco Bay and the Sacramento-San Joaquin delta. Between these two projects, there is an active storage capacity of some 16 million acre-feet of water and conveyance facilities capable of transporting 11 to 12 million acre-feet annually (Orlob 1976). The delta and the bay receive the residual runoff and return flows of man's activities. This decreased freshwater supply has altered salinities and has created significant circulation problems and water quality problems (Conomos and Peterson 1976).

Damming of rivers and diversion of freshwater flows is not limited to the arid Southwest. Freshwater diversions, along with changing land uses, have been implicated in the fisheries catch decline in the Albemarle Sound in North Carolina (Copeland et al. 1983). Catches have declined about 70 percent since the 1970s. The upstream reservoirs can alter salinity patterns, nutrient cycling in the estuary, and migratory movements of anadromous fish.

Even with all this disturbance, pressures on wetlands continue because of tremendous demand for real estate; the demand for water-related facilities such as docks and marinas, as well as canals to connect them to water bodies; and the relative ease with which wetlands can be altered and thus permanently destroyed (Myhrum).

In the last 20 years, we have come to realize that our estuaries provide fish and wildlife habitat and food chain support, maintain ground water supplies, prevent flooding, and stabilize shorelines. We have also come to realize that our various coastal projects have brought about significant environmental and ecological problems. The enactment of current environmental statutes was a Congressional response to the lack of concern that environmental matters had received in the past and to the resulting undesirable environmental consequences and controversies. The enacted coastal wetlands and coastal management legislation has been aimed at trying to preserve these delicate ecological systems.

The Corps of Engineers' regulatory program is the main program involved in reviewing physical alterations to estuaries. Two federal statutes serve as the basis for the regulatory program; they are the Rivers and Harbors Act of 1899 [33 U.S.C. 401-413 (1976)] and the Clean Water Act [33 U.S.C. 1251-1376 (1976 and Supp III 1979)]. In addition, the regulatory program encompasses several other pieces of legislation that must be considered during the evaluation of a permit. Both public and private projects must comply with the program.

The Rivers and Harbors Act of 1899 (33 U.S.C. 403) was originally enacted to promote and protect navigation. Section 9 of the act requires a permit from the Corps of Engineers for the construction of any bridge, dam, dike, or causeway in or over any navigable water of the United States. Section 10 of the act forbids any excavation or construction in navigable waters without the authorization of the Secretary of the Army [33 U.S.C. 403 (1976)]. Specifically, Section 10 makes it unlawful "to excavate or fill, or in any manner alter or modify the course or capacity" of any navigable water body. Therefore, this act covers almost any activity, but in a limited area.

The limited area regulated by this program is navigable waters or waters subject to the ebb and flow of the tide that are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce [33 C.F.R. 329.4 (1982)]. In tidal areas, this jurisdiction has typically been over the entire surface and bed of the tidal water, to mean high water. The rights of the United States are generally considered to be paramount to the possessory interest of individuals in this area (Myhrum).

Initially, the COE limited its review of Section 10 permit applications to the impacts of the proposed project on navigation and allowed work when no adverse effect on navigation was projected (Myhrum). In 1968, the COE interpreted this act to authorize the consideration of environmental factors, as well as navigational factors, based largely on the enactment of the Fish and Wildlife Coordination Act [16 U.S.C. 661-664 (1976)]. Permit regulations were amended to broaden the permit criteria:

> "The decision as to whether a permit will be issued must rest on an evaluation of all relevant factors, including the effect of the proposed work on navigation, fish and wildlife, conservation, pollution,

aesthetics, ecology, and the general public interest." 33 C.F.R. 209.120 (1968).

Following the promulgation of these regulations, Congress enacted the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et seq.). The broadened criteria for permit review was sustained by the U.S. Court of Appeals Fifth Circuit in the case, Zabel v. Tabb (430 F. 2d 199 (5th Cir 1970). cert.den. 401 U.S. 901 (1972)). This case involved the proposed filling of wetlands to construct a mobile home park in Boca Ciega Bay, Florida. The court held that environmental considerations could be the basis for the denial of a permit and stated:

"...dredge and fill projects are activities which may tend to destroy the ecological balance...Because of these potential effects Congress has the power to regulate such projects....The Secretary...was entitled, if not required to consider ecological factors, and, being persuaded by them, to deny that which might have been granted routinely five, ten, or fifteen years ago before man's explosive increase made all, including Congress, aware of civilization's potential destruction..."

Three years after this decision, Congress adopted the Clean Water Act "to restore the physical, chemical, and biological integrity of the nation's waters" [33 U.S.C. 1251(a) (1976)]. This act focuses in on the control of pollution. Section 301 of the Clean Water Act outlaws the discharge of any "pollutant from a point source" into waters of the United States unless a permit is obtained [33 U.S.C. 1311(a) (1976)]. Section 404 of the act regulates the discharge of dredge and fill materials into waters of the United States. The program seeks to reduce adverse impacts by prohibiting discharges affecting sensitive environments and by requiring the adoption of mitigation practices for the discharges it does allow. Four federal agencies have significant program responsibilities--the Environmental Protection Agency, the Corps of Engineers, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. The Environmental Protection Agency, which has the legislative mandate to enforce the Clean Water Act, retained oversight of dredging activities and their effects on water quality and the environment. The Corps of Engineers is the permitting agency; the U.S. Fish and Wildlife Service and National Marine Fisheries Service are commenting agencies.

The Corps of Engineers originally limited this new regulatory responsibility to traditionally navigable waters. In Natural Resources Defense Council v. Callaway, 392 F. Suppl 685 (D.D.C. 1975), the court extended COE jurisdiction from traditional navigable waters to include all waters and wetlands of the United States that the federal government could constitutionally regulate under the commerce clause.

Current COE regulations define wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" [33 C.F.R. 323.2(c) (1982)]. The definition gives as examples "swamps, marshes, bogs, and similar areas."

In addition, these wetlands must be adjacent to waters of the United States. The COE regulations define adjacent to mean bordering, contiguous, or neighboring [33 C.F.R. 323.2(a) (1982)]. Wetlands separated from other waters of the United States by man-made dikes or barriers, natural river berms, beach dunes, and the like are also considered to be adjacent [33 C.F.R. 323.2(a) (1982)].

In a recent case involving the jurisdictional determination of wetlands, Avoyelles Sportsmen's League, Inc. v. Marsh (715 F.2d 897 (1983)) the court agreed that the factors to consider in a wetland determination included types of soil and vegetation and the degree and frequency of inundation. The Corps of Engineers has recently published a draft manual providing guidelines for delineating jurisdictional boundaries for federally regulated wetlands. These guidelines provide that soil, vegetation, and hydrology indicators must be present before a wetland determination can be made.

Therefore, the Section 404 program, while it encompasses a larger geographical area, is only needed when the project involves the placement of fill in the wetlands. Dredging activities without the associated placement of fill, vegetative clearing, and several specifically exempt activities as provided for in Section 404(f) are not covered by the act.

The Corps of Engineers regulatory program requires that all proposed projects go through a public interest review. The decision on whether or not to issue the permit must be based on a balancing process [33 C.F.R. 320.1(a)(1) (1982)]. Factors to be considered and balanced in this public interest review include "...conservation, economics, aesthetics, general environmental concerns, wetlands cultural values, fish and wildlife values, flood hazards, flood plain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, and, in general, the needs and welfare of the people" [33 C.F.R. 320.4 (a) (1982)].

The October 5, 1984, regulations [33 C.F.R. 320.4(b)(4) (1984)] also require that in the issuance of Section 404 permits the Corps of Engineers must comply with the guidelines promulgated by the Environmental Protection Agency in conjunction with the Corps of Engineers under Section 404 (b)(1) of the Clean Water Act [40 C.F.R. 230.10(a)(1),(2),(3) (1980)]. The guidelines serve as the basis to review environmental impacts associated with a proposed project and to determine whether or not it is environmentally acceptable. The guidelines are based on the fundamental precept that dredged and fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact either individually or in combination with known or probable impacts of other activities affecting the ecosystems of concern [40 C.F.R. 230.1(c) (1980)]. The guidelines also state that from a national perspective, the degradation or destruction of special aquatic sites, such as filling operations in wetlands, is considered to be among the most severe environmental impacts covered by them [40 C.F.R. 230.1(d) (1980)].

To ensure that these principles are complied with, the guidelines, with few minor exceptions as provided in Section 404(b)(2) of the Clean Water Act, require that no discharge of dredged or fill material will be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences [40 C.F.R. 230.10(a) (1980)]. This is commonly referred to as the water-dependency test. Practicable alternatives include, but are not limited to, activities that do not involve a discharge of dredged or fill material into the waters of the United States or ocean waters [40 C.F.R. 230.10(a)(1)(i) (1980)]. Likewise, an alternative is considered practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes.

Once the water dependency test is met, the guidelines also require that determinations be made on the nature of the proposed discharge and the effect that it will have on the physical substrate; water circulation, fluctuation, and salinity; suspended particulates and turbidity; contaminants; and the aquatic ecosystem. Cumulative and secondary impacts are also to be addressed [40 C.F.R. 230.20 (1981)]. With each parameter, the guidelines provide the reviewer with a generalized discussion of the associated impacts.

In addition, Section 404(c) vests in the administrator of the Environmental Protection Agency a final veto over the issuance of Section 404 permits if it is determined that the filling would result in adverse impacts to municipal water supplies, shellfish, fishery areas, wildlife, or recreation areas.

The COE regulations also require that the district engineer consider several other laws prior to issuance of a permit for a proposed project. Among those acts which are included in the review are the Marine Protection, Research and Sanctuaries Act of 1972, as amended; Coastal Zone Management Act (CZMA) of 1972, as amended; the National Environmental Policy Act of 1969; the Fish and Wildlife Coordination Act; the Endangered Species Act and the Marine Mammal Protection Act of 1972.

Section 103 of the Marine Protection, Research and Sanctuaries Act. the Secretary of the Army through the Chief of Engineers authorizes to issue permits for disposal of dredged material at designated ocean disposal sites (33 U.S.C. 1413). This stipulation is somewhat misleading in that it includes designated disposal sites in estuaries. Notice and opportunity for public hearings are part of the review process to ensure that the use of the designated disposal site will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentials.

Congress has also passed the Coastal Zone Management Act of 1972 [16 U.S.C. 14 (1975)] to bring about planning for the rational use of coastal resources. Congress noted in passing this act that development of coastal resources must at the same time preserve cultural, historic, and aesthetic values unique to the coastal areas [16 U.S.C. 1451-1452 (1975)]. To achieve this goal, the act makes available federal funds to encourage states to develop comprehensive management programs, in cooperation with federal and local governments. State participation is voluntary.

Section 307(c) of the CZMA [16 U.S.C. 1456(c)] requires federal agencies conducting activities in the participating states' coastal zone areas to comply to the maximum extent practicable with the approved state coastal zone management program. Non-federal applicants for a federal permit must furnish a certification that the proposed activity will comply with the state's coastal zone management program. The 404(b)(1) guidelines, however, note that this compliance is not necessarily comparable to an evaluation under the restrictions stated in the guidelines and should it be less complete than required, it must be supplemented accordingly [40 C.F.R. 230.10 (5)].

The National Environmental Policy Act was passed in 1969. It was intended to force federal agencies to become environmentally conscious, to bring pressure upon them to respond to the needs of environmental quality,...and to reorient them toward a consciousness of and sensitivity to the environment [115 Cong. Rec. 40425 (December 20, 1969)]. The act declares that it is the continuing policy of the federal government... to use all practicable means and measures...in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans. This goal is to be achieved in part through the use of a systematic, interdisciplinary approach to assure the integrated use of natural and social sciences and environmental design arts in agency planning affecting the environment.

Section 102(2)(c) contains the act's well-known requirement that environmental impact statements be prepared for all major federal actions affecting the quality of the human environment, COE permits included. The document is to identify and evaluate the direct, indirect, and cumulative environmental impacts of the project [40 (C.F.R. 1500.8 (1976)]. Therefore, "at the very least, NEPA is an environmental, full-disclosure act" [Environmental Defense Fund v. Corps of Engineers (Gillham Dam) 1 ELR 20130,20141 (E.D. Ark., (1972)]. Full disclosure allows practicability and reasonableness to be considered [Environmental Defense Fund v. Tennessee Valley Authority, 4 ELR 20225, 20225 (6 Cir., 1974)] when assessing the adequacy of a document. Compliance with the National Environmental Policy Act does not require perfection. It was noted in the Tennessee-Tombigbee waterway case that the phrase "to the fullest extent possible" is not synonymous to perfection:

> "If perfection were the standard, compliance would necessitate the accumulation of the sum total of scientific knowledge of the environmental elements affected by the proposal. The phrase... clearly imposes a standard...requiring nothing less than comprehensive and objective treatment by the responsible agency " [Environmental Defense Fund v. Corps of Engineers (Tennessee-Tombigbee Waterway), 4 ELR 20320, 20335 (5th Cir., 1974)].

The court goes on to note that consideration of environmental matters that is merely partial or performed in a superficial manner does not satisfy the standard.

The Fish and Wildlife Coordination Act, along with the Fish and Wildlife Act of 1956 [16 U.S.C. 661-664 (1976)], the Migratory Game-Fish Act (16 U.S.C. 760c-760g), and other wildlife-related acts express the will of Congress to protect the quality of the aquatic environment as it affects conservation, improvement, and fish and wildlife resources. The Fish and Wildlife Coordination Act requires that whenever the waters of any stream or body of waters on any stream or body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States, or by any public or private agency under federal permit or license, such department shall first consult with the United States Fish and Wildlife Service, Department of Interior, and with the head of the agency exercising administration over the wildlife resources of the particular state with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for development and improvement thereof...." (16 U.S.C. 662).

During 1974 and 1975, the Department of Interior acting through the director of the U.S. Fish and Wildlife Service proposed and adopted guidelines for the review of proposal for work and activities in or affecting navigable waters that are sanctioned, permitted, or assisted, or conducted by the federal government [40 (231) Federal Register 55810 (1975)].

The stated objective of the U.S. Fish and Wildlife Service in its review of permits is "to protect and preserve fish and wildlife habitat, conserve fish and wildlife resources, and protect the public trust of use and enjoyment in and associated with...waters of the United States" [40 (231) at p. 55813, 2.1 (1975)]. When mitigation is needed to offset project-related impacts the Fish and Wildlife Service "Mitigation Policy" sets out the goals and objectives by resource categories [46 (15) Federal Register 7656-7663 (1981)].

The Corps of Engineers and the U.S. Fish and Wildlife Service also are to consult should the issuance of a permit affect a federally listed endangered species. The purpose of the Endangered Species Act of 1973, as amended, is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may by conserved..." and mandates that "...all federal agencies seek to conserve endangered species and threatened species...." [P.L. 97-304 2(b),(c) (1982)]. Section 7 of the act requires the consultation. If the service determines that the project may jeopardize the continued existence of the species, the permit cannot be issued [40 C.F.R. 230.10(b)(3) (1981)].

With the level of review for federal permits in estuaries continuing there is a belief by some that these wetlands are fairly well protected (OTA 1984). A National Marine Fisheries study of the regulatory program for the coastal area from Texas to North Carolina found that during fiscal year 1981 projects that would have resulted in the conversion of about 14,000 acres of vegetated wetlands were reviewed. Recommendations, which were accepted in about 98 percent of the cases, should have prevented conversion of about 85 percent of these wetlands. This finding is consistent with the strategy of the COE regulatory program, which has always been to reduce or compensate for impacts rather than to prevent development. On a national basis, only a small number of Section 404 and Section 10/404 permit applications are denied (in fiscal year 1981, 291 permits were denied out of 10,718 applications) (OTA 1984).

There is, nevertheless, an on-going debate by some as to whether activities in wetlands should be regulated. The complaints about the regulatory process are numerous. Because of the program's close relation to land use practices that adversely affect water quality, critics contend that it represents an unprecedented federal presence in land use matters and displaces state and local land use controls (Blumm 1980). Delays in developing projects and associated increased costs are also cited as problems with the regulatory process. Almost all of the 30 coastal states (including those around the Great Lakes) have some type of state wetlands regulatory program. In addition many local governments have wetlands ordinances (Kusler 198). State and local programs however, generally add little to the federal regulatory program (OTA 1984). Therefore, these efforts should generally be considered inadequate to protect wetlands.

Even without existing legislation to control activities in wetlands, there is a responsibility for government to protect wetland resources. The concept of public trust rights or communal resource utilization was developed as a part of ancient Roman law. The Corpus Juris Civilis drafted between A.D. 529 and A.D. 534 set forth public rights in waters and in the seashore. Rights to these areas were generally unrestricted and common to all. This meant that the state as inherent owner of the soil of the harbors held this ownership subject to perpetual use dedicated to the public. The area protected by the public trust extended as far as the greatest winter flood.

The concept of the public trust was brought to the New World by the European colonists: French, Spanish, and English. While the concept of the public trust differed slightly with each colonial power, they each recognized a responsibility to protect for public use that area of the coast up to at least mean high water in tidal areas (Althaus 1978).

In the later 1800s, the United States Supreme Court decided the leading public trust case, Illinois Central Railroad Co. v. Illinois [146 US 387, 36 Led 1018 (1892)]. The Court noted in this case that:

> "It is a title held in trust for the people of the State that they may enjoy the navigation of the waters, carry on commerce over them, and have the liberty of fishing therein freed from the obstruction and interference of private parties."

While this case addresses a state's role in preserving the public trust, the concept also seems to apply to the federal government. The tidal waters, as the courts have recognized are a "...dominant servitude in favor to the United States under which private persons hold physical properties obstructing waters of the United States and all right to use to the water of those streams" [F.P.C. v. Niagara Mohawk Power Corp., 347 U.S. 239 at 249 (1954)].

The public trust doctrine is still recognized. Of all the concepts known to American law, the public trust doctrine constitutes the best practical and philosophical premise and legal tool for protecting public rights and for protecting and managing resources or objects held in trust (Sax 1970). Today the concept of the public trust has evolved to protect the public's expectations against destablizing changes or rates of change (Sax 1981).

The public now expects the environment to be protected. A recent survey by Time found that 45 percent of those polled believed current environmental laws did not go far enough, while 29 percent are satisfied with them, and only 16 percent think they go too far (Magnuson 1985). In addition, this poll found that 63 percent felt that the existing mandated protections are not being enforced by the agencies involved.

As the conflicts between competing uses of estuaries intensify, there will be more pressure from both sides on the current regulatory system. The basic management objective for estuaries, nevertheless, must be sustained long-term yield and productivity of all their economic and environmental resources, especially the renewable resources. As long as coastal resources are viewed primarily as values to be exploited and enjoyed for the economic benefit of today's generation this management objective will not be met.

The possibility exists that the environmental analysis and public interest review that are part of the Corps of Engineers regulatory program can bring about the effective management of estuaries. The regulatory program, and the planning processes it encompasses, has been designed to abate the degradation of and to restore the environment and to resolve conflicts between development and conservation interests. In essence, the Corps of Engineers serves as a mediator among many special interests.

The public interest review has its shortcomings in that with all factors being subjected to a balancing process, adverse impacts associated with a project no matter how severe, may be acceptable as long as they are outweighed by the purported benefits of the project. Impact assessment mandated by the National Environmental Policy Act, the Section 404(b)(1) guidelines, the Fish and Wildlife Coordination Act, and other environmental legislation therefore becomes a critical component of the review.

The problems associated with impact assessments have been recognized. One problem is that ecological science is still a young discipline, and many assumptions and uncertainties underlie calculations of environmental impacts. Disagreements typically arise among professionals as to the environmental impacts that may result. The impact analysis, at best, describes probable impacts. Actual impacts must be discerned through a monitoring program after construction of the project. Even more critical is the fact that some impacts may not be examined at all because agency personnel may not be aware of the need for their identification and measurement. This influences the ability to safeguard wetlands and the equity of regulatory decisions. The Corps of Engineers maintenance dredging studies, the U.S. Fish and Wildlife Service ecological profiles, and the research being conducted by Sea Grant colleges and universities and public agencies are beginning to solve this problem.

The problem is aggravated by the timely review now mandated by the regulatory program [33 C.F.R.320.1(4) (1982)]. Early coordination between the applicant and the concerned agencies has now become an important component of the review process. An aid to the review would be implementation of Section 404 (c). Section 404(c) allows for the withdrawal of designated wetlands as present or future disposal sites to prevent unacceptable adverse impacts to these areas [40 C.F.R. 231 (1981)]. As a management tool, this would allow wetland areas with important ecological values to be protected.

The management of physical alterations to estuaries can be addressed by the regulatory program of the Corps of Engineers. The combined actions of the federal agencies involved can provide protection for the natural renewable resource values of estuaries. This will not be an easy task in that the competition among conflicting uses is so intense. While there is reason to question whether or not the difficult decisions can be made in the future, the regulatory framework is now in place and the information needed to implement the program is being developed.

References

Allen, K.O. and J.W. Hardy. 1980. Impacts of navigational dredging of fish and wildlife: a literature review. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS - 80/07. 81 p.

Althaus, H.F. 1978. Public trust rights. Document prepared for the Portland regional solicitor of the U.S. Department of Interior. Portland, Oregon. 421 p.

Baker, N.J. 1976. Sections 9 and 10 of the Rivers and Harbors Act of 1899: potent tools for environmental protection. Ecology Law Review 6:109.

Blumm, M.C. 1980. The Clean Water Act's Section 404 permit program enters its adolescence: an institutional and programmatic perspective. Ecology Law Quarterly 8:409.

Boesch, D.F. 1982. Preface. pp. iii-iv in : D.F. Boesch (ed.), Proceedings of the conference on coastal erosion and wetlands modification in Louisiana: causes, consequences, and options. U.D. Fish an Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS - 82/59.

Conomos, T.J. and D.H. Peterson. 1976. Suspended-particle transport and circulation in San Francisco Bay: an overview. pp. 82-97 in: M. Wiley (ed.), Estuarine processes, Vol. II. Academic press, New York.

Copeland, B.J. and S.R. Riggs. 1984. The Ecology of the Pamlico River, North Carolina: an estuarine profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS - 82/06. 83 p.

Copeland, B.J., R.G. Hodson, S.R. Riggs, and J.E. Easley, Jr. 1983. The ecology of Albemarle Sound, North Carolina: an estuarine profile. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, D.C. FWS/OBS - 83/01. 68 p.

Davis, C.O. 1982. The San Francisco Bay ecosystem, a retrospective overview. In: W.J. Kockelman, T.J. Conomos, and A.E. Leviton (eds.), San Francisco Bay: Use and Protection. Pacific Division American Association for the Advancement of Science. 61st Annual Meeting held at the University of California, Davis, California. June 22-27, 1980.

Frayer, W.E., T.J. Monagan, D.C. Bowden, and F.A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950s to 1970s. Colorado State University, Fort Collins, Colorado. 31 p.

Gray, L.C., C.L. Steward, H.A. Turner, J.T. Sanders, and W.J. Spellman. 1923. The utilization of our lands for crops, pastures and forests. pp. 415-506 in: The yearbook of agriculture. U.S. Department of Agriculture, Washington, D.C.

Giari, M.J. 1982. Dredging. In: W.J. Kockelman, T.J. Conomos, and A.E. Leviton (eds.), San Francisco Bay: Use and protection. Pacific Division American Association for the Advancement of Science. 61st Annual Meeting held at University of California, Davis, California. June 22-27, 1980.

Gross, M.G. 1982. Man's effect on estuarine shorelines - New York harbor, a case study. In: W.J. Kockelman, T.J. Conomos, and A.E. Leviton (eds.), San Francisco Bay: Use and Protection. Pacific Division American Association for the Advancement of Science. 61st Annual Meeting held at University of California, Davis, California. June 22-27, 1980.

Hutton, R.S., R.D. DeLaune, and W. H. Patrick, Jr. 1983. Sedimentation, accretion, and subsidence in marshes of Barataria basin, Louisiana. Limmology and Oceanography 28(3):494-502.

Johnson, W.B. and J.G. Gosselink. 1981. Wetland loss directly associated with canal dredging in the Louisiana coastal zone. pp. 60-72 in: D.F. Boesch (ed.), Proceedings of the Conference on Coastal

Erosion and Wetland Modification in Louisiana: causes, consequences, and options. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C.

Liroff, R.A. 1980. Judicial review under NEPA - lessons for users of various approaches to environment impact assessment. Technical Report E-80-2. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. 36 p. + appendices.

Myhrum, C.B. Federal protection of wetlands through legal process.

Nelson, R.W. 1983. Wetland impact assessment: problems under the Clean Water Act. Environmental Impact Assessment Review 4(1):25-40.

Office of Technology Assessment (OTA). 1984. Wetlands: their use and regulation. OTA-O-206. U.S. Congress, Office of Technology Assessment, Washington, D.C. 207 p.

Orlob, G.T. 1976. Impact of upstream storage and diversion on salinity balance in estuaries. pp. 3-17 in: M. Wiley (ed.), Estuarine Processes, Vol.II. Academic Press, New York.

Reimold, R.J. 1976. Grazing on wetland meadows. pp. 219-225 in: M. Wiley (ed.), Estuarine Processes, Vol.I. Academic Press, New York.

Sax, J.L. 1970. The public trust doctrine in natural resource law: effective judidcial intervention. Mich. Law Review 68:471.

__________. 1981. Liberating the public trust doctrine from its historical shackles. pp. 6-9 in: H.C. Dunning (ed.), The Public Trust Doctrine in Natural Resource Law and Management, Conference Proceedings. Held at University of California, Davis, California.

Smith, D.D. 1976. Dredging and spoil disposal - major geologic processes in San Diego Bay, California. pp. 150-166 in: M. Wiley (ed.), Estuarine Processes, Vol.II. Academic Press, New York.

Want, W.L. 1984. Federal wetlands law: the cases and problems. Harvard environmental Law Review 8:1-53.

Ward, G.H., Jr., N.E. Armstrong, and the Matagorda Bay Project Team. 1980. Matagorda Bay, Texas: its hydrology, ecology and fishery resources. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS - 81/52. 230 p.

Wilmar, M.B. 1982. Bay Conservation and Development Commission's experience in shoreline management: problems and opportunities. In: W.J. Kockelman, T.J. Conomos, and A.E. Leviton (eds.), San Francisco Bay: Use and protection. Pacific Division American Associated for the Advancement of Science. 61st Annual Meeting held at the University of California, Davis, California. June 22-27, 1980.

A PUBLIC INTEREST PERSPECTIVE ON MANAGEMENT OF PHYSICAL ALTERATIONS OF ESTUARIES

Charles W. Hollis
U.S. Army Corps of Engineers,
Wilmington, North Carolina

For 30 years or more, citizens and members of government have expressed concern for the loss of our nation's estuaries and coastal wetlands, and these expressions have resulted in many strong actions by our lawmakers and the courts. The Congress heard from these interests prior to passing the Fish and Wildlife Coordination Act in 1956 and its amendments in 1958. The strength of that act is felt every day as federal agencies pursue their project licenses or permits that involve fish and wildlife resources. The act was the forerunner of several other significant laws and has remained a significant expression of national policy regarding the protection of fish and wildlife.

The remainder of the 1950s and the 1960s saw the environmental awakening in the United States, which reached a significant peak in late 1969 with the passage of the National Environmental Policy Act (NEPA). NEPA provides the base for national policy regarding all of our natural resources and, for the sake of this conference, especially for our estuaries. It required all federal agencies to place environmental values on an equal footing with engineering and other considerations including those of economics. It has been used as a model for several state environmental policy acts to the point that its influence today is clearly nationwide.

The pace of environmental interest continued with the Federal Water Pollution Control Act amendments in 1972, the Clean Water Act amendments in 1977, and numerous other laws requiring the measured control of various natural resources through prescribed regulatory programs. The federal courts played a significant role in environmental protection as they recognized, in decisions across the nation, that the national policy had become clear: regulation of the use of natural resources was required.

The last few years have seen a slowing of the pace of new environmental legislation as well as a studied evaluation of the existing laws and regulations. This evaluation has logically included an assessment of the costs of regulation on economic growth and a review of the practices and procedures of the various regulatory programs. There have been some changes in regulations in an effort by the current administration to bring the programs into the balanced position envisioned in the NEPA rather than positions that in many cases favored environmental or other specific resources. There has been an increased emphasis on shifting the burden of environmental regulation from the federal government to the state governments as federal budget problems have become more acute.

As we reflect on these past trends, we may make two observations.

1. Our actions to protect natural resources are stronger or weaker depending on our economic health.

This is a rather obvious observation not requiring much discussion. It applies to our personal lives as well as to our national life in that as we are able to move up from economic survival, we then move to maintain and improve our quality of life. The dean of the North Carolina Forestry School pointed out in an address a few years ago that the ability of industry to take strong steps in the direction of environmental enhancement was dependent on industry's enjoying a reasonable profit. Without profit, there was no ability, only survival. We have seen our national and state governments take bold steps in the direction of environmental protection during periods of a strong economy, and as the strength of the economy cooled the national and local governmental priorities moved somewhat away from environmental problems.

2. Environmental legislation has been initiated, for the most part, by special interest groups without much interest and involvement by the public.

There is a disturbing public ignorance about environmental laws and regulations and, perhaps more seriously, an alarming lack of interest in the need for such regulation. Organized interest groups have been primarily responsible for initiating our current environmental legislation through their effective and persistent lobbying. The implementation stage of the process is where problems emerge. An informed interest group may have successfully gained legislative support for enactment of statutes that now foist agency implementation onto a reluctant and uninformed public. The issues become those of government "on the backs of the people" rather than government trying to implement the will of the people as expressed through their elected representatives.

Environmental protection, including management of estuarine alteration, cannot evolve much further without the active involvement of an informed and concerned public. We are at a point where national direction and policy have been established through laws, regulations, and judicial rulings. We are also at a point where the trend of national government is to pass the responsibility for program implementation to the state and local governments. The environmental community has resisted this step and prophesied doom for natural resource protection because, in their view, local and state governments do not place proper value on these resources. If this is true, it must be blamed one of two reasons: the resource values have been overstated, or the state or local governments are ignorant of the values. Assuming we have not overstated the value of the resources, we must face up to the serious mistake of failing to develop an informed and concerned environmental public constituency.

There are already some excellent examples of local government actions taken to protect local natural resources. In North Carolina the designation of several estuarine sanctuaries has required involvement and action on the part of local government and the expenditure of local public funds. It was necessary to inform and convince the local people of the need to take such action before they would support it. There are surely countless other examples of similar actions in communities around the nation. These actions demonstrate what local government can and will do when its people are informed of the threats to its natural resources and when they understand the values of taking action to provide protection.

Federal agencies and state agencies expend considerable energy wrestling with an increasing list of program limitations starting with ambiguous legislative direction and extending through limits of legal authority, limited funds and personnel, and questionable public support. The result is often a confused public that expects the agency to provide regulatory protection for certain resources, only to see the agency disappear through legal and administrative loopholes. These loopholes are closed very effectively by local ordinances and regulations that provide the level of control expected by the local government. But such ordinances will not and cannot be enacted unless the public understands the threats to the resources and the resource value; in other words, unless the public understands the degree of protection that is in the public interest.

In the case of the estuaries, the environmental community, including those of us in this symposium, have probably met enough to swap stories among the well informed. What is needed now is a strong program to pass our knowledge on to the general public and especially to local governments, and for environmental interest groups to lobby at that level for environmental protection action. We must raise the level of concern of the man on the street for estuarine losses. Without his concern, expressed to and through local governments, there will be no real management of the estuary, but only a continuation of reactive efforts by federal regulators to outflank the development attempts by others on a case-by-case basis.

The efforts to put effective environmental legislation in place have been successful. Now is is time to organize a similarly energetic effort to inform the public so that regulatory decisions in the future will not merely reflect a composite opinion of a cadre of federal agencies, but will also be founded on decisive action by the local governments based on their genuine concern for the public interest and their equally genuine concern for protecting our natural resources.

MANAGING PHYSICAL ALTERATIONS IN THE COASTAL ZONE: SISYPHUS AT WORK IN LOUISIANA

R. Eugene Turner and Charles G. Groat
Louisiana State University, Baton Rouge

The paper on physical alteration of coastal wetlands by Dr. Lockhart has introduced (1) the idea of public trust, (2) the existing, or non-existing, management structure necessary to protect that public trust, and (3) recent developments in the present federal legal system that support the management structure. It is the purpose of this paper to build on that introduction to (1) outline the causes of the rather severe rate of coastal wetlands loss in Louisiana, (2) offer an overview of the historical attitude to marsh management and the facilities available to deal with the present problem, and (3) briefly support certain lines of research and management useful in dealing with the issues involved in the physical alteration of estuaries.

The Physical Alteration of the Louisiana Coastal Zone

Louisiana's coastal wetlands comprise 41 percent of the total coastal wetlands of the United States (Turner and Gosselink 1975), and are a state, national, and international natural resource. For 7,000 years there has been net land gain along this coast together with periods and localized instances of land loss. At the beginning of this century the net land gain was about zero; now that rate approaches 0.8 percent annually (about 50 square miles, annually) and is climbing geometrically with time. At that rate the state of Rhode Island would be lost within 21 years, the District of Columbia within 7 years, and within 55 years the Netherlands would lose to the sea all of the land she reclaimed over the last 800 years. As Shakespeare wrote, we will ruminate on the situation to discuss technical issues related to the physical alteration of the coast.

Land gains and losses are the result of many interacting factors. In a natural marsh, mineral matter from rivers, reworked sediments, and plant debris is required to build land. At the same time, land in this sedimentary coast is sinking (because of compaction, for example), and absolute sea level is rising. Any factor that significantly alters subsidence, sedimentation, organic deposition, or relative sea level could easily determine whether an area gains or loses land.

Dredged canals, one of these factors, have both direct and indirect effects. Canals have an obvious direct effect on land loss because the canal itself changes marsh to open water, and the spoil levee built from dredged material blocks both above- and belowground waterflow. The rise of canal density has been coincidental with the exponential rise in land loss rates. This suggests that canals also have an indirect effect, though this relationship is imperfectly understood. Since canal construction in Louisiana usually results in spoil bank levee construction, both canals and canal levees are significantly involved in promoting wetland loss. Canals, and (indirectly) canal levees, are regulated under the implicit assumption that they influence a public resource; otherwise, they would not be regulated. Regulation can reduce wetland losses if the situation leading to losses is understood (Lindall and Saloman 1977, Gosselink and Baumann 1980, Lindall and Thayer 1982). In the following we discuss the formation of wetlands and how canals and spoil levees contribute to coastal erosion. We then outline how the influence of present and future canals and levees might be mitigated.

Wetland Formation

The Louisiana coastal marshes were formed from an overlapping series of riverine deltas extending onto the continental shelf. The currently emerging Atchafalaya delta was preceeded by 16 major deltas over the last 6,000 years. The older delta complexes, the Maringouin and the Sale-Cypremort, became inactive about 4,000 years ago when the river switched its position to the east. This process of delta growth and abandonment continued until the position of the modern birdfoot delta was reached about 900 years ago.

Growth in a new delta is cyclical. In the construction phase, seaward progradation causes delta muds to be overlaid by silts and sands which in turn are topped by delta marsh sediments, including organic deposits (Fisk 1960). In the destruction phase, the river abandons its channel in favor of a shorter route to the sea. The upper layers erode, exposed sediments may be reworked, and marine transgression may occur. Individual crevasses may deposit sediments up to 14 meters (4.5 feet) thick and the entire delta sequence 150 meters (491 feet) deep.

As the distributary channels become smaller and the delta is abandoned, interdistributary ponds, levee flank lakes, and bays form. The levee gradually sinks into the surrounding marsh, which then covers it, leaving only a reduced surface expression of its larger buried form. The overlying deltaic deposits are susceptible to erosion at rates that are influenced by the geologic structure beneath. In general, land loss rates are highest in young deposits near the coast and lowest in older sediments far from the coast. Scaife et al. (1983) provided several reasons for this result. First, as a delta grows, overlaps, and extends seaward, the underlying deposits nearest the sea are necessarily the youngest and sediments within are the least sorted. The more deeply buried material nearest the Pleistocene surface is older and has had longer to compact (consolidate). These latter sediments tend to have lower subsidence rates and are more resistant to erosion. Second, the seaward edge is thicker, thus consolidation, dewatering, and downwarping are greatest there. Third, compared to landward, the seaward edge is more subject to wave attack, currents, and redistribution of sediments. Lastly, older deltas have had more time to stabilize through consolidation, grain sorting, or gravity.

Soil oxidation and subsurface fluid withdrawal may encourage subsidence in surface and deeper soils, respectively. Surface drainage has resulted in a lower water table and soil oxidation and consequently has lowered the land surface in New Orleans (Snowden et al. 1977, Traugher et al. 1979). This is generally observed worldwide in wetlands reclamation projects (Darby 1956, Stephens and Steward 1976;). Oil and gas fluid withdrawal from deep layers has resulted in measurable increases in subsidence outside of Louisiana (Castle et al. 1969; Kesteren 1973), but little is known about these impacts in Louisiana soils (Boesch et al. 1983).

Although geologic factors clearly influence the rates of land loss, other factors are important. Vertical soil accumulation is not simply the result of sediment supply, but also of the interaction of plants and the prevailing hydrologic regime. For example, besides trapping mineral matter at the surface, plants add a substantial amount of organic material to the soil belowground in the rooting zone. Fresh marsh soils are mostly organic debris deposited in situ, not brought in by currents. Even salt marsh soils may be composed of up to 50 percent organic matter. As the organic material is laid down, mostly belowground, the weight per unit volume (measured as bulk density) decreases. Thus, marshes need less mineral matter than does a bay bottom to maintain elevation in the face of a rising sea level or a sinking substrate.

Plants, in turn, are influenced by hydrologic relationships, including belowground water movements. When King et al. (1982) increased subsurface drainage by means of a pipe buried in the marsh, plants located inland became more productive. Too much flooding may lower plant production and also decrease the decomposition of buried organic material.

Although hydrology, subsidence rates, soil organic content, salinity, and vegetation differ widely across the coast, "natural" wetland plant communities maintain a remarkably similar sediment accumulation rate in Louisiana (Hatton 1981). It is as though the total physical and biological system were responding through different pathways to reach the same equilibrium point relative to flooding. The details of how this buffering capacity is maintained are sketchy. Wetland plants are sensitive to waterflow patterns, particularly soil chemistry, and they respond both metabolically and morphologically to altered hydrologic regimes (Linthurst 1979, Mendelssohn and McKee 1981, Mendelssohn et al. 1981). Goodman and colleagues (Goodman et al. 1959, Goodman 1960, Goodman and Williams 1961) have proposed that the increased soil sulfide concentrations occurring in standing waters may be implicated in the physiological demise of some marsh plants. Because the reciprocal feedback loops are balanced in a stable marsh, the disturbance of any one of many factors may result in marsh erosion. Thus the soil pH-redox equilibrium, soil aeration, and plant water requirements are complexly interrelated, but these relationships are not completely understood, even in laboratory settings (Sasser 1977, Mendelssohn 1979, Delaune et al. 1981, Jakobosen et al. 1981, Mendelssohn et al. 1981).

Canals and Spoil Levees in the Coastal Zone

Canals in coastal Louisiana are built with various dredging methods to assist navigation, belowground mineral reco very, pipeline construction and trapping [see Allen and Hardy (1980) and Davis (1973) for a complete description]. Most canals are constructed to serve the oil and gas industry (Adams et al. 1976), which largely developed after 1940

(Figure 1). Each oil and gas field in the coastal wetlands has numerous canals and spoil banks. The canals are dug to float in drilling equipment, and the spoil banks are the residual dredging materials placed on either side of the canal in a continuous and unbroken line.

Annual oil and gas production rates peaked about 10 years ago and have declined since in spite of the deregulation of prices that occurred in the late 1970s. Consequently, fewer canals have been built in recent years although the cumulative total canal area created continues to increase. The surface area of canals is equivalent to 2.3 percent of the wetland area. Every hydrologic unit has a significant area of canals that has increased greatly in the last 25 years. Overall, the total area of spoil bank levees and canal surface is about 9.5 percent of the wetland area in the Mississippi River deltaic plain. The natural channel density in a natural marsh is about 8 percent to 10 percent of the marsh; a major adjustment has taken place in marsh hydrology. There is hardly a place in the Louisiana coastal zone where canals and their effects are not seen.

The annual enlargement of five major canals ranges from 2 percent to 14.8 percent or a doubling rate from about 5 to 35 years (Craig et al. 1979, Johnson and Gosselink 1982). Enlargement of the existing canals now approaches the area of new canals added each year. The land directly lost to the expansion of canal surface area represents about 10 percent of the total coastal land erosion rate. Within 20 years the land loss rate may be doubled, simply through the continued widening of existing canals.

The weight of the levees compacts the former wetland beneath it. Nichols (1959) documented that belowground water had not only a smaller cross-sectional area to pass through beneath a levee, but also a more impenetrable material. This finding indicates that the marsh is effectively isolated from the nearby bodies from both above and below by the presence of a levee.

When the area of the natural drainage features is equaled by the area of the canals and spoil bank levees, as is the average condition for the Louisiana coastal zone, then an adjustment of the natural drainage features is expected. Naturally formed streams often widen at the tips of the formally smaller headwaters (Figure 2) whereas others disappear.

Near Leeville, Louisiana, the area of natural drainage channels decreased exponentially with the linear increase in canals (Craig et al. 1979). As the canals and levees cross the channels the latter often close off, silt in, or erode into open ponds. In Puerto Rico, a transportation levee constructed through a mangrove swamp resulted in the death of the trees and pond formation within the hydrologic unit. A comparable mangrove ecosystem nearby remained healthy. These examples support the hypothesis that it is the interruption of the natural hydrology, not sea-level rise, a loss of sediment supply, or insects, that was the causal agent of change (Zucca 1982).

Wetlands usually erode near canal levees. In 1955, for example, the area within the Belle Chasse 7.5-minute quadrangle was mostly

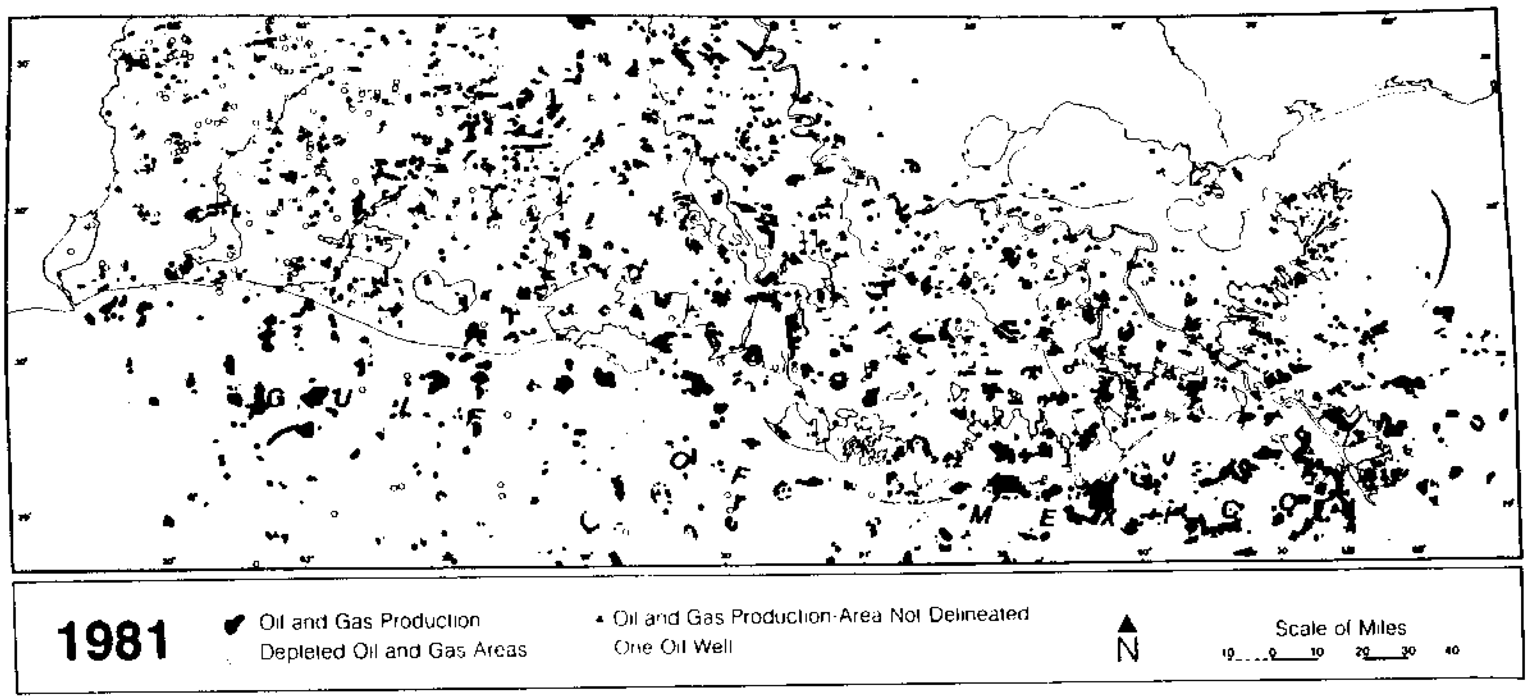


Figure 1. The distribution of oil and gas fields in south Louisiana in 1981 (from Turner, 1985).

Figure 2. The enlargement of a natural channel following a channel damming by a canal levee.

marsh, but the largest area of open water present was surrounded by canals. Between 1955 and 1978, however, numerous holes in the marsh opened up near canals, but not away from canals (Figure 3). The smaller ponds in the Belle Chasse quadrangle were scattered throughout the area. By 1978 larger ponds opened up next to the canals, especially near the corners where canals crossed each other. The largest ponds (greater than 150 acres) formed where the spoil levees impounded an area.

Finally, there is a positive relationship between land loss rates from 1955 to 1978 and canal density for almost all of the Louisiana deltaic plain (Scaife et al. 1983). Where canal density, hence spoil bank levee density, is high, land loss is high; where canal density is low, land loss is low; where canal density is nearly zero, land loss is nearly zero. An example of this relationship is shown in Figure 4. In general, the newer substrates near the coast erode faster than the older substrates far from the coast. In the Atchafalaya delta, land building occurs more slowly in areas with canals than in areas without canals. Whatever relationship there is must be indirect since conversion of land to open water during dredging accounts for a relatively small proportion of the total land loss in most coastal areas.

The conclusion is clear: coastal erosion rates are directly related to canal and spoil levee density. Canals and spoil levees influence most of the various vegetational, geologic, and hydrologic characteristics of the coastal zone. Whereas it may appear that the canal is the agent of change, it must be remembered that the spoil bank levee itself is the major hydrologic obstacle preventing sediment exchange between water and wetlands and is the barrier influencing water movement over and under the marsh.

Experience with impoundments and mosquito ditches on the East Coast provides further illustrations of the empirical, if not causal, relationships between wetland hydrologic changes and coastal erosion. The parallels to canal and spoil bank levee effects on coastal erosion in Louisiana include (1) canal widening, (2) vegetation changes following hydrologic modifications, (3) levee compaction and panne formation alongside the levee, (4) saltwater intrusion and increased saltwater residence times over the marsh, (5) impoundment followed by changes from land to open water, (6) water flow blockage over land between marsh and water, (7) blockage of the natural drainage features, (8) loss of the dendritic channel network, (9) groundwater level changes, and (10) increased subsidence following impoundment (Daigh et al. 1938, Stearns et al. 1940, Bourn and Cottam 1950, Eliot 1748, Warren 1911, Okey 1918a,b).

Reversal and mitigation

Examples from other areas also indicate steps to mitigate the present negative impact of canal levees. For example, when levees were initially constructed to form a mosquito impoundment in Florida, the resulting blockage of natural hydrologic flows resulted in dead and dying vegetation. When the levees were removed, the vegetation returned (Harrington and Harrington 1982). Marsh vegetation also reappeared

20-50 ac

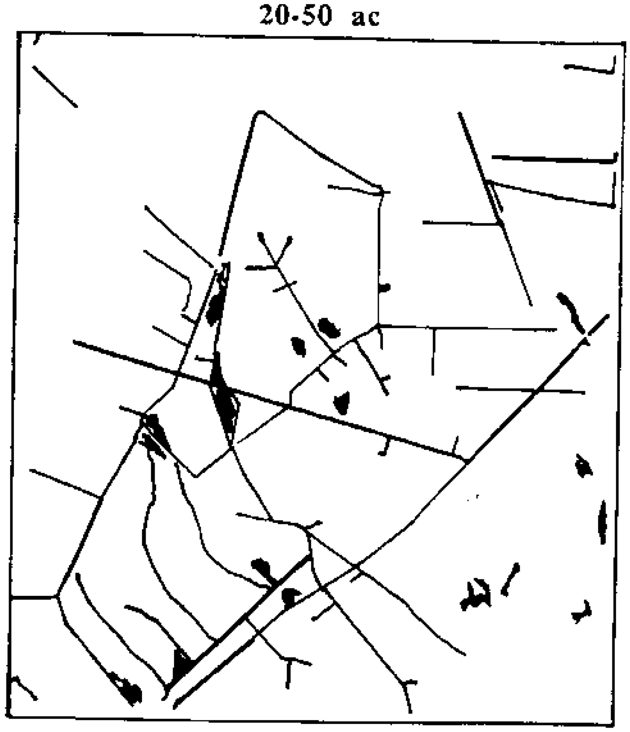


Figure 3. The location of erosion zones in the marsh from 1955 to 1978 in the Belle Chasse 7 1/2 minute quadrangle map (adapted from Turner, 1985). Shown are only those new erosion zones (marsh to water changes) which are between 20 and 50 acres.

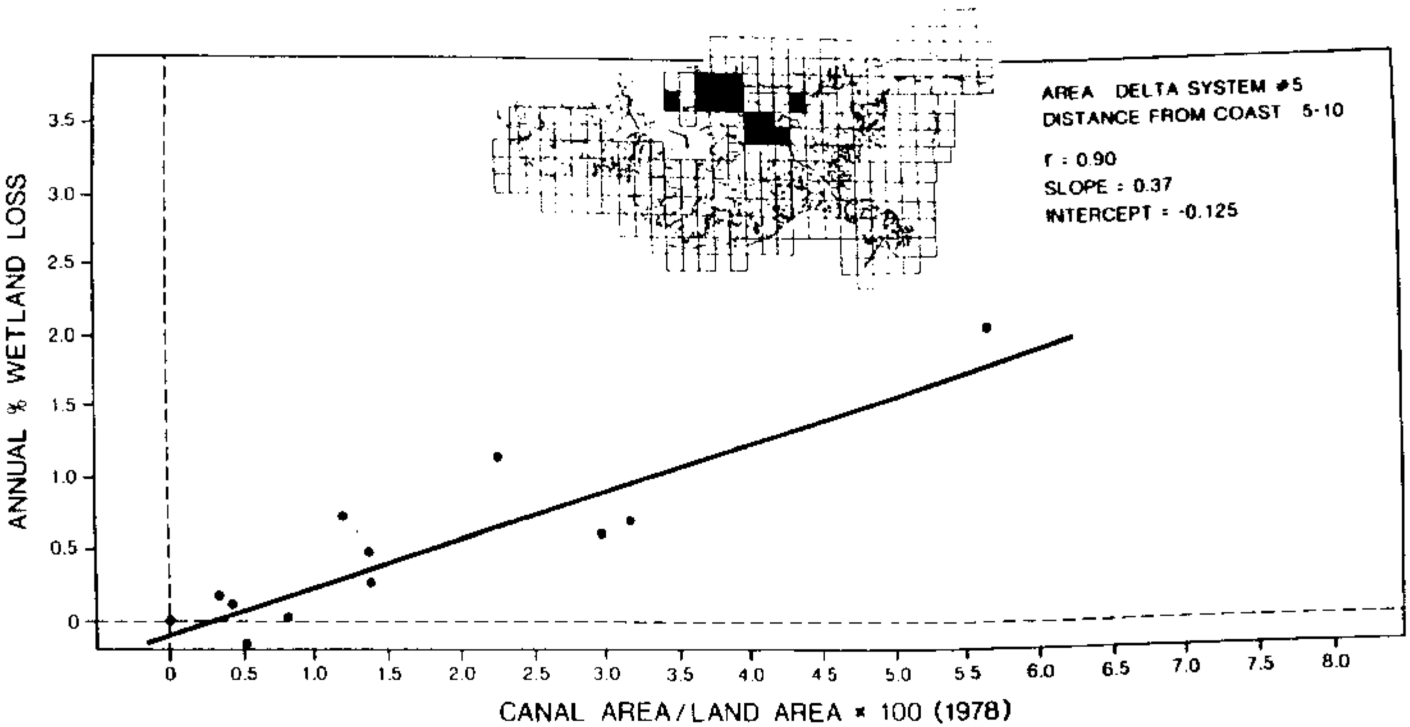


Figure 4. The relationship between canal density and annual wetland loss rates during 1955-1978 for the quadrangle maps depicted in the inset map (from Scaife et al., 1983).

when dikes were breached in two 200-acre marshlands near San Francisco (Faber 1982; Josselyn and Perez 1982). The same circumstances prevailed in experiments with mosquito ditching in Delaware (Stearn et al. 1940). Subsidence, as well as vegetation and groundwater level, was reversed when the ditches were refilled from the existing turf line created from the ditching (Figure 5).

These study results suggest that interference with the natural hydrologic processes is the main pathway for interruptions in vertical soil accumulation. With vertical soil formation reduced belowground and subsidence continuing, the marsh turns to open water.

Coastal land erosion is, of course, not solely the result of increased canal and spoil bank engineering. It is, however, strongly influenced by canals, canal spoil levees, and other natural factors (subsidence, river levees, and rising sea level) that are now largely unmanageable.

Canals can be managed. Minimizing canal construction, making the most use of existing canals, drilling to several targets from one well head location, changing canal spoil levee design (including levee manipulations), backfilling canals, and plugging canals can improve the situation. Some dredging operations might spray the spoil over the marsh rather than place the spoil in a uniform spoil bank.

Avoiding the Tragedy of the Commons (as defined by Hardin 1968)

Whatever options may be available to manage canals and levees, we do not have sufficient data to make decisions regarding these options. Clearly something must be done; improving the data will require a multidisciplinary effort which includes the study of plants, sediments, wildlife, and aquatic organisms. Experience with a variety of management systems has repeatedly demonstrated the value of observing the results of direct manipulation of ecosystems, of replicating controlled conditions, and of investigating competently and inquisitively over long periods. The tendency is to arrange for a quick solution to a pressing problem. This is shortsighted and, ultimately, an inefficient use of money. Conditions are always changing and so our understanding must be constantly improved and reevaluated in light of new circumstances.

From a management perspective, there are typically two approaches to develop solutions. The first, described as an engineering approach, assumes that the necessary 'equations' needed for a solution already exist, that the system is understood (as though all that is needed are equations, steel, and a river to cross), and that conditions will not change. This approach works well for building a slightly different version of the same bridge, dam, or road. It does not work well with biological systems because of the nonlinear relationships between an enormous number of parts, the natural disorder in climatic events, random or cyclic perturbations from outside the system, and insufficient understanding or data resources.

The enormously successful and influential Hubbard Brook forest ecosystem study is an example of the alternative approach to solving large natural resource management problems. It is best described by

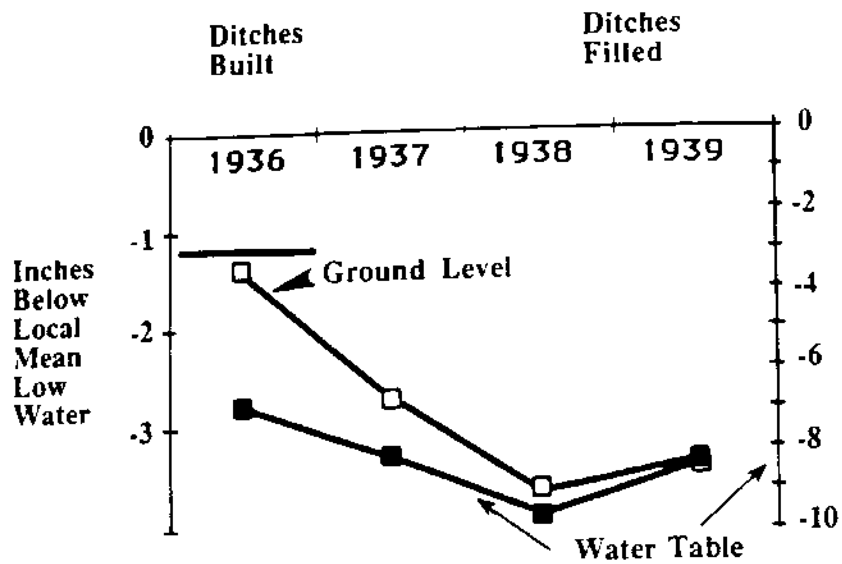


Figure 5. Ground level and water level in tidal marsh before mosquito ditches were dug, after construction, and after the ditches were filled back in (adapted from Stearns et al., 1940).

the main program managers, Gene Likens and Herbert Bormann: "Generally, the method we used to guide the growth of the Hubbard Brook research proposals was as follows: First, based on our own perception or feedback from ongoing studies, from cooperating scientists, or from outside advisors, we recognized research problems that were timely and particularly pertinent to our overall research goals. Some of the studies were launched under our direction, others were brought to the attention of an established investigator working in that research area. We then sought a mutually satisfactory arrangement to allow the investigator to work at Hubbard Brook. From the beginning we have called attention to the kinds of information a cooperative study might produce, but always we have encouraged individuality in the design and execution of the research. We deem this individual research freedom one of the greatest assets of the Hubbard Brook study. Individuality in selection of problems and conduct of research is also encouraged among graduate students at Hubbard Brook. Not only does this contribute to the intellectual ferment and sound growth of the Hubbard Brook study, but as educators, we feel this approach absolutely necessary if the Hubbard Brook study is to contribute to graduate education." (G. E. Likens and F. H. Bormann, p. viii; in Likens et al. 1977). [Emphasis added.]

Siry (1984) has coherently and concisely traced the development of our national estuarine management ethic. Reading that history, one thinks of Sisyphus, the Greek god, sentenced to forever advance a large boulder up a hill, only to have it roll down again just as he approached the summit. The history of wetlands management tells of almost continuous wetlands loss, despite significant efforts by conservationists, resulting from the physical alteration of estuaries. There has been no real stability - only loss.

Camus, in "The Myth of Sisyphus," writes that the condemnation of Sisyphus is not necessarily an unhappy situation. Sisyphus was sentenced for his dislike of authority, hatred of death, and passion for life; he was, in many ways, very American. Camus considered the situation of Sisyphus instructive in that it presented Sisyphus with an opportunity (which he fully grasped) for both abandoning the external dieties in favor of learning from his own experience and forming his own fate, and for appreciating the challenge of moving the immovable, time and time again. Camus wrote that by not being overwhelmed by the boulder and his sentence, Sisyphus became "stronger than the rock itself."

Similarly, estuarine management must not be overwhelmed by the large size of the problems and the repetitive actions required to address them. Despite its problems, estuarine management is not a sentence, but an opportunity. And the shortest path to a solution is through understanding. However, we must caution that complete understanding is also not likely until some decisions are made. Some balance between understanding and action is needed. To expect that absolute understanding is obtainable is foolish; and to avoid seeking understanding is equally foolish.

References

Adkins, G. and P. Bowman. 1976. A study of the fauna of dredged canals of coastal Louisiana. La. Wildl. Fish. Comm. Tech. Bull. 18. 72 pp.

Boesch, D.F., ed. 1982. Proc. of the conference on coastal erosion and wetland modification in Louisiana: Causes, consequences, and options. Biological Services Program, U.S. Fish and Wildlife Service, Washington, D. C. FWS/OBS-82/59. 259 pp.

Bourn, W.S. and C. Cottam. 1950. Some biological effects of ditching tidewater marshes. U.S. Fish Wildl. Serv., Res. Rep. 19.

Castle, R.O., R.F. Yerkes, and F.S. Riley. 1969. A linear relationship between liquid production and oil-field subsidence. Assoc. Int. Hydrol. Scientif. Actes du Colloque de Tokyo. 1969:162-173.

Craig, N.J., R.E. Turner, and J.W. Day, Jr. 1980. Wetland losses and their consequences in coastal Louisiana. Z. Geomorphol. Suppl. Bd. 34:225-241.

Daiber, F.C. 1982. Animals of the tidal marsh. Van Nostrand Reinhold Co., New York. 422 pp.

Daigh, F.C., D. MacCreary, and L.A. Stearns. 1938. Factors affecting the vegetative cover of Delaware marshes. Proc. N. J. Mosq. Extermination Assoc. 25:209-216.

Davis, D.W. 1973. Louisiana canals and their influence on wetland development. Ph.D. Dissertation. Louisiana State Univ., Baton Rouge. 199 pp.

Delaune, R.D., W.H. Patrick, Jr., and R.J. Buresh. 1978. Sedimentation rates determined by 137-Cs dating in a rapidly accreting salt marsh. Nature 275:532-533.

Eilers, H.P. 1980. Ecology of a coastal salt marsh after long-term absence of tidal fluctuation. Bull. Southern California Acad. Sci. 79:55-64.

Eliot, J. 1748. Essays upon field husbandry in New England. Reprinted by the Columbia University Press, 1924. H.J. Carman and R.G. Tugwell, eds. 261 pp.

Faber, P. 1982. Muzzi marsh restoration, a mitigation project. Page 100 in M. Josselyn, ed. Wetland restoration and enhancement in California. California Sea Grant Program, University of California, La Jolla. Report T-CSGCP-007. 110 pp.

Gagliano, S.M. 1973. Canals, dredging, and land reclamation in the Louisiana coastal zone. Hydrologic and geologic studies, Rep. 14. Center for Wetland Resources, Louisiana State Univ., Baton Rouge. 104 pp.

Gagliano, S.M., K.J. Meyer-Arendt, and K.M. Wicker. 1981. Land loss in the Mississippi River deltaic plain. Trans. Gulf Coast Assoc. Geol. Soc. 31:295-300.

Gilmore, R.G., D.W. Cooke, and C.J. Donohoe. 1981. A comparison of the fish populations and habitat in open and closed salt marsh impoundments in east-central Florida. Northeast Gulf Sci. 5:25-37.

Goodman, P.J. 1960. Investigations into "die-back" in Spartina townsendii Agg. II. The morphological structure and composition of the Lymington Sward. J. Ecol. 48:711-724.

Goodman, P.J. and W.T. Williams. 1961. Investigations into "die-back" in Spartina townsendii Agg. III. Physiological correlates of "die-back". J. Ecol. 49:391-398.

Goodman, P.J., E.M. Braybooks, and J.M. Lambert. 1959. Investigations into "die-back" in Spartina townsendii Agg. I. The present status of Spartina townsendii in Britain. J. Ecol. 47:651-677.

Gornitz, V., S. Lebedeff, and J. Hansen. 1982. Global sea-level trend in the past century. Science 215:1611-1614.

Gosselink, J.G. and R.E. Turner. 1978. The role of hydrology in the ecology of freshwater wetland ecosystems. pp. 63-78 in R.E. Good, D. Whigham, and R. Simpson, (eds.), Freshwater marshes: present status-future needs. Academic Press, New York. 378 pp.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An ecological characterization of the Chenier Plain coastal ecosystem in Louisiana and Texas. Vol. 1. Biological Services Program, U.S. Fish and Wildlife Service, FWS/OBS-78/9. 302 pp.

Gosselink, J.G. and R.H. Bauman. 1980. Wetland inventories: wetland loss along the United States coast. Z. Geomorphol. N.F. 34:173-187.

Hardin, G. 1968. The tragedy of the commons. Science 162:1243-1248.

Harrington, R.W., Jr. and E.S. Harrington. 1982. Effects on fishes and their forage organisms of impounding a Florida salt marsh to prevent breeding by salt marsh mosquitos. Bull. Mar. Sci. 32:523-531.

Harrison, R.W., and W.M. Kollmorgen. 1947. Past and prospective drainage reclamations in coastal marshlands of the Mississippi River delta. J. Land and Public Utility Econ. 23:297-320.

Johnson, W.B. and J.G. Gosselink. 1982. Wetland loss directly associated with canal dredging the Louisiana coastal zone. pp. 60-72 in D.F. Boesch, (ed.), Proceedings of the conference on coastal erosion and wetland modification in Louisiana: causes, consequences, and options. Biological Services Program, U.S. Fish and Wildlife Service, Washingtron, D. C. FWS/OBS-82/59. 259 pp.

Kesteren, J. Van. 1973. The analysis of future surface subsidence resulting from gas production in the Groningen field. Verh. K. Ned. Geol. Mijnbouwk. Gen. Vol. 28:11-28.

King, G.M., M.J. Klug, R.G. Wiegert, and A.G. Chalmers. 1982. Relation of soil water movement and sulfide concentration to Spartina alterniflora production in a Georgia salt marsh. Science 218:61-63.

Likens, G.E., F.H. Bormann, R.S. Pierce, J.S. Eaton, and N.M. Johnson. 1977. Bio-geochemistry of a forested ecosystem. Springer Verlag, New York. 146 pp.

Lindall, W.N. and G.W. Thayer. 1982. Quantification of National Marine Fisheries Service habitat conservation efforts in the southeast region of the United States. Mar. Fish. Rev. 44:18-22.

Mendelssohn, I.A., K.L. McKee, and W.H. Patrick, Jr. 1981. Oxygen deficiency in Spartina alterniflora roots: metabolic adaptation to anoxia. Science 214:439-441.

Miller, W.R. and F.E. Egler. 1950. Vegetation of the Wequetequock-Pawcatuck tidal-marshes, Connecticut. Ecol. Monogr. 20:143-172.

Mock, C.R. 1967. Natural and altered estuarine habitats of penaeid shrimp. Proc. Gulf Caribb. Fish. Inst. 19:86-98.

Nichols, L.G. 1959. Rockefeller Refuge levee study. Louisiana Wildlife Fisheries Commission Refuge Division. Tech. Rep. 17 pp.

Nixon, S.W. 1982. The ecology of a New England high salt marsh: a community profile. Biological Services Program, U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-81/55.

Okey, C.W. 1918a. The subsidence of muck and peat soils in southern Louisiana and Florida. Am. Soc. Civil Eng. 82:396-422.

Okey, C.W. 1918b. The wetlands of southern Louisiana and their drainage. USDA Bull. 652. Prof. Pap. 67 pp.

Penland, S., R. Boyd, D. Nummedal, and H. Roberts. 1981. Deltaic barrier development on the Louisiana coast. Trans. Gulf Coast Assoc. Geol. Soc. 31:471-476.

Price, W.A. 1947. Equilibrium of form and forces in tidal basins of the coast of Texas and Louisiana. Bull. Am. Assoc. Petrol. Geol. 31:1619-1663.

Scaife, W., R.E. Turner, and R. Costanza. 1983. Coastal Louisiana recent land loss and canal impacts. Environ. Manage. 7:433-442.

Seybert, A. 1799. Experiments and observations on the atmosphere of marshes. Trans. American Philosophical Society 4:415-428.

Siry, J.V. 1984. Marshes of the ocean shore: development of an ecological ethic. Texas A & M University Press, College Station, Texas. 216 pp.

Smith, J.B. 1907. The New Jersey salt marsh and its improvement. New Jersey Agric. Exp. Stn. Bull. 207:1-24.

Stearns, L.A., D. MacCreary, and F.C. Daigh. 1940. Effects of ditching for mosquito control on the muskrat population of a Delaware tidewater marsh. University of Delaware Agric. Exp. Stn. Bull. 225:1-55.

Swenson, E.M. and R.E. Turner. 1985. Spoil banks: effects on a coastal marsh water level regime. Manuscript submitted for review.

Traugher, E.B., J.O. Snowden, and W.B. Simmons. 1979. Differential subsidence on reclaimed marshland peat in metropolitan New Orleans, Louisiana. pp. 479-499 in S.K. Saxena, (ed.), Evaluation and prediction of subsidence. Am. Soc. Civil Eng., New York.

Turner, R.E. 1977. Intertidal vegetation and the commercial yields of penaeid shrimp. Trans. Am. Fish. Soc. 106:411-416.

Turner, R.E. 1982. Wetland losses and coastal fisheries: an enigmatic and economically significant dependency. pp. 112-120 in D.F. Boesch, (ed.), Proceedings of the conference on coastal erosion and wetland modification in Louisiana: causes, consequences, and options. Biological Services Program, U.S. Fish and Wildlife Service, Washington, D.C., FWS/OBS-82/59. 259 pp. Washington, D.C.

Turner, R.E., S.M. Peterman, and J.H. Cowan, Jr. 1983. Louisiana's infrastructure for natural resource management. pp. 141-156 in R.J. Varnell (ed.), Water Quality and Wetland Management Conference Proc. New Orleans, La. Aug. 4-5, 1983.

Turner, R.E. 1985. Coastal land loss, canals and canal levee relations in Louisiana. U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-84/xx. in press.

Turner, R. E. and C. Neill 1984. Revisiting the marsh after 70 years of impoundment. pp. 309-322 in R.J. Varnell (ed.), Water Quality and Wetland Management Conference Proceedings. New Orleans, LA., August 4-5, 1983.

Turner, R.E., R. Costanza, and W. Scaife. 1982. Canals and wetland erosion rates in coastal Louisiana. pp. 73-84 in D.F. Boesch (ed.), Proceedings of the conference on coastal erosion and wetland modification in Louisiana: causes, consequences, and options. Biological Services Program, U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-82/59. 259 pp.

Warren, G.M. 1911. Tidal marshes and their reclamation. U.S. Dep. Agric. Exp. Stn. Bull. 240. 99 pp.

Zucca, C.P. 1982. The effects of road construction on a mangrove ecosystem. Trop. Ecol. 23:105-123.

WATER QUALITY MANAGEMENT

Kent Mountford
Environmental Protection Agency,
Annapolis, Maryland

Since passage of the Clean Water Act we have spent, nationwide, many billions of dollars towards the goal of clean water. I do not like to feel that these resources have been wasted or that we have failed in making some progress against environmental problems. Some $700 million was spent between 1969 and 1979 on restoration of water quality in the Potomac River through improved sewage treatment at a number of plants within and around Washington, D.C. In the early 1970s, phosphorus removal was instituted at the Blue Plains Wastewater Treatment Plant (largest in the Chesapeake watershed). Today, phosphorus levels in some 350 million gallons a day of effluent are lowered from several milligrams of phosphorus per liter in the raw water to somewhere between 0.18 and 0.23 milligrams per liter in the treated water. Phosphorus removal, beginning in the early 1970s and increasing through the early 1980s, has achieved substantial easing of water quality problems in the estuary.

In a single recent year the Environmental Protection Agency (EPA) invested about $186 million on wastewater treatment facilities and wastewater treatment related improvements in the Chesapeake Bay basin. Some of my respected sanitary engineer colleagues take the position that these capital investments have been necessary just to hold our own on water quality. I must concur at least to the extent that I do not see where we have substantially <u>reversed</u> water quality. With increasing demands on wastewater treatment facilities, will we continue to require expenditures of this degree or more, with inflation, simply to hold our own? This need flies in the face of deficits that cry out that federal participation should decline, not advance.

Will we actually be able to reverse water quality declines and restore some of these habitats?

I've been involved in monitoring coastal ecosystem water quality from an ecological perspective since 1964 and I have always believed in, and spoken out for, the need to carry on consistent observation and stewardship of natural systems. One of my great frustrations has been trying to persuade people and regulatory agencies to support monitoring on a continuing basis. Well-designed monitoring is the only way we can track long-term changes in the system against the incredible variability of the natural environment.

This is not a simple task because it requires elegance of design and an understanding of process and linkage sufficient to sort out natural cycles and the inherent variability of biological responses in coastal systems. My former colleague, Andy McErlean, now with EPA at Gulf Breeze, said upon leaving the Chesapeake after 17 years that he had indeed seen some unusual years. In fact, he had been through 17 of them!

How do we establish and sustain monitoring networks that will enable us to track and monitor progress or decline in our natural systems?

In recent years many workers have begun to focus on the temporal and spatial scales over which environmental variables change. Larry Haas at Virginia Institute of Marine Science (VIMS) showed us how the water column in tributary rivers of the lower Chesapeake River mixes twice monthly on schedule with the spring tides, restratifying at the neaps. Dave Goodrich of the National Oceanic and Atmospheric Administration (NOAA), analyzed continuous meteorological and salinity records in the Chesapeake and showed perhaps 15 lunar-independent, wind-forced mixing events in a single study year. John Tuttle, with co-authors Malone, Ducklow, and Cargo at the University of Maryland, has recently demonstrated wind-driven lateral seiches that result in nutrient upwelling events that could be pulsing phytoplankton growth an order of magnitude by feeding them nutrients on a three to four day time scale. Mary Tyler and Bob Biggs at the University of Delaware communicate that the pycnocline in fact may oscillate laterally even more frequently with perhaps a five-hour period when the wind stops. Tyler in other work has seen internal waves rolling up the bay at pycnocline depth with amplitudes of a couple of meters.

Against this background, which I fancy to be about as predictable as a 1960s "Lava Lamp," I sponsor field teams on behalf of the Chesapeake Bay Program to go out to monitor twice a month and expect to see patterns consistent enough that we can detect the results from our management actions.

How do we find and document statistically supportable trends against the estuary's dynamic and unpredictable background?

My strongest interest in ecology for many years was the plankton system. After I had worked in the Chesapeake for a few years, Walt Boynton came up from Florida to the Chesapeake Biological Laboratory following some years with H.T. Odum. For a while we shared a friendly rivalry in our mutual attempts to establish what components of the system were most important.

I had the strong feeling, having worked with plankton for so many years, that they were the key to basic processes in the system. Walt eventually convinced me of the importance, the sometimes overriding importance, of the benthic component; and in the years since, I have accepted benthic processes as powerful forcing functions.

I hoped for a number of years that Walt and other workers would be able to quantify the role that these complex processes had in storing, buffering, and intermingling with planktonic processes and allochthonous elements from surrounding watersheds. Over the last few years, we have spent a large amount of money measuring benthic nutrient fluxes, sediment oxygen demand, and the effects of living organisms in the bottom structure on these processes. We have learned a great deal but still seem to be a long way from being able to model (quantify and project) these processes.

Another colleague now suggests (while not denying the importance of benthic processes) that water column processes, especially where integrated over a substantial depth, may, at the end of the day, be dominant. One unifying principle succeeds another, and as managers we struggle to make rational decisions in the face of changing messages from the scientific community.

Jim Bennett, with the U.S. Geological Survey, did a broad nutrient budget based on his team's work in the Potomac River, and similar efforts were made by former colleagues of mine during the Chesapeake Bay program research phase. Both determined that the bay and, by inference, many coastal estuaries may well be nutrient sinks and serve as storage repositories for many of the materials (and the resulting effects) that are discharged into them from their respective basins. Using essentially the same source data, another colleague recently generated a manuscript, yet unpublished, which concluded precisely the opposite: that while some storages do occur, most of the materials entering large coastal systems appear to be discharged into the neighboring ocean. The resolution of this controversy will determine how we manage estuaries, what we should be concerned about, and depends--in a very basic sense--on how the things work.

There is a corollary concern: whether sediment behavior in aggregate implies a hopelessly long memory for those of us managing nutrients and toxics in the system. Will we still be struggling a century from now with residual effects from our abuse of coastal systems over the last 300 years? Can we understand the behavior patterns in and relationships between benthic and water column processes well enough to quantify the storages, releases, and infaunal effects?

Even attempting the management process means somehow making and implementing decisions--decisions we wonder about after the fact. We try to base them on guidance from an admittedly iterative process called science. Because of this iterative nature, we often couch our decisions against the probabilistic backdrop of statistics.

As a result of the differing (translation: opposing) interests in many of our watersheds, much of the conflict resolution ends up in some kind of adjudicatory situation. Sometimes this may be as informal as a briefing, a presentation before a committee, or a hearing, but often it is in a court. Here the uncertainties and assumptions inevitably associated with proper statistics are used by both sides to oppose allegations or to challenge the other.

How do we choose statistical criteria and methodologies used to set and enforce standards that have real meaning in sustaining an estuarine ecosystem? Can we accomplish this and still survive the reality of interest groups?

This challenge is connected with the popular area of estuarine and water quality modeling. Modeling provides superb intellectual exercise and can indeed be a process that contributes real insight into how ecosystems operate. Models are also used as management tools. I participated with some exceptional people, including Bob Thomann from

Manhattan College, in designing a model called the PEM: the Potomac Eutrophication Model. This management tool was designed to function somewhat like the upper Potomac estuary that crosses the borders of Maryland and Virginia and passes through the District of Columbia.

Because of eutrophication problems in the Potomac, there has been tremendous interest in understanding what effects various types of wastewater treatment would have under a variety of meteorological and climatological conditions. During periods of high flow, for example, mean residence time in the upper estuary can be a matter of a day; and during periods of low flow mean residence can extend to several weeks. Models are frequently used in situations like this to demonstrate various methods of wastewater treatment, which are then considered in light of the costs. The tradeoff is made between costs and some agreed measure of ecological effect, whatever that might be.

A long process of consensus building resulted in each of the bordering state and local jurisdictions signing off on key assumptions going into calibration and verification of the PEM and its use as a water quality management tool. This has not occurred very often in East Coast politics and it gave me some renewed faith in the process to see it happen and be sustained for some three years.

One can look at various model projections and compare them with observed data during years for which the model was calibrated and verified. We may find relatively comfortable agreement, but when we add data the model projection may fail to agree in any plausible sense with what was seen in the estuary.

There was during 1983, and to a lesser extent in 1984 and 1985, a very intense summer blue-green algae bloom (Microcystis aeruginosa) in the Potomac River. This came as a tremendous shock to regional interests because no substantial and persistent blooms had been seen for about 13 years, the very period during which great expenditures and claims of success were made for water quality objectives in the estuary. The water quality model, when run with an unusually complete data set, was unable to reproduce the observed bloom conditions.

It was necessary for political (not to mention technical) survival to understand why such a bloom occurred when phosphorus removals had been carried out at area wastewater plants in amounts exceeding those achieved in any of the previous dozen years.

A special expert panel convened and worked diligently for several months. The final result indicated that a pH mechanism might be operating to trigger phosphorus release from the sediments. This mechanism was previously thought to have no real importance in the Potomac but, as shown in the studies done by Seitzinger at the Academy of Natural Sciences of Philadelphia, it appeared to provide phosphorus inputs sufficient to sustain the bloom. There was no mechanism in our carefully crafted and widely accepted eutrophication model to deal with this. The unaltered model would simply not generate enough chlorophyll to explain the bloom until that surprise mechanism was inserted into the system. The result then became plausible and useful.

Can we avoid being surprised this way? It's very easy to spend a million dollars on a major eutrophication modeling effort. We may well be embarking on a program to do just that in the Chesapeake, and I'm sure we will do it elsewhere as well. Government is probably more willing to spend money on modeling than on structural changes when we can't absolutely justify the need for specific remedial actions. Governments and taxpayers are often unwilling to spend money for remedial actions even at the conclusion of the process simply because the model product is so easily challenged.

Can we negotiate a modeling process that will provide justification for management decisions?

It would be convenient if estuaries or even our rivers and lakes had arranged their basins to correspond with the boundaries of our political subdivisions. Had that been the case we'd at least have had some uniformity within subsystem. This is not the case. In the Chesapeake basin, for example, we have six states and the District of Columbia. Our Great Lakes (the freshwater estuaries) have problems that transcend national boundaries and that are quite as complex as those related to the continental shelf.

Governments, on behalf of taxpayers with a bewildering variety of personnel and economic interests, must commit tens, even hundreds, of millions of dollars to management and restoration practices--often a decade before the results can be expected to show up.

Can we control or guide the political aspect of environmental decision making so the process can proceed across jurisdictional boundaries and continue in an orderly manner as the participants change?

How can this be done with reasonable confidence? I'll coin a phrase (not that we need another one)--transpolitical surety--because the decisions they make must inevitably transcend changes in department or agency heads, governors, and Presidents.

Can we bring together water quality and fisheries interests to define the relationships between living communities and environment and to make decisions about how work in both areas can be complementary?

The final challenge comes from the perspective I have gained as a water quality biologist and from my inherent interest in natural systems, especially the physical and lower trophic levels. The bulk of the society recognizes the importance of estuarine systems: the natural resources that can be used for commercial or recreational purposes. It is incredibly difficult to make sound, defensible connections between water quality, the lower trophic levels in our systems, and the living resources that people wish to harvest. In my position at EPA, as coordinator of monitoring for the Chesapeake basin, I have been frustrated repeatedly in trying to bring together fisheries and water quality interests. This problem appears to transcend the state, federal, and research organizations that make up our regulatory community. I am left with the nagging worry that the harvestors, people who make decisions on harvesting the resources, and the people who make decisions about water quality standards and water quality criteria are not communicating adequately or coming together to solve a common problem.

Can we do any of things I have discussed well enough to reverse the decline in this nation's estuaries? I'm not sure this conference will answer that for us, but the very fact that we are asking is encouraging. Certainly the benefits we can realize are great, and future generations will profit from our efforts and successes.

WATER QUALITY MANAGEMENT PROBLEMS IN TEXAS BAYS AND ESTUARIES

Gary L. Powell,
Texas Water Development Board, Austin, Texas

Introduction

Water is precious in Texas, a semiarid state larger than Illinois, Indiana, Iowa, Wisconsin, and Michigan combined. Perhaps that is why Texas took action in the 1930s to require primary and secondary treatment of municipal wastes, long before other states took similar action. Now, like other states, Texas is still experiencing pollution and development problems, some of which are related to older problems, while others are new issues of importance. Some problems may even seem to disappear on their own. Take for example the environmental disturbance and water quality effects of shell dredging.

Shell Dredging

Historically, molluscan (mostly oyster) shell was dredged out of the bays from submerged, dead reefs that had accumulated over a thousand years or more. The calcium carbonate shells were used as road base materials, as well as in livestock feed, in the petrochemical industry, and in the cement that helped build the rising skyline of coastal communities, such as Houston and Corpus Christi, Texas. Since the 1880s, more than 300 million cubic yards of shell material has been produced from Texas bays by dredging. Production peaked in the 1950-60 interval at about 10-12 million cubic yards a year, but by 1982 had fallen to less than 1 million cubic yards per year (MacRae 1985).

Although vocal opposition to shell dredging reached a peak in the late 1960s, the demise of the shell dredging industry was not just a product of the enthusiasm generated by the popular argument that environmental impacts were greater than economic benefits. Rather, it was mostly due to a changing market and economic balance; that is, calcium-rich minerals in the form of central Texas limestone, now quarried in the "Hill Country" region by some former shell dredging companies, replaced shell resources in the open market for building construction materials. The real argument was recognized as one over which product was better and cheaper for ordinary projects such as driveways and building foundations.

Other factors that added momentum to the shifting economic balance included actions by the Texas Parks and Wildlife Commission: (1) to increase the state shell dredging fee and tie it to the consumer price index, which caused state fees to rise from 10 cents per cubic yard in 1955 to $1.55 per cubic yard in 1985; (2) to require shell dredging companies to pay up to $50,000 per year to cover state costs associated with environmental monitoring; and (3) to require dredgers to put back 5 percent of the dredged shell as cultch material for mitigation purposes. At present, only one shell dredging company remains to seek renewal of its two-year state permit. Texas still uses some shell resources, but only about 5,000 cubic yards of oyster shell per month are currently imported as poultry and livestock feed supplements.

Point and Nonpoint Source Pollution

Another water quality problem, this one growing as population does, relates to the runoff produced by rainstorms over urban areas. In some areas, stormwater flow is recognized as one of the principal components or sources of water pollution. For example, in the Houston metropolitan area, urban stormwater runoff accounts for about 5 percent of the suspended solids and 7 percent of the organic material associated with nonpoint sources of pollution. Unfortunately, three-fourths of this water enters the Houston Ship Channel, a state waterway already under the stress of intensive industrial development.

According to the Texas Water Commission (Johnson 1985), there are 682 direct waste discharges to the channel at present (162 industrial permits and 520 municipal permits). Moreover, about 13 percent of all wastewaters discharged statewide under permit, flow through the Houston Ship Channel and Galveston Bay on their way to the sea. Water quality improvements are difficult and expensive here, but the continuous efforts of state and federal governments, as well as the cooperation of local municipal and industrial entities, are making a difference. As a result, the abundance of freshwater and marine organisms is increasing in areas where few were previously found.

In the future, water quality improvements may arise from both improved wastewater treatment technology and the use of in-situ methods, such as artificial aeration or direct injection of oxygen into the Houston Ship Channel to recharge the water column and protect downstream animal life.

Texas has 23 river and coastal drainage basins within its boundaries, containing 16,129 stream miles that have been further divided into 311 water segments. The state has recently determined that 242 segments (78 percent) currently comply with all applicable stream standards, or are projected to be compliant following incorporation of best practicable treatment by industry and secondary treatment by municipalities (Texas Department of Water Resources 1984a). Only 1,676 stream miles are not considered fishable and swimmable, and most (944.1 miles) are associated with the six large metropolitan areas in Texas (Figure 1). Since these areas are also the focus of much public concern and government spending, the Texas Water Commission will be encouraged to continue with rigorous permitting practices and strong enforcement measures. But what about the state's coastal bays and estuaries? Are they as inherently unmanageable as they seem because of their natural variablility?

Texas Bays and Estuaries

New collective solutions for water problems are needed in several areas of Texas, but few are as complex and none involve more public

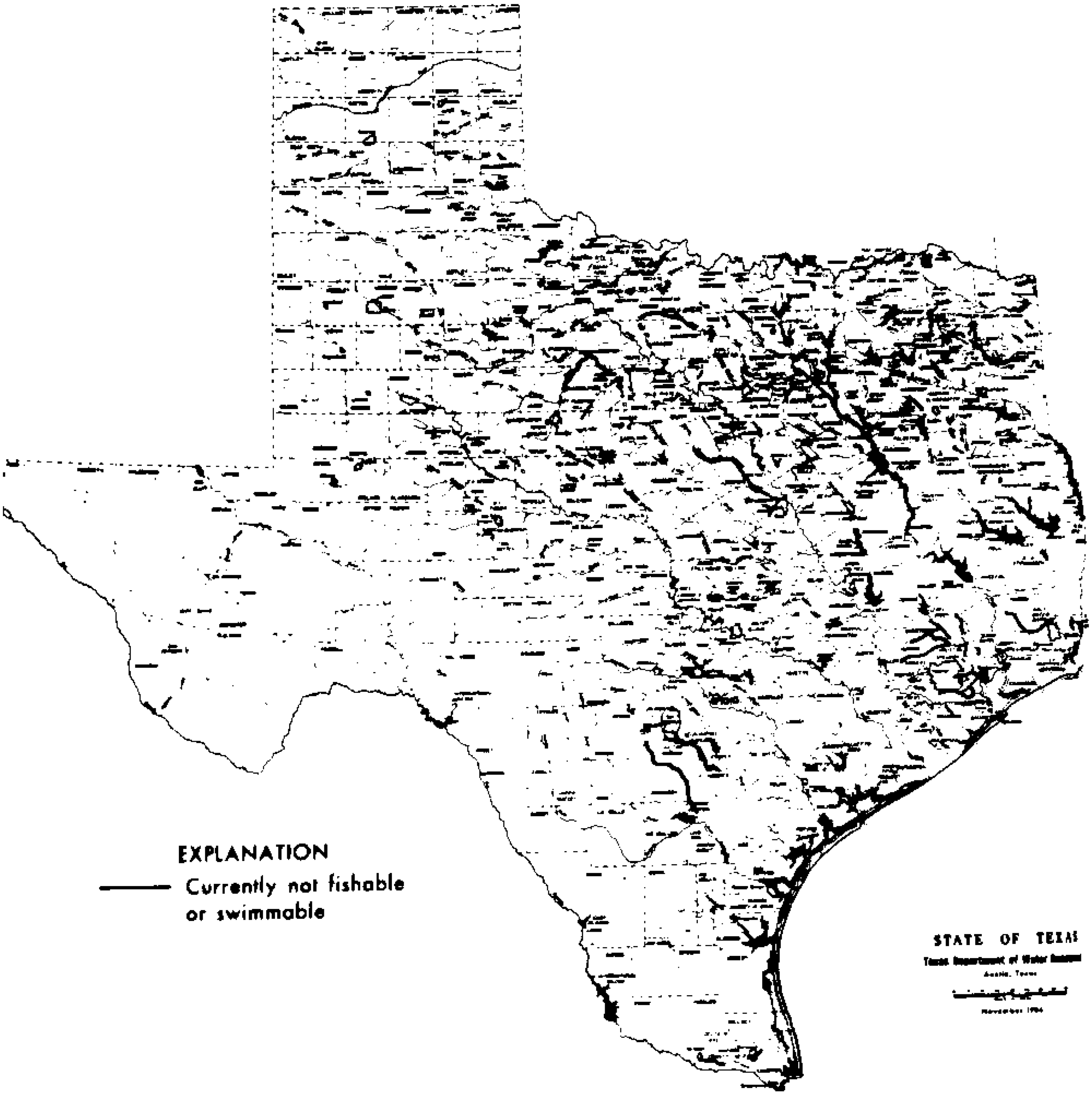


Figure 1. Texas stream segments not currently fishable or swimmable.

lands, waters, and wildlife than do the state's bays and estuaries. There are seven major and three minor estuarine systems located along the 367 linear miles of Texas coastline on the Gulf of Mexico (Figure 2). These estuarine systems contain approximately 1.5 million acres of open-water bays, 1.1 million acres of adjacent marshes and tidal flats, and about 250,000 acres of submerged aquatic vegetation (Diener 1975).

In addition, these coastal environments contain natural and man-made resources that contribute to the Texas economy in several forms that include, but are not limited to: (1) a navigation network of national importance; (2) a vast resource base for minerals, seafoods, and recreational opportunities; and (3) an environmental source of natural waste treatment for many nutritive materials and other by-products of our modern society. Total annual values to Texas are at billion dollar levels in each major economic category such as shipping, oil and gas production, fishing, and recreation and tourism (Texas Department of Water Resources 1984b).

One important part of the state's fishing sector involves the Gulf shrimp fishery. In 1984, the catch by Texas commercial bay shrimpers led the nation and exceeded the combined harvests of Florida, Alabama, and Mississippi. The Texas harvest of 91.6 million pounds of penaeid shrimp (mostly *Penaeus aztecus* and *P. setiferus*) had a dockside landings value of $179.5 million, in spite of the fact that prices had dropped from $2.47 to $1.96 per pound between the years 1982 and 1984 (Ferguson 1985). Nevertheless, at this level of fishing activity, the total economic value to the state from the direct, indirect, and induced economic impacts of commercial shrimping alone is over $500 million. Therefore, the state government should attempt to balance economic and environmental concerns in the management of its bays and estuaries, recognizing that the Texas coast is truly a multipurpose resource.

Freshwater Inflow

The inflow of freshwater is widely recognized as an essential factor influencing the biological productivity of estuarine areas as diverse as the Black Sea (Rozengurt and Haydock 1981), the Nile Delta (Ben-Tuvia 1973, Halim 1975), the Gulf of St. Lawrence (Sutcliffe 1972 and 1973), San Francisco Bay (Turner and Chadwick 1972, Stevens 1979), Chesapeake Bay (Pearson 1948 Shea et al. 1980, Ulanowicz et al. 1982), and the bays and estuaries of the Gulf of Mexico (Copeland 1966, Copeland et al. 1972, Hackney 1978, Schroeder 1978, Stone et al. 1978, Texas Department of Water Resources 1982).

In Texas, virtually all coastal fishery species are considered estuarine-dependent in at least some portion of their life cycle, while the estuaries in particular are dependent upon freshwater inflows for new nutrients, sediments, and a salinity gradient that allows the inhabiting organisms to survive, group, and eventually reproduce. In addition, periodic flushing of the estuaries by high inflows inundates river delta marshes; transports sediments, nutrients, and food materials; stimulates the cycling of essential nutrients; and removes or limits many pollutants, parasites, predators, bacteria, and viruses harmful to estuarine-dependent

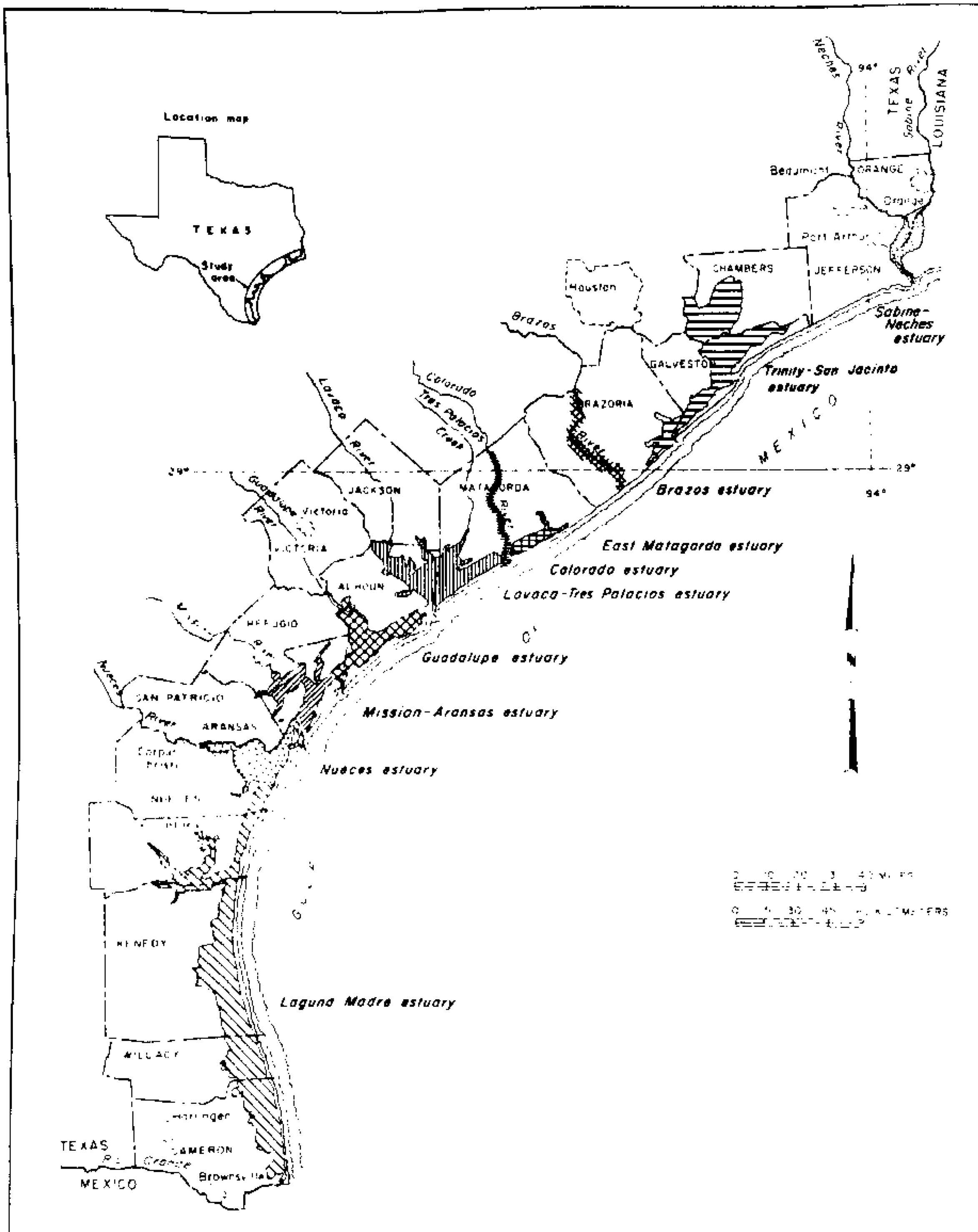


Figure 2
Locations of the Estuaries

Base from Official State Highway Map of Texas, 1971 organisms (Snedaker et al. 1977, Texas Department of Water Resources 1980).

Texas estuaries are associated with and dependent upon 11 river basins; 10 originate and flow only within the state. The combined freshwater inflow to the major Texas estuaries from their contributing river and coastal drainage basins has historically (1941-1976) averaged 36.6 billion cubic meters annually (Texas Department of Water Resources 1982), with 77 percent of the freshwaters flowing to only two of the state's coastal areas--Sabine Lake and Galveston Bay. Minimum river discharge, measured at the last streamflow gauging station on each river during the critical drought period of the 1950s, amounted to as little as 5.1 billion cubic meters per year or only about 14 percent of the long-term average annual inflow to the bays and estuaries. It is important to note that during the 1948 to 1957 drought, bay oyster (Crassostrea virginica) production in Texas practically ceased, white shrimp (Penaeus setiferus) harvests were drastically reduced, and sciaenid fishes such as the black drum (Pogonias cromis) were blinded and exhibited body lesions as a result of high salinity stress (Simmons and Breuer 1962).

Clearly, the severely reduced inflow of freshwater to the bays and estuaries caused extensive damage to the coastal fisheries; however, this effect was temporary, and estuarine-dependent populations recovered rapidly at the end of the drought (Hoese 1960). Therefore, drought should be viewed as part of the natural cycle to which the estuarine organisms of Texas have adapted. Unfortunately, our modern social and economic systems have not developed the resilience that the natural systems exhibit. As a result, severe disruptions and economic damages can occur if preference for the use of the state's limited freshwater supplies during critical droughts is not given to high priority human needs (e.g., domestic, municipal, and industrial water use). Some public interest groups have argued that the state should require releases of water stored in Texas reservoirs in order to maintain the estuaries through such low flow periods. An example may illustrate the impracticality of this suggestion.

In 1956, the Lavaca-Tres Palacios estuary was in the grip of the 1950s Texas drought. Freshwater discharge to the estuary at the Lavaca River delta amounted to only 35.1 million cubic meters that year, whereas the average historical (1941-1976) flow rate was 942.0 million cubic meters per year (Texas Department of Water Resources 1980). Although the river basin's major reservoir project, Lake Texana, was not completed until 1980, if it were assumed to exist at the time of the drought, and further, if its firm annual yield of 92.5 million cubic meters per year was assumed available for release to the estuary, some interesting comparisons can be made.

For example, results of legislatively mandated studies indicate that the long-term (multiyear average) fisheries maintenance need may be about 909.8 million cubic meters per year of freshwater inflow through the Lavaca River delta (Texas Department of Water Resources 1980). Even the short-term (monthly) salinity viability limits for good growth and survival of the fisheries species could require an estimated 154.9

million cubic meters of freshwater inflow over the course of a year (Texas Department of Water Resources 1984b).

The drought was finally broken by rains in the spring and fall of 1957, when the annual freshwater discharge into the estuary from the Lavaca River delta reached 1.48 billion cubic meters. Therefore, as a practical matter, there is not enough water available from the reservoir's firm yield to significantly reduce the effects of a major drought on the estuary or to maintain the estuary's fisheries production through the drought. Nevertheless, an attempt to ameliorate minor drought conditions was made in 1984 when the Texas Water Commission granted an application by the Texas Parks and Wildlife Department for an emergency release of state water from Lake Texana, located about 15 river miles above the estuary.

Extremely arid conditions prevailed over much of Texas in the summer of 1984, reducing freshwater inflows to the bays and estuaries and causing elevated salinities to occur in normally low-salinity estuarine nursery habitats. In response, the Texas Water Commission ordered a unique emergency release of 12.3 million cubic meters of freshwater stored in Lake Texana on August 29, 1984. The water was released at a rate of about 20.7 cubic meters per second beginning on the night of August 31 and continuing through September 7. Because of the drought conditions, state water released from the reservoir was the only major source of freshwater inflow to the estuary at this time.

Salinities were reduced 2-5 parts per thousand (ppt) throughout the delta area, while the release had no significant influence on dissolved oxygen or nutrient concentrations, particularly in deeper waters. Effects of the release can be illustrated by examining measured salinities in Redfish Lake, a small tertiary bay located in the river delta about 8 miles below the reservoir (Figure 3). The release response is apparent by the approximately 4 ppt drop in salinity at this site; however, a salinity rise a few days later is equally apparent. The abrupt termination of beneficial effects from the state's emergency release of freshwater to the estuary occurred when high tidal elevations pushed high salinity Gulf waters into the upper estuary and raised salinities.

The normal tidal progression along the Texas coast changes over a two-week period from a high amplitude diurnal (tropical) tide to a low amplitude semidiurnal (equatorial) tide as a consequence of the moon's cyclical rotation about the earth, but the normal pattern can also be greatly influenced by other factors such as wind and atmospheric pressure gradients. During the September 16-25 interval, a period beginning only 8 days after completion of the emergency freshwater release, tropical disturbances in the northern Gulf of Mexico substantially raised water elevations in the estuary. A maximum water surface elevation of 3.1 feet above mean sea level, or almost three times the normal tide level, occurred in the Lavaca River delta on September 21. This was the highest tide recorded at the site in the prior 12-month period, and the significance of this event relates to the intrusion of large quantities of high salinity seawater into the estuary as a result of the elevated Gulf water levels (Hauck 1985).

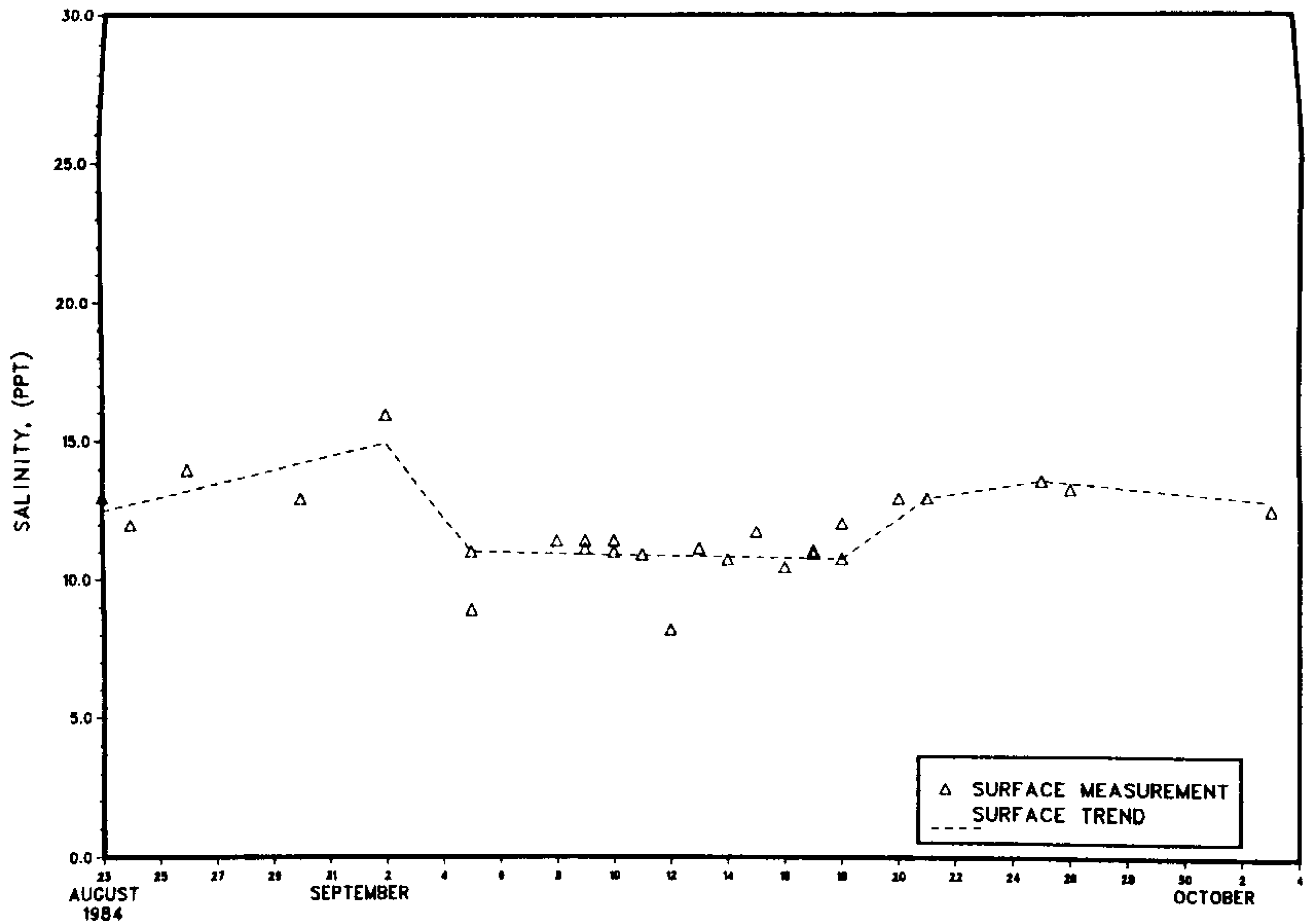


Figure 3. Measured salinities in lower Redfish Lake, Site 610-2, August 23-October 3, 1984.

It could not be determined whether salinities would have declined further if the saltwater intrusion had not occurred. It is apparent that the large influx of seawater not only negated the beneficial diluting effect of the freshwater release, but also it actually raised salinities in the upper delta near Lake Texana more than 4 ppt above the pre-release salinity levels that originally prompted the commission's emergency release order (Figure 4). In addition, the freshwater release to the estuary did not seem to produce any beneficial effects on the white shrimp population, although ameliorating biological conditions for the fall recruitment of small white shrimp to nursery habitats in the delta marshes was a primary focus of the commission's order. As evidenced by Texas Parks and Wildlife Department catch data from bag-seine samples taken in the deltaic nursery habitats, white shrimp densities during the freshwater release were lower than levels either before or after it (Figure 5). Thus, it seems that even well-meant plans can be thwarted by the natural variability of estuaries.

Current Controversies

In recent years, some controversies have arisen concerning basic principles of estuarine ecology, such as which factors control primary productivity, the source of nutrients required for the observed high biological production, and the role of freshwater and marshes in supporting coastal fisheries (Day et al. 1982). In retrospect, it is obvious that the early detritus food-chain concepts were too simplistic. Indeed, as Nixon (1980) remarked, "The path from the emergent marsh to the open coastal water is not through a pipe, but through a complex chain of subsystems."

The traditional view of marshes as net exporters of organic detritus and carbon has been questioned by Woodwell et al. (1977) and Haines (1977, 1979), among others. Specifically, Woodwell et al. (1977) showed that Flax Pond, a small (24.71 acres) tidal marsh on the north shore of Long Island Sound, was a net consumer of chlorophyll throughout the year and a strongly heterotrophic system in summer. These findings do not support the concept of marshes as net sources of fixed carbon. But the Flax Pond example is somewhat unusual and the findings may not be transferable to other estuarine areas, such as Gulf coast marshes.

Furthermore, Welsh et al. (1982) have determined that differences in abundance and relative dominance of carbon sources in other New England estuaries are related to simple physical attributes such as area: volume ratios. That is, high estuarine area to water volume ratios were found to correlate with high benthic production by macrophytes and microalgae, as well as high total ecosystem production. With this in mind, it is interesting to note that the Flax Pond area:volume ratio is only 1.6 (Welsh et al. 1982), while the ratio of the Lavaca-Tres Palacios estuary in Texas is 4.75 (Armstrong 1982). It also appears that Odum et al. (1979) were correct in suggesting that estuarine wetlands basically function as net importers or exporters of particulate organic carbon over the long-term depending upon (1) the geomorphology of the wetland drainage basin, (2) the tidal amplitude, and (3) the magnitude of freshwater inflow to the wetland.

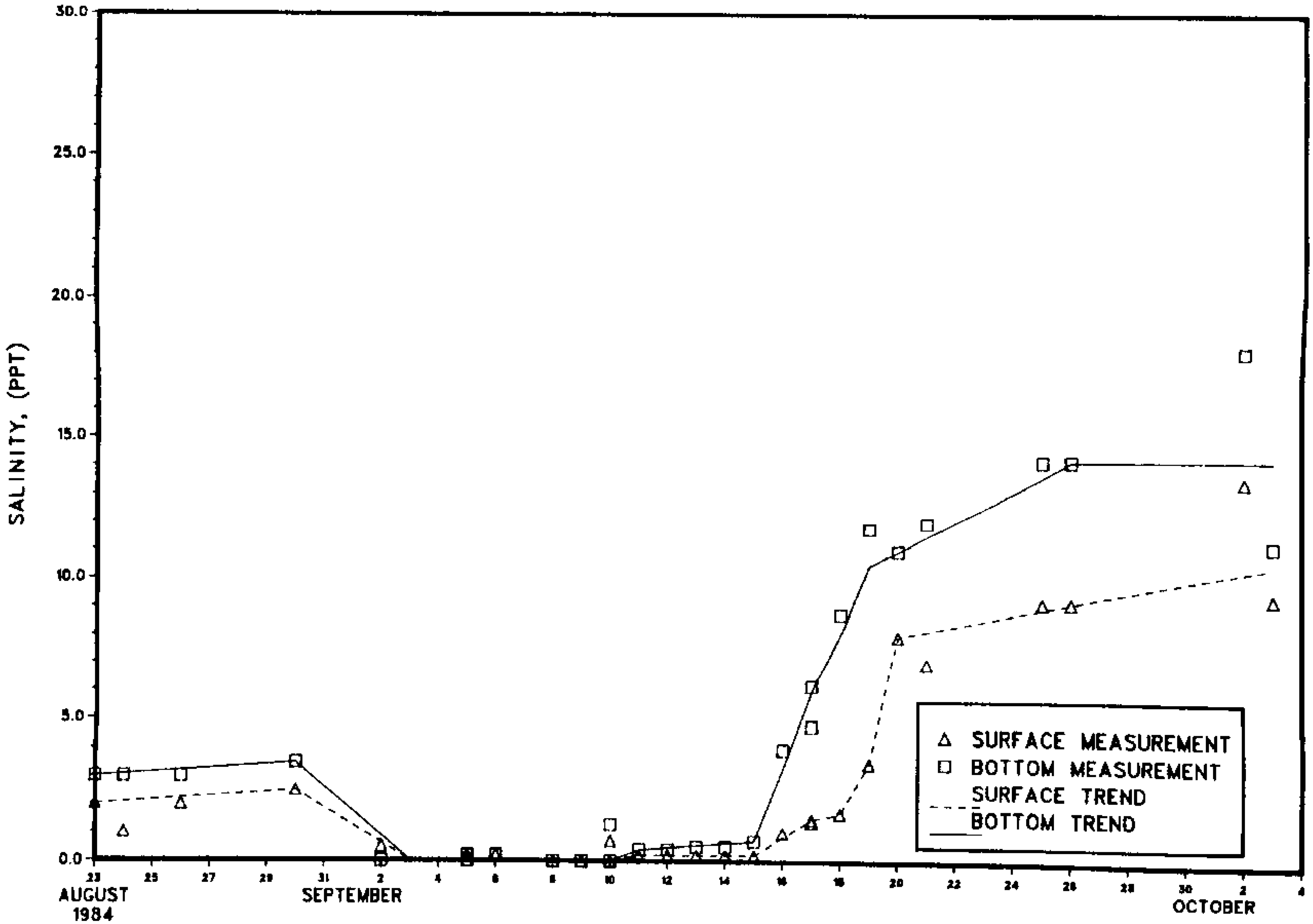


Figure 4. Measured salinities below Lake Texana, Site 22-2, August 23-October 3, 1984.

LAVACA RIVER DELTA

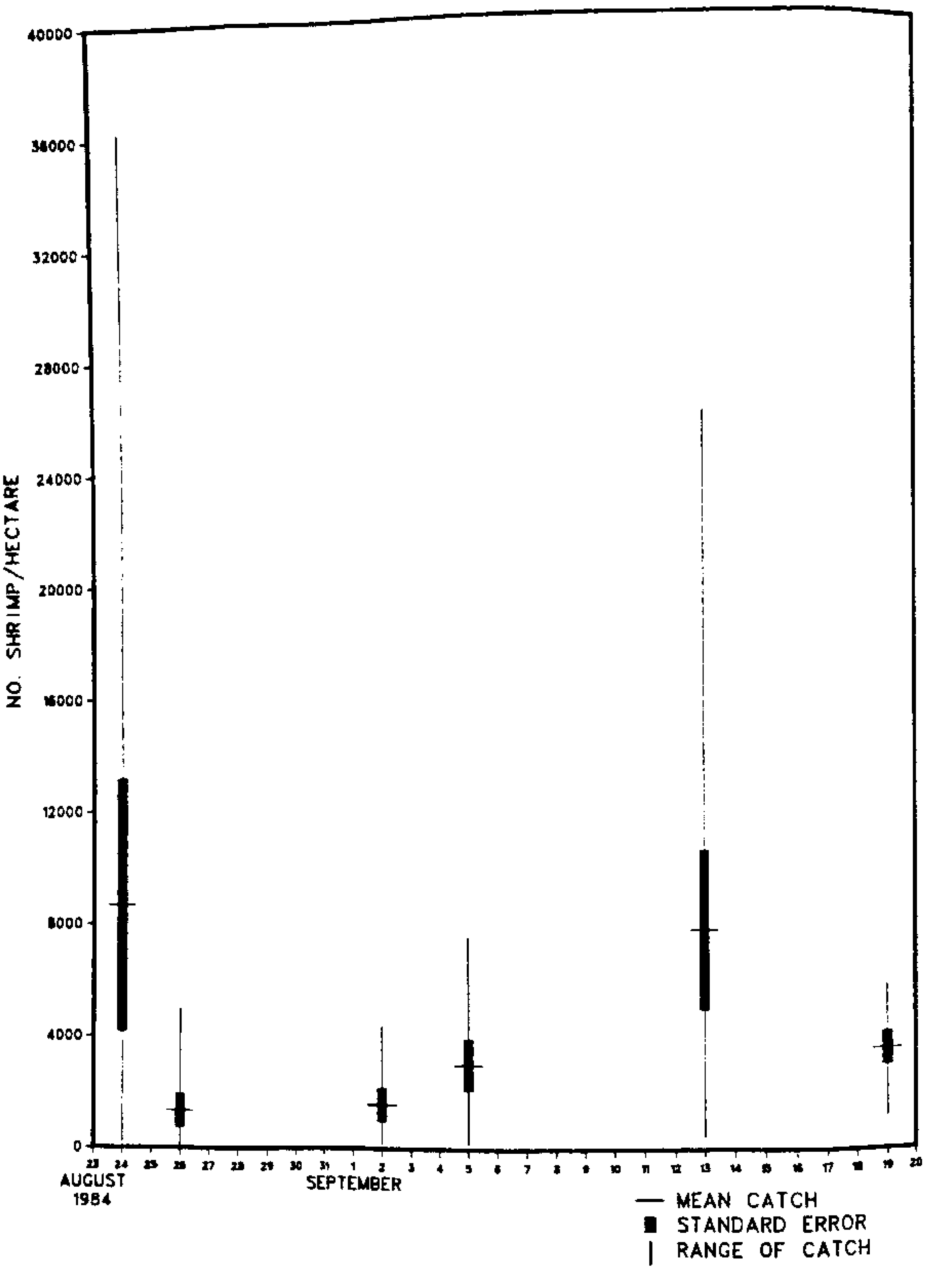


Figure 5. Measured densities of white shrimp in the Lavaca River Delta.

Although Armstrong (1982) showed that nutrients associated with freshwater inflows dominate the external nutrient supplies of Texas estuaries, he also concluded that marshes play a very small role in the overall nutrient budget and calculated their contribution at less than 5 percent of the total external nutrient input to the estuaries. Similarly, Ward et al. (1982) estimated that the external sources of nitrogen, which are mainly associated with freshwater inflows, account for only about 2 percent of the nitrogen fixed by primary producers (mostly phytoplankton) in the Lavaca-Tres Palacios estuary. An explanation for these findings may be found in other evidence that indicates that a general feature of most estuaries and coastal shelf areas is the high rate of nutrient biogeochemical cycling (Nixon 1981, Kemp et al. 1982), particularly by the benthic community in shallow, turbid bays like those in Texas (Flint and Kamykowski 1984). On a day-to-day basis, this nutrient regeneration is probably most important for maintaining estuarine primary production.

In a study of the Nueces estuary, Flint et al. (1982) reported that the benthos supplies 12-98 percent of the nitrogen needed to account for the observed primary production in the estuary, while the input of new nitrogen from the Nueces River only accounted for 4-24 percent of the total nitrogen available from both sources combined. In addition, they noted that benthic production at a mid-bay site in Nueces Bay always exceeded phytoplankton production in the water column, often by as much as 400 percent, apparently because of this site's proximity to the Nueces River delta, a source of freshwater inflow, nutrients, and organic detritus.

More recently, Flint et al. (1985) have shown that approximately 90 percent of the nitrogen required for phytoplankton in the upper portion of Nueces estuary is derived from benthic regeneration, decreasing to about 33 percent outside the estuary in the shallow waters of the Gulf near the barrier island. However, the value of new nitrogen supplied by freshwater sources is not diminished, because it was also shown that the episodic pulses of freshwater inflow to the estuary directly correlated with ecosystem productivity and were thought to be extremely important in replacing nutrients lost from the estuary each time organic materials are recycled. This is because no system is 100 percent efficient, and some portion of the nutrients recycled each time in estuaries is lost to the deep sediments or the atmosphere or is differentially transported out of the estuaries.

The interpretation given by Flint et al. (1985) was not intended to suggest that any one source of nutrients to an estuarine ecosystem is ultimately more important than another. Rather, they state the purpose was to demonstrate that there is a subtle coupling between new and recycled nitrogen that acts to balance nutrient supplies, providing a more continuous supply to the ecosystem and buffering biological production against periods of low external input, such as during times of low freshwater inflow. Nevertheless, extended or permanent reduction of freshwater inflows can lead to degraded, estuarine nursery environments, increased levels of marine parasites and diseases, and reduced production of fish and shellfish (seafood) resources in the bays and estuaries. In fact, according to Rozengurt and Haydock (1981), no more than 25-30 percent of the normal inflow of freshwater to an estuary can be diverted without disastrous ecological consequences to the ecosystem.

However, while the "Rozengurt Rule" may serve as a general rule of thumb, it is probably not suitable for water management purposes since estuaries are obviously not all alike. Armstrong (1984) has proposed a list of research needs and priorities to answer the questions that water managers in Texas are asking about the effects of and needs for freshwater inflow to the bays and estuaries. In response to new legislative directives, the Texas Water Development Board is currently conducting a joint data collection and study program with the Texas Parks and Wildlife Department to determine cause and effect relationships, and the reliability of freshwater need estimates developed for estuarine management purposes.

References

Armstrong, N.E. 1982. Responses of Texas estuaries to freshwater inflows. pp. 103-120 in V.S. Kennedy (ed.), Estuarine comparisons. Academic Press, N.Y., 709 p.

Armstrong, N.E. 1984. Water management and estuarine productivity. pp. 27-42 in B.J. Copeland, K. Hart, N. Davis, and S. Friday (eds.). Research for managing the nation's estuaries. UNC Sea Grant Publication No. 84-08, Raleigh, N.C., 420 p.

Ben-Tuvia, A. 1973. Man-made changes in the eastern Mediterranean Sea and their effect on the fishery resources. Mar. Biol. 19(3):197-203.

Copeland, B.J. 1966. Effects of decreased river flow on estuarine ecology. J. Water Poll. Contr. Fed. 38:1830-1839.

Copeland, B.J., H.T. Odum, and D.C. Cooper. 1972. Water quantity for preservation of estuarine ecology. pp. 107-126 in E.F. Gloyna and W.S. Butcher (eds.), Conflicts in water resources planning. Center for Research in Water Resources, The University of Texas at Austin.

Diener, R.A. 1975. Cooperative Gulf of Mexico estuarine inventory and study -- Texas: area description. U.S. Dept. Commerce, NOAA Technical Report, NMFS Circ. 393, 129 p.

Ferguson, M.F. 1985. (personal communication). Texas Parks Wildl. Dept., Coastal Fisheries Branch, Austin, Tex.

Flint, R.W. and D. Kamykowski. 1984. Benthic nutrient regeneration in south Texas coastal waters. Estuar. Coastal Mar. Sci. 18:221-230.

Flint, R.W., G.L. Powell, and R.D. Kalke. 1985. Ecological effects from the balance between new and recycled nitrogen in Texas coastal waters. In: D.A. Wolfe (ed.), Estuarine variability. Academic Press, N.Y. (in press).

Flint, R.W., S. Rabalais, and R.D. Kalke. 1982. Estuarine benthos and ecosystem functioning. pp. 185-201 in J.R. Davis (ed.), Proc. Symp. Recent Benthological Findings in Texas and Adjacent States. Aquatic Sci. Sect., Tex. Acad. Sci., Austin, Tex., 278 p.

Hackney, C.T. 1978. Summary of information: Relationship of freshwater inflow to estuarine Productivity along the Texas coast. U.S. Fish Wildl. Ser., FWS/OBS-78/73, 25 p.

Haines, E.B. 1977. The origins of detritus in Georgia salt marsh estuaries. Oikos 29:254-260.

Haines, E.B. 1979. Interactions between Georgia salt marshes and coastal waters: A changing paradigm. pp. 35-46 in R.J. Livingston (ed.), Ecological processes in coastal and marine systems. Mar. Sci., Vol. 10, Plenum Press, N.Y., 548 p.

Halim, Y. 1975. The Nile and the east Levantine Sea, past and present. pp. 76-84 in R. Natarajan (ed.), Recent researches in estuarine biology. Hindustan Publ. Corp., Delhi, India.

Hauck, L.M. 1985. Investigation of the effects of releases of water from Lake Texana, Lavaca River basin, on August 31 - September 7, 1984. Unpublished technical report, Texas Dept. Water Res., 25 p. + Appen. A-D.

Hoese, H.D. 1960. Biotic changes in a bay associated with the end of a drought. Limnol. Oceanogr. 5:326-336.

Johnson, S.J. 1985. (personal communication). Texas Water Comm., Water Qual. Div., Austin, Tex.

Kemp, W.M., R.L. Wetzel, W.R. Boynton, C.F. D'Elia, and J.C. Stevenson. 1982. Nitrogen cycling and estuarine interfaces: some current concepts and research directions. pp. 209-230 in V.S. Kennedy (ed.), Estuarine comparisons. Academic Press, N.Y., 709 p.

MacRae, J.R. 1985. (Personal communication). Texas Parks Wildl. Dept., Resource Protection Div., Austin, Tex.

Nixon, S.W. 1980. Between coastal marshes and coastal waters -- a review of twenty years of speculation and research on the role of salt marshes in estuarine productivity and water chemistry. pp. 437-525 in P. Hamilton and K.B. MacDonald (eds.), Estuarine and wetland processes with emphasis on modeling. Mar. Sci., Vol. 11, Plenum Press, N.Y., 653 p.

Nixon, S.W. 1981. Remineralization and nutrient cycling in coastal marine ecosystems. pp. 111-138 in B.J. Neilson and L.E. Cronin (eds.), Estuaries and nutrients. Humana Press, Clifton, N.J., 643 p.

Odum, W.E., J.S. Fisher, and J.C. Pickral. 1979. Factors controlling the flux of particulate organic carbon from estuarine wetlands.

pp. 69-80 in R.J. Livingston (ed.), Ecological processes in Coastal and marine systems. Mar. Sci., Vol. 10, Plenum Press, N.Y., 548 p.

Pearson, J.C. 1948. Fluctuations in the abundance of the blue crab in Chesapeake Bay. U.S. Fish Wildl. Ser., Res. Rept. No. 14, 26 p.

Rozengurt, M. and I. Haydock. 1981. Methods of computation and ecological regulation of the salinity regime in estuaries and shallow seas in connection with water regulation for human requirements. pp. 474-506 in R.D. Cross and D.L. Williams (eds.), Proc. natl. sym. on freshwater inflow to estuaries. Vol II. U.S. Fish Wildl. Ser., FWS/OBS-81/04, 528 p.

Schroeder, W.W. 1978. Riverine influence on estuaries: A case study. pp. 347-364 in M. Wiley (ed.), Estuarine interactions. Academic Press, N.Y., 603 p.

Shea, G.B., G.B. Mackiernan, L.C. Athanas, and D.F. Bleil. 1980. Chesapeake Bay low flow study: biota assessment. Phase I final report. Submitted to U.S. Army Corps of Engineers by Western Ecosystems Technology, Laurel, Md., Vol. 1 & 2, 326 p.; Vol. 3, 202 p.

Simmons, E.G. and J.P. Breuer. 1962. A study of red fish, Sciaenops ocellata Linnaeus, and black drum, Pogonias Cromis Linnaeus. Publ. Inst. Mar. Sci. Univ. Tex. 8:184-211.

Snedaker, S.C., D.P. deSylva, and D. Cottrell. 1977. A review of the role of freshwater in estuarine ecosystems. Final report to southwest Florida Water Management District by Univ. Miami Rosenstiel School Mar. and Atmos. Sci. SWFWMD Planning Rept. No. 1977-2, Brooksville, Fla., Vol 1, 126 p.; Vol. 2, 294 p.

Stevens, D.E. 1979. Environmental factors affecting striped bass (Morone saxatilis) in the Sacramento-San Joaquin estuary. pp. 469-478 in T.J. Conomos (ed.), San Francisco Bay: the urbanized estuary. Pacific Div., Amer. Assoc. Adv. Sci., San Francisco, Calif., 493 p.

Stone, J.H., J.W. Day, Jr., L.M. Bahr, and R.A. Muller. 1978. The impact of possible climate changes on estuarine ecosystems. pp. 305-321 in M. Wiley (ed.), Estuarine interactions. Academic Press, N.Y., 603 p.

Sutcliffe, W.H., Jr. 1972. Some relations of land drainage, nutrients, particulate material, and fish catch in two eastern Canadian bays. J. Fish. Res. Bd. Canada 29:357-362.

Sutcliffe, W.H., Jr. 1973. Correlations between seasonal river discharge and local landings of American lobster (Homarus americanus) and Atlantic halibut (Hippoglossus hippoglossus) in the Gulf of St. Lawrence. J. Fish. Res. Bd. Canada 30:856-859.

Texas Department of Water Resources. 1980. Lavaca-Tres Palacios estuary: a study of the influence of freshwater inflows. TDWR Rep. No. LP-106, Austin, Tex.

Texas Department of Water Resources. 1982. The influence of freshwater inflows upon the major bays and estuaries of the Texas Gulf coast. TDWR Rep. No. LP-115 (2nd Edition), Austin, Tex., 53 p. + Appen. I-VI.

Texas Department of Water Resources. 1984a. The state of Texas water quality inventory. TDWR Rep. No. LP-59 (7th Edition), Austin, Tex., 557 p.

Texas Department of Water Resources. 1984b. Water for Texas: technical appendix. TDWR Rep. No. GP-4-1, Vol. 2, Austin, Tex.

Turner, J.L. and H.K. Chadwick. 1972. Distribution and abundance of the young striped bass Marone Saxatilis in relation to river flow in the Sacramento-San Joaquin estuary. Trans. Amer. Fish. Soc. 101:442-542.

Ulanowicz, R.E., M.L. Ali, A. Vivian, D.R. Heinle, W. Rickhus, and J.K. Summers. 1982. Identifying climatic factors influencing commercial fish and shellfish landings in Maryland. Fish. Bull. 80(3):611-619.

Ward, G.H., J.M. Wiersema, and N.E. Armstrong. 1982. Matagorda Bay: a management plan. Report to U.S. Fish Wildl. Ser. by Espey, Huston & Assoc., Inc. and Univ. Texas at Austin, Tex., 147 p.

Welsh, B.L., R.B. Whitlatch, and W.F. Bohlen. 1982. Relationship between physical characteristics and organic carbon sources as a basis for comparing estuaries in southern New England. pp. 53-67 in V.S. Kennedy (ed.), Estuarine comparisons. Academic Press, N.Y., 709 p.

Woodwell, G.M., D.E. Whitney, C.A.S. Hall, and R.A. Houghton. 1977. The Flax Pond ecosystem study: exchanges of carbon in water between a salt marsh and Long Island Sound. Limnol. Oceanogr. 22:833-838.

ECOSYSTEM REHABILITATION - A SHIFT TOWARD A DIFFERENT PARADIGM

H.J. Harris, C.J. Yarbrough, P.E. Sager,
University of Wisconsin-Green Bay, Green Bay, Wisconsin

S. Richman, Lawrence University, Appleton, Wisconsin

Introduction

In 1972 the United States and Canada signed a Great Lakes Water Quality Agreement affirming a commitment to restore and enhance the water quality of the Great Lakes. This agreement included specific objectives for various properties of Great Lakes water quality and called for the development of objectives for additional significant properties. These objectives are defined as "... the concentration or quantity of a substance or level of effect that the parties agree, after investigation, to recognize as a maximum or minimum desired limit for a defined body of water or portion thereof, taking into account the beneficial uses or level of environmental quality which the parties desire to secure and protect ..." The development of such objectives has been based primarily on information gathered by exposing individuals of certain species of biota to known concentrations of specific chemicals or physical properties in the laboratory. Inferences are drawn from the results of such tests as to the effects on populations of the same or related organisms in the Great Lakes.

Use of objectives based on such "limits of tolerance" testing can provide a large measure of environmental protection. However, the weaknesses of such an approach have been pointed out by Ryder and Edwards (1985) as follows:

1. The information on relationships between effects and concentrations of polluting substances is obtained in the controlled environment of the laboratory. Experience has shown that frequently there are poor agreements between laboratory effects observed and effects actually observed in the field.

2. Chemical pollutants are tested singly, yet in most natural environments, including the Great Lakes, a number of chemical substances in both dissolved and particulate forms are found.

3. There are many polluting substances in the Great Lakes for which there is not adequate toxicity information to permit development of a satisfactory objective. Very little is known concerning chronic toxicity or other more subtle effects that may be sublethal over a long term.

4. Consideration is given only to the direct effects on the species under study. Repercussions in the populations of other species and community integrity are not considered.

For these and other reasons it has become increasingly apparent that one-demensional thinking associated with the reductionistic approach will not in and of itself be capable of halting and reversing the degradation processes in the Great Lakes.

The United States and Canada signed a revised and strengthened Great Lakes Water Quality Agreement in 1978. At that time the weaknesses in the objectives approach were recognized and great emphasis was placed in the agreement not only in controlling levels of chemical pollutants but also in assuring the biological integrity of the waters of the entire Great Lakes basin ecosystem.

This agreement reflected a developing recognition of the need for ecosystems scale management (International Joint Commission (IJC) 1978), in particular rehabilitative management in the Great Lakes. Rehabilitation in this sense is a combination of restoration, enhancement, and protection.

In 1977, the Great Lakes Fishery Commission (GLFC) supported a study of the technical and social feasibility of rehabilitating Great Lakes ecosystems. In 1979, the results of the examination were published (Francis et al. 1979). The conclusion reached was that it is feasible to develop strategies for comprehensive ecosystem rehabilitation, and it is probable that rehabilitative measures can be made operational. The optimistic results of that study stimulated research into ways of implementing rehabilitative management in particular ecosystems around the Great Lakes.

Follow-up work to develop specific approaches to help initiate rehabilitation planning and management was also funded by GLFC. Green Bay of Lake Michigan was one focus for a major case study (Harris et al. 1982). This bay was a particularly apt choice because of the extensive and intensive work related to rehabilitation that had been carried out under the University of Wisconsin Sea Grant Program. Green Bay (or portions thereof) represented a highly degraded state which would require large scale remedial measures. In Canada, interest became focused on the Long Point ecosystem on Lake Erie (Francis et al. 1985). The challenge at Long Point was to develop protective strategies for a fortuitously well-preserved natural ecosystem and attendant low-intensity human use of that system.

Propositions for a Different Paradigm

Beginning in 1979 the Great Lakes Ecosystem Rehabilitation working group (GLER), a binational group of scientists and managers, conducted studies and workshops leading to the development of a prospectus for Long Point and Green Bay. In sum, the GLER effort yielded a number of specific findings much too detailed to relate here (Harris et al. 1982, Francis et al. 1985). Perhaps more importantly it led to some general propositions with regard to ecosystem management, and it presented a set of challenges to ecological and institutional research and indeed to our present management capabilities. The general propositions are these:

1. Ad hoc reductionistic policies determined on an individual factor-by-factor basis, do not promote ecosystem rehabilitation. Such reductionistic policies are of some help in dealing with the issues, but ad hoc policies do not promote rehabilitation.

2. Holistic systems perspectives are needed to guide research for policies capable of reversing the continued deterioration across much of the Great Lakes ecosystem.

3. Successful rehabilitation of Great Lakes ecosystems, including Green Bay will require systemwide approaches to management.

These general propositions are central to the evolution of a different management paradigm and will be discussed further below.

The first general proposition arising from the GLER research, i.e., ad hoc reductionistic policies do not promote ecosystem rehabilitation is not an indictment of current or past efforts, rather it represents an observation based on past experiences. For example, the narrow focus on biochemical oxygen demand (BOD) and dissolved oxygen over the last 15 years is a case in point for the Fox River/Green Bay system as it may well be for other estuaries and bays.

From 1973 to 1978, at least $300 million was invested in waste water treatment facilities by two municipalities and industry along the lower Fox River. The largest single capital investment, $72 million, was by the Green Bay Metropolitan Sewerage District (GBMSD) for a new activated sludge plant designed to receive all local municipal wastes as well as the pulp mill wastes from two large pulp and paper mills. Federal and state grants provided 80 percent of the GBMSD capital investment. The impact of the new treatment plants up and down the lower Fox River was rapid and impressive. The average discharge decreased from approximately 400,000 pounds of BOD per day in 1971 to 20,000 pounds per day by 1978 (Figure 1).

Data collected at eight stations in the extreme southern bay from 1970 to 1982 (Table 1) reveal a marked increase in dissolved oxygen concentrations coinciding with the reduction in BOD loading to the river (Sager, unpubl. data).

TABLE 1

Summer Average Dissolved Oxygen Concentration from 8 Stations of the Inner Bay From 1970 to 1982

Year	mg/l
1970	1.6
1971	2.9
1972	6.8
1973	6.6
1976	9.3
1977	9.3
1982	8.1

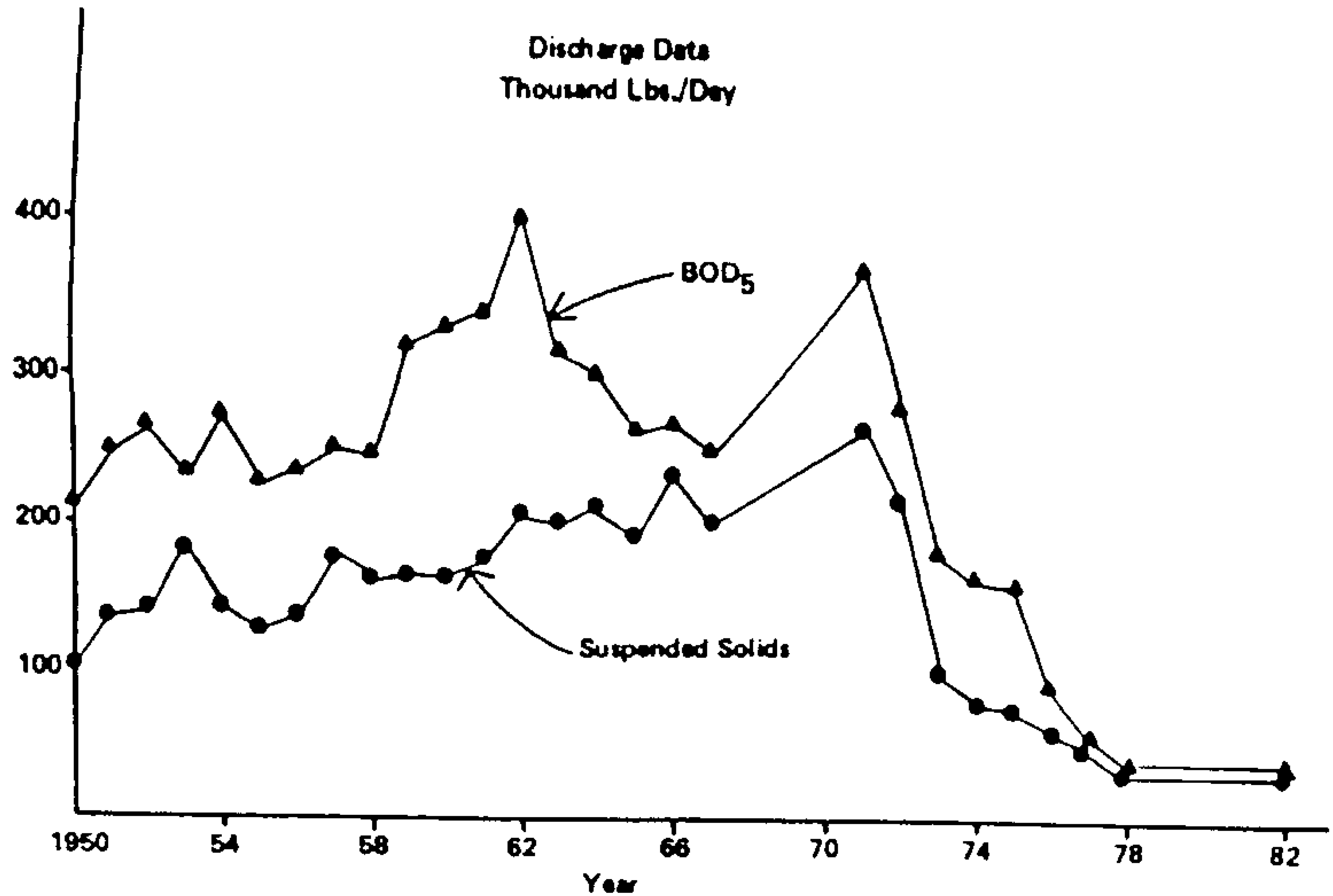


Fig. 1. Discharge of BOD and suspended solids to the Lower Fox River (after Ball, et al., 1985).

These data lead justifiably to the conclusion that the abatement policies and regulations involved were an unmitigated success. But there is more. While the water quality section in the Wisconsin Department of Natural Resources was focused on dissolved oxygen, the fishery people were trying to restore the once thriving walleye fishery. They did this by using one of the few management alternatives available to them - stocking. Since 1977, 58 million fry and over 600,000 fingerlings have been stocked in the lower Fox River and southern Green Bay (Lychwick 1984). In 1984, an estimated 38,000 walleyes were harvested by sport fishermen.

While these are impressive results--and we can take heart in knowing that the stocked walleyes survive--there is only limited circumstantial evidence that the fish are reproducing naturally. Even more disturbing is the fact that because of high PCB levels women and children are advised not to eat the fish at all and adult males are advised not to eat fish over 20 inches in length (Wisconsin Division of Health and Wisconsin Dept. of Natural Resources 1985).

The maddening irony of this situation is that regulation of a conventional pollutant (BOD) over the past decade (as described earlier) may exacerbate the impact of toxic pollutants on fish and aquatic life in the lower Fox River system. Increased dissolved oxygen concentrations allow gamefish to inhabit the river for longer periods of time. The longer residence time increases the probability of bioaccumulation of substances present in the sediments or water column or both. Thus, toxic substances in the river system could cause fish and aquatic life to show signs of acute or chronic toxicity. Bioaccumulation of these substances is also cause for concern to the general public who may consume contaminated fish. This concern is heightened by the fact that a fish-eating, colonial nesting bird (Forster's Tern) that nests in Green Bay marshes has been found to have impaired reproduction. Several chlororganic compounds, particularly PCBs and PCDDs, were in the eggs of these birds and are implicated as likely causative factors (Harris et al. 1985).

This example serves only to demonstrate the weakness and partial inadequacies of single-factor management strategies. Increasingly, there appears a need to develop management strategies that address the intricate network of interactions within ecosystems and the necessity for appraising the impacts of human activities upon natural systems as a whole (White 1980, Harris et al. 1982, Rapport et al. 1985).

The second general proposition arising from the GLER effort, i.e., the need for holistic system perspectives, has been addressed (in part) in both the Green Bay and Long Point case studies by adopting a stress-response ecological paradigm (Francis et al. 1979, Harris et al. 1982, Francis et al. 1985). We use the term <u>stress</u> with respect to natural and cultural impacts in the sense of a forcing process, a perturbation, a stimulus that alters the existing conditions at least temporarily, and an activity or intervention with respect to the structure or process of an ecosystem (Francis et al. 1985).

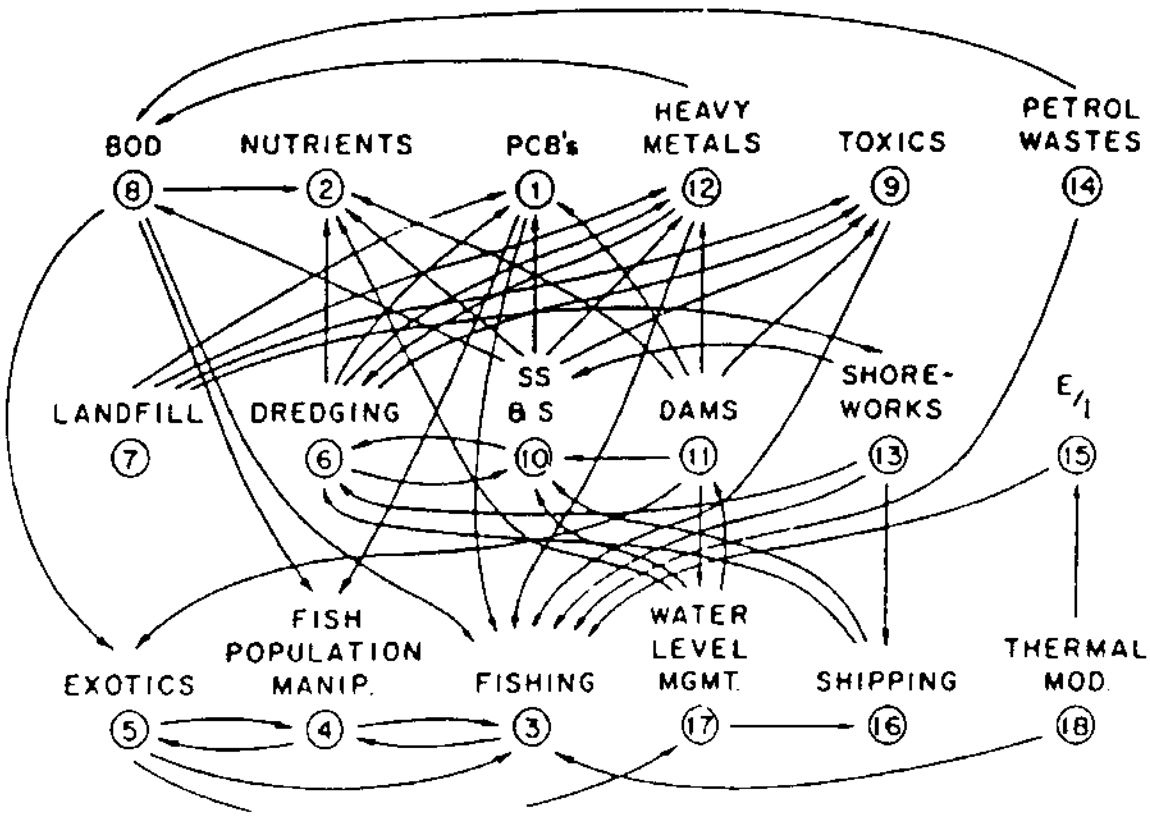


Fig. 2. A digraph of interactions among stresses.

Essentially what was done in Green Bay and Long Point was to identify known stresses, natural and antropogenic. The relationships of particular stresses to other stresses, ecosystem users, ecosystem components, and institutions were examines using a matrix analysis and graph theory. Figure 2 is an example of a resulting digraph showing the interrelationships of stresses in the Green Bay ecosystem.

The objective of such an exercise is to identify how critical stresses are acting on the biophysical system, what the connections of these stresses are to particular user groups, and which agencies or institutions have existing management policies addressing individual stresses or groups of stresses. This approach facilitates the organization of social uses and ecological effects and identifies critical stresses requiring remedial action.

While we should not and do not delude ourselves about the limitations of our knowledge regarding ecosystems, in general we remain optimistic that quantitative examination of ecosystem responses around a supposed equilibrium state can be insightful and can assist in evaluating stress management strategies (Loucks 1985). The main conceptual advantage of the stress-response ecological paradigm is that the analysis of the stresses degrading an ecosystem can often be linked directly to management measures that could alleviate or remove stresses and in so doing, release some of the natural recovery processes that constitute the resilience of ecosystems. An analysis of ecosystem users, components, and institutions clarifies the relationship between the ecosystem resource base and the political and economic control system that determines its uses, alterations, and allocation. Yarbrough has described this relationship in a generalized model which he refers to as a conceptual model of ecosystem management and politics (Yarbrough 1985b).

In this model, (Figure 3) ecosystem management and politics depend on five sets of variables: (1) the ecological status and dimensions of the ecosystem resource base; (2) user interaction and market forces; (3) affected publics and their identification of problems; (4) the general political setting; and (5) the policy areas and intergovernmental management context.

The model essentially recognizes that the influence of socioeconomic systems on ecosystem dynamics cannot be ignored nor should resource management decisions be made that are not based on sound ecological theory. Barrett (1985) refers to this integrative paradigm as the noosystem and suggests that it could serve as a basic unit for such an integrative approach.

The third general proposition that emerged from the GLER activities follows logically from the first two. That is, that successful rehabilitation or ecosystem recovery will require systemwide ecosystem approaches. The challenges to estuarine management inherent in this proposition may be better understood by examining the general requirements of an ecosystem approach to management and the more specific requirements of a policy of ecosystem rehabilitation. From our experiences at Green Bay and Long Point the requirements of an ecosystem approach can be described in the following terms:

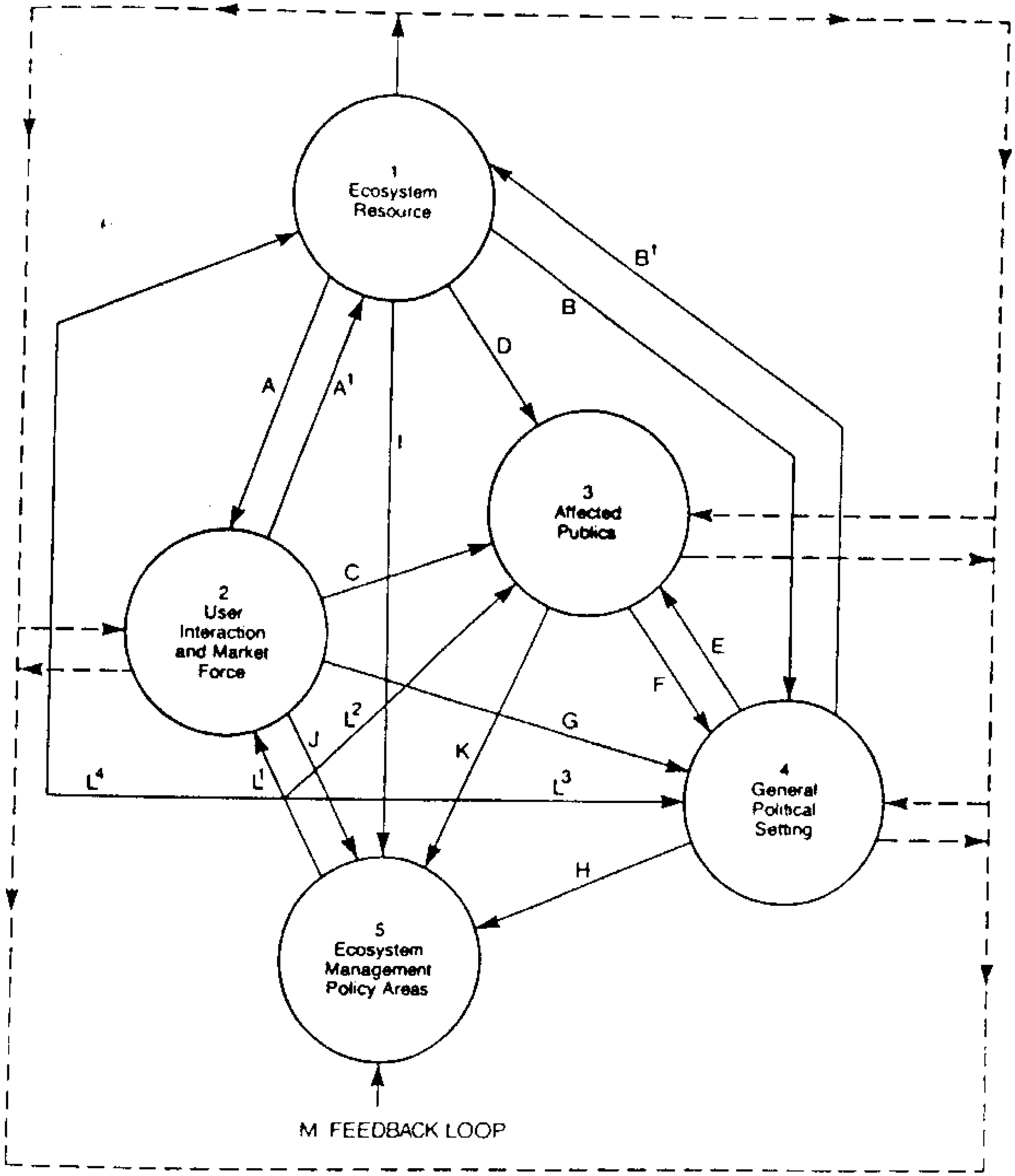


Fig. 3. Conceptual Scheme of Ecosystem Management and Politics (from Yarbrough, 1985b).

A System Perspective. This entails understanding of water bodies such as Green Bay as natural systems, i.e., ecosystems. The approach requires an understanding of ecosystems in terms of user/ecosystems interactions. Ecosystems must be understood in terms of how they respond to externally imposed stresses, particularly human uses. This requires identifying the ecological effects of social uses. The challenge is to achieve a scientific grasp of the configuration of social uses and ecological effects (Rapport et al. 1985).

Interdisciplinary Methodology. Such a holistic understanding requires an integrative approach in both research and management. The challenge is to bring together discrete studies of ecosystem phenomena. This is more than the accumulation of particular studies under an ecosystem label, however. On the contrary, the ecosystem perspective starts from theoretical pluralism, but it requires the interconnection of theories and concepts--a choice of what is useful from a variety of methodologies, the creation of new concepts, and the search for a common vocabulary among scientists and managers.

In keeping with the requirement of an interdisciplinary methodology, an additional challenge is to bring together the "natural half and the social half" of ecosystem study (National Academy Press 1985). The ecosystem approach requires this connection because ultimately the purpose of the approach is to protect and restore the well-being of ecosystems that are under the influence of biophysical as well as socioeconomic factors.

An Ecosystem Level Goal The goal of the ecosystem approach is to "... deliberately foster recovery processes that are natural to ecosystems" (National Academy Press 1985). In sociopolitical terms, this means that the goal is to make the ecosystem perspective the basis for environmental management. The idea is to further develop the ecosystem approach in order to "interrelate explicitly the various ecosystemic components now managed relatively independently under a variety of laws, agreements, international treaties, and conventions." (National Academy Press 1985). Such components as water quality, water levels and flows, fish quantity and quality, wetlands and water birds, cross media transport (air, land, water) of pollutants, and so on would be brought within an integrating perspective and managed accordingly.

Operational Guidelines - Ecosystem Standards as Management Options. If the goal of deliberately fostering recovery processes that are natural to ecosystems is to be achieved, it must be specified in operational terms. In other words, appropriate criteria for the management of ecosystems must arise from ecology and the criteria must be operational. The analogy is to the existing management options presently in use: effluent standards, technology based standards, and receiving system standards (Cairns 1985). In short, ecosystem standards must become operational management objectives.

A program of ecosystem rehabilitation is a strategic attempt to devise and apply ecological therapy. To that end, ecosystem well-being must be defined and translated into specified operational guidelines for action. In sum, the strategy is to translate an ecological level of comprehension into technical standards, legal categories, patterns of behavior, and institutional measures of success (Yarbrough 1985a).

Formulating Ecosystem Objectives

What is needed is an extension of ecosystem concepts into a realm of practicality. The feasibility and efficacy of this extension are now being tested in portions of the Great Lakes in the form of Remedial Action Plans for Areas of Concern (Environmental Protection Agency 1985). In essence the Environmental Protection Agency (EPA) has encouraged state natural resource agencies to apply an ecosystem approach to management of areas of concern by "considering effects of use of the lakes on the health of biota and human health" (EPA 1985). This directive challenges the states to develop management plans that will ensure the integrity and health of the ecosystem (i.e. area of concern). The Wisconsin Department of Natural Resources now faces the challenge of developing a remedial action plan to rehabilitate the Fox River-Green Bay system through an ecosystem approach.

The initial step for developing the remedial action plan for Green Bay was taken in September 1985 in the form of a workshop where the goal was: "To identify meaningful ecosystem properties (characteristics) which can serve as operational guides for management of Green Bay or more importantly for Great Lakes ecosystems in general." This goal was determined by over 20 academicians, government representatives, ecological specialists, and environmental managers who attended the workshop. This approach represents a change from dependence solely on a single parameter, such as dissolved oxygen, to an emphasis on properties that characterize important features of ecosystems. Ideally, the properties selected should reflect complex processes of an ecosystem (Goedmakers 1985, Odum 1985, Risser 1985, Rapport et al. 1985).

The work group identified 40 ecosystem properties. Six criteria were used in selecting meaningful properties:

1. How important is the property for understanding the ecosystem?
2. How universal or representative is it?
3. Is the property measurable?
4. Is the property quantifiable?
5. Is the property diagnostic (i.e., sensitive to change over time and space)?
6. Is the property predictable?

The initial list of 40 was condensed to 19; these are presented in Table 2.

This list largely represents <u>emergent</u> <u>properties</u> of aquatic ecosystems. Emergent properties have been defined as macrosystem ecological properties (Kerr 1974) and are often not recognized by those who are more inclined to regard ecosystems from a micromechanistic point of view (Cairns 1985). In order to utilize ecosystem indicators as a methodology within the context of an ecosystem management approach it is most appropriate to avoid undue dissection of the system in favor of a holistic application dealing primarily with system emergent properties. Indeed, many ecosystem problems may best be approached at the community level or higher before attention is paid to individual stocks or species (Ryder and Edwards 1985). Unfortunately, a major gap exists between the concept of an emergent property and the practical application of the concept as a means of assessing ecosystem quality.

Because each ecosystem has developed under a different set of external variables, ecosystems have different capacities to resist or recover from stresses. In addition each ecosystem will likely have a different mix or set of stresses that may be responsible for degrading the quality of that system. Consequently, the emergent properties that are the most useful for assessing the health of an ecosystem will likely differ from one system to another.

In Green Bay considerable effort has been expended to identify the most critical stresses affecting the system (Harris et al. 1982). These turn out to be toxics, nutrients, suspended solids and sediments, and the fishery. By identifying the critical stresses (those that must be addressed if rehabilitation is to occur) and knowing something of the ecology of the system, and appropriate set of ecosystem properties useful in assessing the well being of the system can be identified. For Green Bay the following properties have been tentatively identified by selecting or combining key environmental parameters from Table 2:

-- Optimal species composition and size distribution of phytoplankton; proportion of macrophytes to phytoplankton.

-- Size distribution of zooplankton, grazing rate, consumptive capacity, and growth rate.

-- Species composition and size distribution of planktivorous fish, growth rate, consumptive capacity.

-- Biomass, growth rate, reproductive rate, and chemical body burden of keystone predators.

The rationale for the choice of these properties (parameters) has been provided primarily through Sea Grant-sponsored studies on trophic interactions in the Green Bay ecosystem conducted by Sager et al. (1984) and Richman et al. (1984a, 1984b). They have characterized in some detail a trophic gradient in the bay ranging from hypereutrophic conditions in the lower bay to oligotrophic Lake Michigan-like northern waters.

These studies describe the trophic gradient in terms of phytoplankton and zooplankton community structure, biomass and size distribution, and respective productivities. The estimates of fish standing stock and production derived from existing mean annual yield statistics are in close agreement with predictions from simplified size-ratio analysis (Sheldon et al. 1977) and productivity of lower trophic levels. This relationship has promise for the use of such measurements as a predictor of standing stock and productivity of higher trophic levels.

The data clearly identify a variability in biological activity in different regions of the Green Bay ecosystem, which we believe is influenced significantly by a nutrient (phosphorous) influx (perturbation) at the head of the bay (Harris and Sager 1984). In the extreme southern reach of the bay, the influx constitutes a stress (with lower food chain efficiences and yield) while in mid-region it acts as a subsidy. In northern regions the nutrient perturbation has little effect, neither subsidy nor stress.

Clearly, the status of Green Bay with regard to trophic conditions could be assessed by monitoring some of the proposed emergent ecosystem properties. These properties are not only linked to one of the critical stresses, nutrients, but also to PCBs which have been identified as a problem in Green Bay (International Joint Commission 1985). These compounds have been shown to affect productivity and growth reduction in nanooplankton species (Lin and Simmons 1981) and zooplankton grazing rates in Saginaw Bay (McNaught 1984). Thus, nutrients or chlororganic hydrocarbons such as PCBs may disrupt the species composition and size distribution of phytoplankton and the size distribution, grazing rates, and consumptive capacity of zooplankton. This could result in a reduced carbon transfer efficiency similar to that observed in the southern portion of Green Bay.

In effect these two stresses (nutrients and toxics) may create an ecosystem dysfunction that shunts a large portion of the primary productivity into the detrital food chains. A shift to large, inedible, blue-green algae and enhanced periphyton growth may further result in an adverse effect on submergent aquatic vegetation (SAV)--as demonstrated in Chesapeake Bay (Stevenson et al. 1985, Kahn and Kemp 1985)--thereby reducing the proportion of macrophytes to phytoplankton.

The trophic status of lakes and productivities at various trophic levels may be regulated by fish predation and herbivory as well as governed by nutrient loading. Carpenter et al. (1985) refer to this as cascading trophic interactions. In their words:

> "Simply put, a rise in piscivore biomass brings decreased planktivore biomass, increased herbivore biomass, and decreased phytoplankton biomass. Specific growth rates at each trophic level show the opposite responses. Productivity at a given trophic level is maximized at an intermediate biomass of its predators. Productivity at all trophic levels, and energy flow through the food web are highest where intensities of predation are intermediate at all trophic levels (Kitchell 1980)."

They further describe the ecosystem dynamics in terms of piscivore density as follows:

"An increase in piscivore density cascades through the food web in the following way. Vertebrate zooplanktivores are reduced while planktivory by invertebrates increases, shifting the herbivorous zooplankton community toward larger zooplankters and higher biomass. Chlorophyll a concentration declines."

The ecosystem properties tentatively identified for Green Bay and discussed above can be expected to respond as management actions reduce the magnitude of the critical stresses. These responses will reflect changes occurring in the system health and integrity of the Green Bay ecosystem.

As yet, we cannot recommend specific ecosystem standards related to the proposed emergent system properties, but it is possible to formulate some related ecosystem management objectives. The overall goal remains rehabilitation or system recovery, and some objectives to this end can be identified:

-- The realization of a self sustaining edible walleye population.

-- A shift in food chain efficiencies in the southern bay to those that more closely approximate those in the mid bay region.

-- A shift toward an increase in macrophyte production with reduced phytoplankton production.

-- A shift in phytoplankton composition from blue green algae to green algae as dominant forms.

-- An increase in the numbers of piscivorous predators to more effectively control carp and planktivorous fishes.

With these and perhaps other objectives in place specific management actions can be formulated and incorporated in an ecosystems-based remedial action plan.

By turning attention to emergent ecosystem properties, management objectives by necessity become more holistic and integrated. For example, the mandate of fishery biologists and managers becomes linked to that of water quality managers if the management objective is a self sustaining edible walleye population. Similarly, fishery managers and water quality managers may think jointly about the role of piscivorous sport fish populations in relation to the abundance of planktivores and water quality. This is quite different from the present, single-species focus of fishery managers or the single pollutant focus of water quality managers. It should be pointed out however that inclusion of ecosystem-level objectives do not necessarily exclude single-species focused objectives.

Legislative Mandate

Ecosystem rehabilitation will require changes in the law. "The literature leads to the conclusion that legislative strategies that aim to make ecosystem rehabilitation the context for management--the constraint around which interests and institutions should work--are a necessary but not a sufficient part of any comprehensive approach to ecosystem rehabilitation." (Yarbrough 1985b)

Efforts at multi-institutional resource management have been more successful where they were enabled and supported by legislative mandates. The requirement is to incorporate the ecosystem perspective into law, to establish that perspective as the accepted scientific, social, and legal definition of the problem. The basic idea is to make the ecosystem the legal and political, as well as the scientific, framework for environmental problem solving.

Existing environmental legislation, while important and in many respects effective, is not capable of promoting a program of ecosystem rehabilitation. The laws themselves, which are ad hoc and particularistic, impede a holistic view of the environment. "What has happened is that the scientific understanding of basic ecological principles has changed the definition of the problem, but the laws have lagged behind this shift in scientific comprehension ... The correlative to this proposition is that the emerging body of ecological concepts must necessarily become legal concepts if ecosystem rehabilitation is to be achieved." (Yarbrough 1985a)

In summary, ecosystem rehabilitation requires ecosystem level goals, operational guidelines, biophysical and behavioral strategies of action, and legislative mandates. Stated in deceptively simple terms, the ecosystem must become the scientific and social framework for environmental problem solving, and ecosystem rehabilitation must be mandated by law.

References

Barrett, G.W. A problem-solving approach to resource management. BioScience 35:423-427.

Ball, J.R., V. Harris, and D. Patterson. 1985. Lower Fox River, DePere to Green Bay water quality standards review. Wisconsin Dept. of Nat. Res. Madison, Wisconsin. 69 p.

Cairns, J., Jr. 1985. Evaluating the options for water quality management. Water Resources Bull. 21:1-6.

Carpenter, S.R., J.F. Kitchell, and J.R. Hodgson. 1985. Cascading trophic interactions and lake productivity. BioScience 35: 634-638.

Environmental Protection Agency. 1985. Five year program strategy for Great Lakes National Program Office 1985-1990. EPA-905/9-85-002. 49 p.

Francis, G.R., J.J. Magnuson, H.A. Reiger, and D.R. Talhelm. 1979. Rehabilitating Great Lakes ecosystems. Tech. Report No. 37, Great Lakes Fishery Commission. 99 p.

Francis, G.R., A.P. Lino Grima, H.A. Regier, and T.H. Whillans. 1985. A prospectus for the management of the Long Point ecosystem. Tech. Report No. 43. Great Lakes Fishery Commission. 109 p.

Goedmakers, A. 1985. Ecological water quality policy: an attempt at concept clarification and a plea for the use of biological ecosystem parameters. Verb. Internat. Verein. Limn. 22:2277-2280.

Harris, H.J., D.R. Talhelm, J.J. Magnuson, and A.M. Forbes. 1982. Green Bay in the future - a rehabilitative prospectus. Tech. Report No. 38, Great Lakes Fishery Commission. 59 p.

Harris, H.J. and P.E. Sager. 1984. Water management and estuarine productivity: a freshwater view of the Great Lakes. In Research for managing the nation's estuaries: proceedings of a conference in Raleigh, NC, March 13-15, 1984.

Harris, H.J., T.J. Kubiak, and J.A. Trick. 1985. Microcontaminants and reproductive impairment of Forster's Tern on Green Bay. Final report to U.S. Fish and Wildlife Service, U.W. Sea Grant Institute, Wis. Dept. of Nat. Res. and Green Bay Metropolitan Sewerage District. 42 p. Sea Grant Office, ES-105, UW-Green Bay. Green Bay, WI 54301-70001.

International Joint Commission. 1985. Report on Great Lakes water quality. Great Lakes Water Quality Board, International Joint Commission, Kingston, Ontario. 212 p.

International Joint Commission. 1978. Great Lakes water quality agreement of 1978. IJC Ottawa, Ontario. 52 p.

Kahn, J.R. and W.M. Kemp. 1985. Economic losses associated with the degradation of an ecosystem: The case of submerged aquatic vegetation in Chesapeake Bay. J. Env. Econ. and Mgt. 12:246-263.

Kerr, S.R. 1974. Structural analysis of aquatic communities. Proc. lst. Int. Cong. Ecol. pp. 69-74.

Lin, C.K. and M.S. Simmons. 1981. Effects of pentachlorobiphenyl on growth of nutrient enriched phytoplankton from Lake Michigan. J. Great Lakes Res. 7:481-485.

Loucks, O.L. 1985. Looking for surprise in managing stressed ecosystems. BioScience 35:428-432.

Lychwick, T.J. 1985. Status of walleye in Wisconsin waters of Lake Michigan (Green Bay). Project AFC 15-5, Wisconsin Dept. of Nat. Res., Madison, Wisconsin, 53707. 49 p.

McNaught, D.C., D. Grieamer, M. Buzzard, and M. Kennedy. 1984. PCBs in Saginaw Bay: development of functional indices to estimate inhibition of ecosystem fluxes. Report to EPA - EPA-600/3-84-008. Env. Res. Lab., U.S. Environmental Protection Agency, Duluth, Minn. 55804.

National Academy Press. 1984. Review of the Great Lakes water quality agreement: conference proceedings, National Academy Press, Washington, D.C.

Odum, E.P. 1985. Trends expected in stressed ecosystems. BioScience 35:419-422.

Rapport, D.J., H.A. Regier, and T.C. Hutchinson. 1985. Ecosystem behavior under stress. The American Naturalist. 125:617-640.

Richman, S., P.E. Sager, G. Banta, T.R. Harvey, and B.T. Destasio. 1984a. Phytoplankton standing stock, size distribution, species composition and productivity along a trophic gradient in Green Bay, Lake Michigan. Verh. Internat. Verein. Limnol. 22:460-469.

Richman, S., M. Bailiff, L. Mackey, and D. Bolgrien. 1984b. Zooplankton standing stock, species composition and size distribution along a trophic gradient in Green Bay, Lake Michigan. Verh. Internat. Verein. Limnol. 22:475-487.

Risser, P.G. 1985. Toward a holistic management perspective. BioScience 35:414-418.

Ryder, R.A. and C.J. Edwards, eds. 1985. A conceptual approach for the application of biological indicators of ecosystem quality in the Great Lakes basin. Report to the Great Lakes Science Advisory Board. International Joint Commission and the Great Lakes Fishery Commission. 169 p.

Sager, P.E., G. Banta, and J. Kirk. 1984. The relation between areal and volumetric expressions of ^{14}C productivity in Green Bay, Lake Michigan. Verh. Internat. Verein. Limnol. 22:470-474.

Sheldon, R.W., W.H. Sutcliffe Jr., and M.A. Paranjape. 1977. Structure of pelagial food chain and relationship between plankton and fish production. J. Fish. Res. Board Can. 34:2344-2353.

Stevenson, C., W. Boynton, M. Kemp, and R. Twilley. 1985. Estuarine water quality: implications for management of submerged aquatics in Chesapeake Bay. Paper presented at the Estuarine Management Practices Symposium. Nov. 11-14, 1985, Baton Rouge, LA.

White, G.F. 1980. Environment. Science 209:183-190.

Wisconsin Division of Health and Wisconsin Dept. of Nat. Resources. 1985. Health advisory for people eating fish from Wisconsin waters. Flyer 8503. Wis. Dept. of Natural Resources, Madison, Wis.

Yarbrough, C.J. 1985a. The legal environment of ecosystem rehabilitation. unpublished manuscript prepared for committee to review the Great Lakes water quality agreement. National Research Council, The Royal Society of Canada.

Yarbrough, C.J. 1985b. Multi-institutional management. The Green Bay experience. Report to The Great Lakes Science Advisory Board. International Joint Commission. 87 p.

MITIGATION: DILEMMA OR OPPORTUNITY

Franklin D. Christhilf
Sanctuary Programs Division,
National Oceanic and Atmospheric Administration,
Washington, D.C.

The title, Mitigation: Dilemma or Opportunity, has some thought behind it. In the time allotted to me I intend to state six propositions. The first three are dilemmas. The second three are opportunities. All six propositions are challenges.

Proposition 1: We can't agree on what mitigation is. This is not to say that mitigation has not been defined. Indeed, the dilemma is created by the opposite situation. There is a plethora of definitions, and some of the definitions are not very helpful.

Proposition 2: We don't know if mitigation works. The scientific evidence that we need is not in. Mitigation is still largely experimental. The jury is still out.

Proposition 3: Nevertheless, mitigation is increasingly used by decision makers as a tool to balance the loss of valuable wetlands by some hocus-pocus rationale based on economics, habitat replacement, or some other specious comparison.

These dilemmas are opportunities in disguise. They force us to take a second look at what we are doing, and this can lead to take some positive steps to do better in the future.

Proposition 4: We can intensify the national dialogue on what constitutes good public policy in terms of acceptable and non-acceptable forms and degrees of mitigation.

Proposition 5: We can continue to develop a more experimental approach to research into what is required to restore marshes and wetlands as one means of achieving parity in mitigation trade-offs.

Proposition 6: We can develop ways to store, synthesize, and share information on methods that have succeeded or that have failed to restore or rehabilitate an estuarine environment--thus satisfying the developer, our laws and regulations, and the public trust that we are committed to uphold.

These are my six propositions or challenges. I could stop here, but I want to develop these propositions and give each one at least a broad-brush treatment so you will know why I think these are important concepts to consider in mitigation.

Proposition 1: We can't agree on what mitigation is.

Margaret Race and Donna Christie (1987) are correct when they say, "The first hurdle to overcome in discussing mitigation of any type is defining the term mitigation. There seems to be no universally accepted definition of mitigation in general or specifically when applied to projects involving the destruction of wetlands."

That statement does not mean to imply that there are no definitions codified in law or regulations. The problem is that the definitions contained in CEQ regulations for the National Environmental Policy Act (NEPA), and adopted by the U.S. Fish and Wildlife Service in its mitigation policy promulgated in 1981, are so broad that they are of limited value in practical mitigation decision making.

For example, the definition for mitigation under NEPA ranges from avoiding the impact altogether by not taking action to "compensating for impacts by replacing or providing substitute resources or environments."

Within that broad spectrum of possibilities, it has been easy for mischief to occur, either intended or unintended, as new interpretations are generated and manipulated to suit the purpose of a given regulator, developer, or politician. If everything that I do is mitigation, the term becomes meaningless.

When a precise definition is lacking, the danger is that, on the one hand, the decision maker may be "giving the store away" and the public loses an irreplaceable wetland area. On the other hand, the developer may be paying for what should be considered a public good. In either case, lack of consensus on a definition and interpretation of mitigation gives rise to the cynical views of Dziedzic and Oliver, who in the 1979 Mitigation Symposium unabashedly characterized mitigation, as currently practiced, as a "ripoff applied in strategic fashion to legitimize environmentally unjustifiable projects." In the words of another, "Mitigation is little more than the sugar coating to render a bitter pill more palatable."

I like the notion of limiting the definition of mitigation to "specific actions taken to restore or compensate for unavoidable damage to the environment" (Race and Christie 1982). [Emphasis added.] This limited definition puts the concept of "avoiding or minimizing damage" in the category of good planning. This will be discussed later.

If we use this limited definition, then some activities undertaken in the name of mitigation may not constitute mitigation at all. This is very important, because if you can tell a developer what's not accepted as mitigation, you have gone a long way toward arriving at a decision that will achieve no net-loss of in-kind estuarine ecosystem value. Oregon and California have already moved in that direction.

After conducting a thorough literature review, interviewing people involved in the mitigation process, and selectively muddling through countless Corps of Engineers (COE) permit application files, Daniel Ashe (1982) was able to classify estuarine mitigation activities into nine general categories:

1. regulatory approach
2. good planning approach
3. public use approach
4. acquisition approach
5. single purpose mitigation
6. indemnification payments
7. acquisition and management
8. habitat establishment
9. restoration of previously altered resources

In his analysis, Ashe was able to toss out the first five, which means, if we accept his scheme, that we should not entice or allow developers to substitute dedicated land, fish hatcheries, or a fishing pier for valuable wetlands that are permanently and irrevocably removed from an ecosystem. Some positive actions identified by Ashe will be brought up under Proposition 4.

Proposition 2: We don't know if mitigation really works.

Mitigation is still in its infancy or, perhaps, adolescence. Collectively, we don't have enough evidence over a long enough period of time to know whether mitigation decisions have been justified.

It is not difficult to find case studies that seem to indicate successful restoration projects, but on closer examination one finds that the results are over a one to two year period, hardly long enough to constitute a successful experiment.

On the other hand, Race and Christie (1982, 1985) have done extensive evaluations of restored wetland projects in a number of states and particularly in San Francisco Bay, and the result has hardly been reassuring. In one of her kinder comments based on her research, Race (1985) says, "Although many projects in San Francisco Bay have been categorized as completed or partially completed wetlands projects, they do not demonstrate an ability to establish marsh habitats in a predictable manner."

Other cautions raised by these researchers include: "Marsh creation by definition must be done at the expense of some other habitat," and "It is certain that marsh is more than the presence of vegetation." Again, "It is essential to determine whether man-made marshes are comparable to natural marshes in the important functions."

These cautions are directed toward marsh restoration or construction where we at least have some criteria for judging success. Once we step onto the slippery ground of trying to place an economic value on marshes and wetlands in a trade-off called mitigation, we have entered a "never-never land" where the hand is quicker than the eye.

Perhaps it is time for us to become a little more humble and to acknowledge that we don't know whether mitigation works. That would be better than to act as though we really know and then make some unfortunate errors in judgment.

A movie comes to mind--"The Marathon Man"--in which Dustin Hoffman is supposed to have some information that could affect the life and security of Sir Lawrence Olivier. In one unforgettable scene, Olivier is trying to obtain information from Hoffmann by torturing him, extracting each of his teeth one by one without any anesthetic. As each tooth is pulled, he asks Hoffman, "Is it safe?" Unfortunately, Hoffman doesn't know what it refers to, but he is desperate to give the correct answer! First, he says, "No, it isn't safe." More torture is applied, so he says, "Yes, it is safe." Finally, the torture stops but only when Olivier is convinced that Hoffman doesn't really know "if it's safe."

This scene could be an analogy for a typical regulator. Is mitigation safe, i.e., protecting the ecosystem? First, to be on the safe side, he may say "No," but later he may cave in and say "Yes" because basically he doesn't know whether the mitigation formula is safe or not. This is a real dilemma.

Proposition 3: Nevertheless, mitigation is increasingly used by decision makers as a tool to balance the loss of valuable wetlands by some hocus-pocus rationale based on economics, habitat replacement, or some other specious comparison.

Of course! It could not be otherwise in the rough and tumble world in which those kinds of decisions have to be made. A private citizen, let alone a corporation with lots of money and political clout, can put a lot of pressure on an agency decision maker to find a way to make mitigation work. I am not saying that this private citizen or developer is doing a bad thing. He is acting in his own self-interest--it is the American way--and in his behalf let it be said that the applicant for a permit is up against a system that will try to wear him down to the point where he gives up.

Mitigation is rarely mentioned as a factor in the state decision making process. Most often, a catchall condition on a permit allows a permitting agency to impose restrictions or compensating action as the primary vehicle for requiring mitigation.

We are talking about a game in which each side is thinking in terms of a winner and loser in the transaction. But people are smart, and where a lot of money (profit) is involved in a development project sophisticated developers have come to realize that if they submit extensive mitigation plans with their permit applications, the process becomes less adversarial. The mitigation, rather than the development, becomes the focus of the decision makers. In other words, mitigation is being offered as a justification for the development and (parenthetically) the destruction of wetlands.

In this context, the use of mitigation can prove to be dangerous because it creates a perception of quid pro quo where the scientific evidence is not there to support the decision.

Another factor in the mitigation game is what I call the PIP principle Progress is Persistence. By just keeping the pressure on the decision maker, eventually a person or corporation is going to increase the chances of getting a favorable decision.

One other aspect of this proposition is that, to the extent that developers design and prepare restoration projects themselves, the developers are taking the public interest into their own hands. John Clark (1983) suggests that in Florida this de facto mitigation policy of promoting the use of private sector funds to rehabilitate Florida's vast acreage of degraded wetlands has meant that rehabilitation will usually occur only at or near development sites.

Counter to the games developers play is the assortment of games that bureaucrats play. Robert Snyder (1980) wrote an article entitled "Is There Life After Mitigation?" in which he describes an application submitted to the COE that took years to resolve because the COE kept deferring a decision while waiting on formal comments from the National Marine Fisheries Service and U.S. Fish and Wildlife Service. Bureaucrats are experts at the game of avoiding a decision.

So much for the dilemmas of mitigation. Let's look at the opportunities.

Proposition 4: We can intensify the national dialogue on what constitutes good public policy in terms of acceptable and non-acceptable forms and degrees of mitigation.

That's what we are about today, to some extent. We are taking the measure of mitigation and seeing how it fits into the total concept of managing the nation's estuaries. We need this kind of dialogue.

Earlier, I referred to an article by Dan Ashe (1982) in which he reported on nine empirical categories of activities that occurred in the actual practice of mitigation. He discards five of these categories, which leaves him with four that he finds acceptable:

1. acquisition and management (with emphasis on management)
2. using a mitigation land bank framework
3. habitat establishment (from uplands)
4. rehabilitation of previously altered habitats

This is an important contribution to the dialogue, as well as the articles by Race and Christie and all of the other folks who have their thinking caps on. And they are challenging us to put our thinking caps on so that we can come up with some ideas on giving the estuaries a fighting chance when it comes to mitigation.

Let's take the concept of whether mitigation should emphasize similarity of habitat or similarity of ecosystem function. I'd vote for similarity of ecosystem function. In 1980, the Office of the Chief of Engineers Environmental Advisory Board cast the same vote in the statement, "The Corps should approach the opportunity for mitigation in certain areas of the country on an ecosystem basis. It should examine the possibility for mitigation regularly and articulate policies that are best suited to prevent and compensate for losses."

This is a recommendation of relevance to all agencies involved in the mitigation process.

It makes sense. If emphasis is placed upon the functional roles of system components and the flexibility of energy and matter pathways, mitigation efforts can suggest methods of constructive alteration that will exploit the estuary's capacity for self-adjustment to change and assure that the system continues to function despite the alterations.

The point is, whether you agree or not with the ecosystem-based concept of mitigation, it should be discussed by knowledgeable people.

Perhaps the time has come for other means to intensify this national dialogue so that ideas can be shared and all of us--managers and scientists and policy makers--can be involved in making some sensible recommendations for improving the mitigation process.

Proposition 5: We can continue to develop a more experimental approach to research into what is required to restore marshes and wetlands as one means of achieving parity in mitigation trade offs.

I have already referred to the weaknesses that have been found in the various wetlands restoration projects around the country and have mentioned that we cannot rely on them.

There is concern in the scientific literature that as marsh creation policy becomes institutionalized, we will find more natural habitats being replaced with artificial substitutes whose long-term value and survival are questionable. If we continue manipulating marshes through uncontrolled experimentation on a grand scale, we may be buying a pig in a poke and end up with nothing or very little.

As an alternative, I want to refer to an article on "Salt Marsh Restoration in Southern California" by Dr. Joy Zedler. In her article (CZM 83 Proceedings), Dr. Zedler describes a controlled experimental approach to restoration research. The key is to be able to replicate conditions well enough so that you can determine why a particular modification succeeded or failed. As she describes the process of discovery, Zedler emphasizes how, when various factors are changed, each experiment builds on what has previously been learned. It's elemental, but this approach needs to be tried in other places.

We are fortunate in the National Estuarine Sanctuary Program to have Dr. Zedler working in the Tijuana River National Estuarine Sanctuary, and to have two marsh restoration projects being monitored at the Elkhorn Slough National Estuarine Sanctuary, both in California. Sanctuaries provide a natural control against which a restored wetlands can be compared. Perhaps, estuarine sanctuaries could also serve as a tool for long-term research with mitigation banking.

Proposition 6: We can develop ways to store, synthesize, and share information on methods that have succeeded or that have failed to restore or rehabilitate an estuarine environment--thus satisfying the developer, our laws and regulations, and the public trust that we are committed to uphold.

It is a truism that we never have all of the information we need when we need it to do our jobs. This is certainly true of mitigation. Published reports of restoration projects, in most cases, do not provide an accurate picture of the great variability in type, size, local conditions, and other physical features of the sites. All too often data and other documentation are totally unavailable or only partially reported in the "grey" literature. Coastal planners are faced with a confusing picture in which it is difficult to distinguish between failures or degrees of success in various mitigation techniques. In addition to lack of sufficient data, we also suffer from what one volume of conference proceedings referred to as the "debris of complexity," a typographical error with a comical discernment.

No one system can overcome this problem. However, researchers and managers who have worked on restoration or rehabilitation projects can be encouraged to see the importance of voluntarily disseminating whatever they have discovered into the refereed journals and through other means to reach a wider audience, including the public, which ultimately pays the bills. Dr. Zedler's "Salt Marsh Restoration Guide" has some recommendations concerning this. One suggestion is to have a repository for such reports at each national estuarine sanctuary. She may be biased, but it would be helpful to have a repository, and national estuarine sanctuaries offer one alternative.

In conclusion, estuarine environments must be capable of providing habitat for the industrial, commercial, residential, recreational, and aesthetic activities of *Homo sapiens*, as well as other users of the estuary. That is both a dilemma and an opportunity. Mitigation can be an effective tool in this effort. And it will take effort.

Today, I was looking out over the Mississippi River and I saw two tugboats. One was going downstream--fat, dumb, and happy--and nothing impeded its progress. It passed from my view in a short time. The other tug, however, was headed upstream with a long line of barges attached. It was moving very slowly, so slowly that at first I thought it wasn't moving at all. It continued to move very slowly but never stopping. By the time I was ready to leave, the tug had just passed out of sight. It brought to my mind my PIP principle--Progress is Persistence!

Preserving and rehabilitating our estuaries will be a long, slow process like that tugboat heading upstream, but we must not stop. Rather, let us persevere.

WETLAND MITIGATION AND RESTORATION IN THE SOUTHEAST UNITED STATES AND TWO LESSONS FROM SEAGRASS MITIGATION

G.W. Thayer, M.S. Fonseca, W.J. Kenworthy
National Marine Fisheries Service,
Beaufort, North Carolina

Introduction

The mission of the National Marine Fisheries Service (NMFS) is "to achieve a continued and optimum utilization of living marine resources for the benefit of the nation." Recently, NMFS published its Habitat Conservation Policy (Federal Register 1983) that states: "The goal of NMFS's habitat conservation activities will be to maintain or enhance the capability of the environment to ensure the survival of marine mammals and endangered species and to maintain fish and shellfish populations which are used, or are important to the survival and/or health of those used...NMFS will direct its habitat conservation activities to assist the agency in meeting its resource management, conservation, protection, or development responsibilities contained in (1) the Magnuson Fishery Conservation and Management Act, the Marine Mammal Protection Act, and the Endangered Species Act; ...since most of NMFS's programs under its broad mandates are influenced by habitat considerations, habitat conservation will be considered and included in the agency's decision making in all of its programs. NMFS will bring all of its authorities to bear in habitat conservation. These authorities include those which give NMFS an active, participatory role and those, particularly the Fish and Wildlife Coordination Act, which give NMFS an advisory role."

NMFS Environmental Assessment Activities

Projects, mostly water-dependent, considered of vital importance or in the public interest by the U.S. Army Corps of Engineers, continue to cause alteration and substantial loss of wetland habitat, particularly when their cumulative impacts are considered. In a review of wetlands in the United States, Tiner (1984) identified nine national problem areas where wetland loss and degradation were considered to be grave threats, six of which have major impacts on coastal fisheries. The chief problem area on this list is the loss of estuarine wetlands, and NMFS (1983) has estimated that wetlands loss in the United States from 1954 to 1978 resulted in an annual loss of $208 million in fishery products.

Pursuant to the mission and habitat conservation goal of NMFS, regional offices, specifically the Habitat Conservation Division (HCD) and its area offices, receive permit applications to review from the U.S. Army Corps of Engineers (COE) under the Corps of Engineers Sections 404 and 10 permit programs. Under the Fish and Wildlife Coordination Act, NMFS is required to assess the potential impacts that each project may have on fishery resources and recommend modifcations, denial, or no change (Lindall and Thayer 1982). Because HCD does not maintain an independent research capability, Regional Fishery Centers, which are mandated to "conduct environmental and ecological research, including long-term studies necessary to implement the policy..." (Federal Register 1983), interact closely with HCD to provide scientific information. Information also is gathered from state fishery agencies, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency (EPA), and academic and private research institutions.

During a typical year, between 6000 and 8000 applications under the Corps of Engineers permit program are received in NMFS regional offices nationwide. Almost 70 percent of these applications are for projects in the Southeast Region (Table 1). Permit applications are reviewed by Beaufort (North Carolina), Panama City (Florida), and Galveston (Texas) area offices of HCD to ascertain their potential adverse impact upon fishery habitat and water quality and upon the overall functioning of the aquatic ecosystem that provides the necessities for continued productivity of marine fishery resources.

Table 1

Number of permit applications received annually by National Marine Fisheries Service Regional or Area Offices for coastal development. Data are from National Ocean Service (1985).

NMFS Region	Number of Permits Received for Review
Northeast (Virginia to Maine)	1700
Southeast (North Carolina to Texas)	4000-6000
Southwest (California and Hawaii)	600
Northwest (Oregon, Washington and Alaska)	1000

Approximately 80 percent of the permit applications in the southeast are given a "no objection" response because it is believed that, based on NMFS project evaluations using regional guidelines and criteria, impacts to marine fishery resources and their habitats would not occur or would be minimal (Lindall and Thayer 1982). Concerns, however, are now arising that this may not be entirely the case and that cumulative acreage in this category may be considerable. Of the remaining 20 percent, almost 18,000 acres of habitat were proposed for alteration during the period October 1, 1980, through September 5, 1981. NMFS did not object to alteration of 4,600 acres. However, 13,000 acres of proposed alteration were recommended for denial.

The impacts were not broken down by habitat type in this assessment, but were combined and included mangroves, high and low salt marshes, submerged seagrasses, hardwood swamps and freshwater marshes, clam beds, oyster beds, and unvegetated intertidal and subtidal bottoms--all important to living marine resources. It was recognized that information was needed on the quantity of each type of habitat involved to assess trends in alteration by habitat and activities associated with each (Lindall and Thayer 1982). This process currently is underway through the development of a national data base management system for permit recommendations by HCD personnel.

NMFS Mitigation Approach

In its responsibility to evaluate federal, state, and local permit applications, the NMFS HCD considers habitat conservation as its primary goal, and mitigation is considered in cases where the U.S. Army Corps of Engineers determines there are no project alternatives. Where the project is clearly in the public interest HCD recommends some form of mitigation to reduce or eliminate adverse impacts. In some instances, projects are recommended for denial because they are of such scope or require technology that is unavailable to mitigate damages. Wetland mitigation recommendations are made by HCD personnel because of the recognized ecological and fisheries value of wetland habitats (Lindall et al. 1979, Peters et al. 1979, Thayer et al. 1979, Nixon 1980, Josselyn 1982, Lindall and Thayer 1982, Thayer and Ustach 1982, Zieman 1982, Boesch and Turner 1984). The objective of NMFS's mitigation recommendations is to attempt to reestablish wetland fishery habitats and presumably their ecological functions that are unavoidably lost through issuance of permits by the Corps of Engineers. The unmitigated loss of coastal wetlands constitutes a direct threat to the nation's ability to maintain fishery resources. These recommendations are not made frivolously because, although techniques exist to revegetate salt marsh (Mason 1980, Reimold 1980, Seneca 1980, Ternyik 1980, Zedler et al. 1982, Getter et al. 1984, and references therein), mangroves (Lewis and Lewis 1977, Lewis 1981, Teas 1977, 1980, Goforth and Thomas 1979, Getter et al. 1984), and seagrass meadows (Phillips 1974, Thorhaug 1974, 1980, Fonseca et al. 1979, 1982, 1985, Phillips et al. 1980, Thayer et al. 1984, 1985), we know the science of habitat reestablishment and creation is still young and imperfect.

The topic of mitigation has been addressed in detail by several authors (Lindall et al. 1979, Ashe 1982, Race and Christie 1982, Race 1985). Mitigation of unavoidable habitat loss can take several forms: pre-application (up front) mitigation, habitat creation, restoration and enhancement, and mitigation banking. In reviewing permit applications and making recommendations, HCD initially seeks onsite alternatives that would lessen or avoid adverse impacts. These types of mitigation (alternative sites for the project, careful construction methods, etc.), often recommended during pre-application meetings, are important since they seek to avoid net habitat loss or degradation. Habitat creation in estuarine areas frequently is recommended and includes creation of intertidal areas from previously filled wetlands or clearing and excavation (downgrading) of upland sites followed with revegetation by transplantation or hoped for natural revegetation. Natural revegetation may not take place or may occur only over a long time. Upland alteration may provide new habitat for estuarine species but is performed at the expense of riparian species and is sometimes in conflict with recommendations of other agencies whose responsibilities cover wildlife in these areas, although this is a rare occurrence. Oyster reef creation, in some cases, also is considered an acceptable mitigation measure for certain impacts. Restoration of habitat that previously had been affected is also a mitigation technique, particularly in instances where unauthorized activities in wetlands have been discovered. Wetland areas that were filled in the past can be reduced to appropriate elevations to create fishery habitat of the same kind adjacent to the site of lost habitat or within the same aquatic system. Open waters that previously were marsh areas that have subsided or are subsiding may be refilled to intertidal elevations to once again support marsh (Moore et al. 1985). Mitigation banking, which incorporates the concepts of enhancement and preservation of areas to be used to offset adverse impacts of yet to be identified future projects, is also a form of mitigation.

Enhancement of existing habitat that has been adversely affected in the past is a frequently recommended mitigation option. Enhancement can take the form of increasing access by marine organisms to impounded or partially impounded areas; increasing flushing of stagnant areas; restoring past hydrological regimes; or reducing the impacts of other adverse actions.

In areas where revegetation activities are being considered, addition of vegetation to already existing, natural, and unchanged habitat has been suggested. This is not considered an acceptable mitigation measure. Such a revegetation action provides only a transitory phase in productivity and not a long-term replacement, which is a precept of the mitigation measures recommended by NMFS (Lindall et al. 1979, Lindall and Thayer 1982). In some cases, planting seagrasses or marsh grasses into presently barren estuarine sediments is considered. This constitutes a form of in situ habitat trade-off that also is less than desirable. At the very least, long-term absence of vegetation from an area suggests environmental conditions unsuitable for plant growth. Experience, principally in seagrass meadows, has shown us that pulsing a natural system with transplants is a short-term measure and that the system will return to its natural configuration and plant density in a short period. Thus, habitat has been lost because of the permit action, and there has been no net enhancement of the system except for a fleeting moment.

Habitat loss resulting from permit actions should be mitigated by the same kind of habitat, and this replacement should be adjacent to the area of habitat loss, or at least, in the same aquatic system. It must be recognized, however, that the productivity of that system or the portion lost can never be returned to what it had been originally. Once a segment of a system is lost, the biological, chemical, and physical links within the system are permanently disrupted even though mitigation occurs (Fonseca et al., in press).

Proper site selection is of paramount importance to the success of any mitigation measure. In an attempt to keep mitigation within the same system, HCD recommendations often are made to grade down existing high ground (preferably already affected areas) to intertidal estuarine levels and contours within the same system as a means of replacing lost wetland and intertidal habitats. Although onsite mitigation is most desirable, frequently the available habitat is not suitable because of alteration or is incapable of supporting the desired new habitat types. At this point in the decision process offsite mitigation should be considered. Offsite mitigation, however, may not result in replacement "in kind," and frequently is used by applicants to obtain their permits, consequently destroying long-existing and productive wetlands.

NMFS Mitigation Activities

Area offices of HCD NMFS mitigation activities in the Southeast Region report that 40-60 percent of the applications involving loss or damage to estuarine fishery habitat that are not recommended for permit denial, result in mitigation recommendations. These recommendations include creation, restoration and enhancement of wetlands, intertidal-subtidal unvegetated bottoms, and oyster reefs. From October 1980 to September 1981, area offices in the Southeast Region recommended that 2500 acres be restored and 800 acres of upland area be modified to estuarine habitat (Lindall and Thayer 1982). Although the type of habitat involved was not categorized at that time, a large portion pertained to unvegetated bottom.

Since these initial efforts and short-comings of the information base noted by Lindall and Thayer (1982), the Southeast Region has developed a computerized system, called a habitat logger, for manipulating permit application data. Data entered include the habitat type involved (frequently distinguished to species), acreage involved, and mitigation action. This data base generally contains only habitat data pertinent to the applications objected to (approximately 20 percent of the total received). Provisions have been made to track a subsample of the permits issued to determine what was really done at the project site after permit issuance. However, only 110-125 permits issued each year are tracked to evaluate compliance, and only a few of these may include mitigation recommendations.

During the period from June 1, 1981, to September 30, 1984, Beaufort (North Carolina), Panama City (Florida), and Galveston (Texas) area offices of HCD recommended wetland plant mitigation on approximately 1000 permit applications. This does not include mitigation activities (alternate site selection, mode of construction, etc.) that occurred as a result of pre-application meetings. Recommendations included mitigation to salt marshes, seagrasses, mangrove swamps, hardwood swamps, freshwater marshes, and intertidal-subtidal unvegetated habitats. A substantial proportion of the total dealt with freshwater marshes and intertidal-subtidal unvegetated habitats and will not be considered in this discussion. Approximately 2900 acres of marsh, 680 acres of mangrove swamp, 500 acres of hardwood swamp, and 75 acres of seagrass meadow (250 acres of seagrass meadow were recommended for mitigation at the port of Miami during 1980 and are not included in our estimates) were recommended for mitigative action as a condition of the permit (Table 2). The recommendations ranged in size from approximately 0.03 acres to 600 acres (a federal project in

Galveston Bay near Texas City), but by and large actions were of 2.5 acres or less.

Table 2

Approximate acreage recommended by Southeast Regional Office HCD personnel for mitigation from June 1981 - September 1984.

Wetland Category	STATE NC	SC	GA	FL	AL	MI	LA	TX	SUM
Marsh	59[a]	62[a]	87[a]	118[b]	25[b]	12[b]	1510[d]	1050[e]	2923
Hardwood swamps	448[f]	4	2	51	11	3	--	--	519
Mangrove[b]	--	--	--	671	--	--	--	14	685
Seagrass[c]	2	--	--	5	--	--	--	66	75

[a]Majority involve grading of upland or spoil to estuarine levels with no transplanting.

[b]Majority request for transplanting.

[c]All recommended for transplantation.

[d]Involved grading and backfilling as well as grading for marsh creation.

[e]800 acres in two federal projects, both requesting transplanting; majority of remaining involved grading with no transplanting.

[f]400 acres in a single project.

Figure 1 shows the distribution of HCD mitigation recommendations throughout North Carolina, South Carolina, and Georgia. With the exception of a single 400-acre hardwood swamp mitigation project, there have been about equal acreages of salt-marsh and hardwood swamp recommended for mitigation in North Carolina. The 400-acre site was a restoration project in which an illegal impoundment had occurred, and return of normal water flow was recommended. For the most part, recommendations that are made by the Beaufort area office are to grade upland to preproject (hence, specifically referring to affected rather than natural uplands) elevations and contours to allow for natural revegetation. Grading of natural uplands to estuarine elevations and contours also is recommended. The seagrass mitigations handled by this office, while small (two acres), are all very recent and involve transplantation.

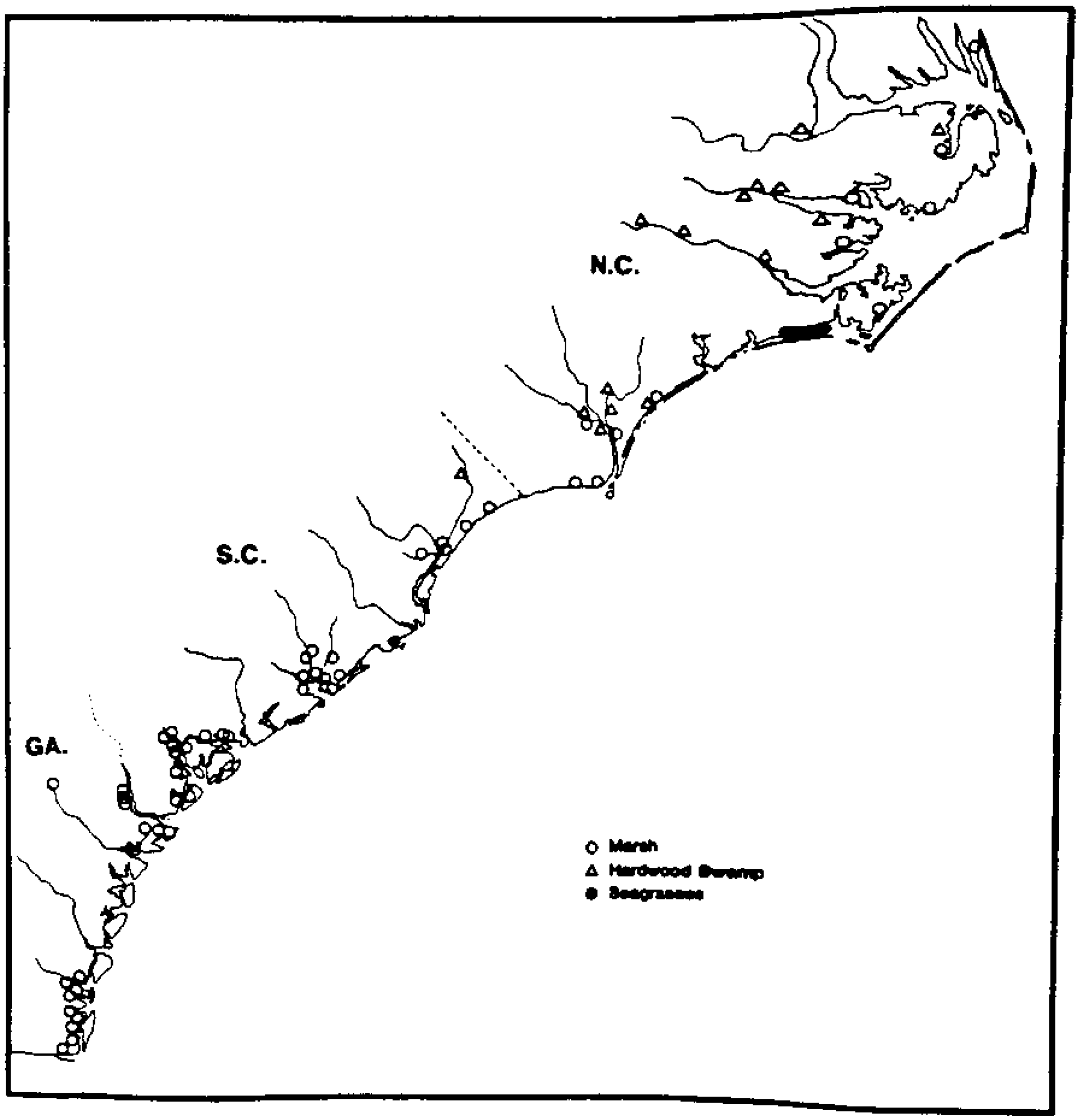


Figure 1. Distribution and type of wetland mitigation recommendations made by the Beaufort, North Carolina, area field office of HCD from June 1981 to September 1984.

Salt marsh and hardwood swamp mitigation recommendations for both South Carolina and Georgia also have been primarily grading down of high ground or old spoil sites to allow natural revegetation, although reestablishing sheet flow to impounded marshes and breaching existing impoundments are frequently recommended. Only occasionally have recommendations been made on emergent wetlands that requested sprigging with Spartina or Juncus as part of the permit. Because planting or sprigging should enhance the rate of recovery of a system, this area office is requesting it more frequently in current mitigation recommendations.

Along the Gulf coast most of the mitigation activities occur in Florida, Texas, and Louisiana. The majority of mitigation recommendations related to permit applications (Figure 2a) and unauthorized activities (Figure 2b) in Florida pertain to mangroves (79 percent of the total acreage), although marsh mitigation projects also form a significant fraction of the total (see Table 2). In the majority of instances, as is the case for both Alabama and Mississippi, grading down of high ground or spoil banks, followed by revegetation efforts, is recommended. Although seagrass mitigation projects for permits filed between June 1, 1980, and September 30, 1984, affect only a small fraction of the total acreage in Florida (less than 1 percent), they represent about 4 percent (18 of 415) of the mitigation recommendations dealing with categories listed in Table 2. Each project has been small, usually less than 0.5 acre.

The total seagrass mitigation acreage does not include experimental studies (Fonseca et al. 1985) nor does it include a 251-acre seagrass mitigation project at the port of Miami that was permitted in October 1980; this project is still ongoing with highly variable results. As is the case in North Carolina, the frequency of seagrass mitigation recommendations in Florida is increasing, partially as a result of more permit activity in seagrass areas and partially because transplanting technology recently has been improved.

Marsh mitigation projects are the prevalent mitigation recommendations in Louisiana (Figure 3). Sixty-five permits (about 520 acres) were recommended to include backfilling of proposed channels and slips to as near to preproject levels as practicable by returning spoil above 2' MSL to the dredged area. Most of these recommendations were associated with permits for exploratory oil well canal construction. There are several intended effects of backfilling: (1) reestablish marsh vegetation in the canal to the extent practicable; (2) reestablish marsh vegetation on the former spoil bank; (3) restore natural hydrological flows; (4) create shallow water habitat in the partially refilled canal for aquatic fauna; and (5) reduce erosion of additional wetlands. The Center for Wetland Resources at LSU has been carrying out research on the problem of backfilling (Neill and Turner 1984), a project partially supported through funding from HCD.

Approximately 100 permits (involving almost 1000 acres) included recommendations that spoil from dredging activities be spread in shallow open water areas in existing marshes to an elevation not to exceed 2' MSL settled height. Most of these areas formerly supported marsh, but

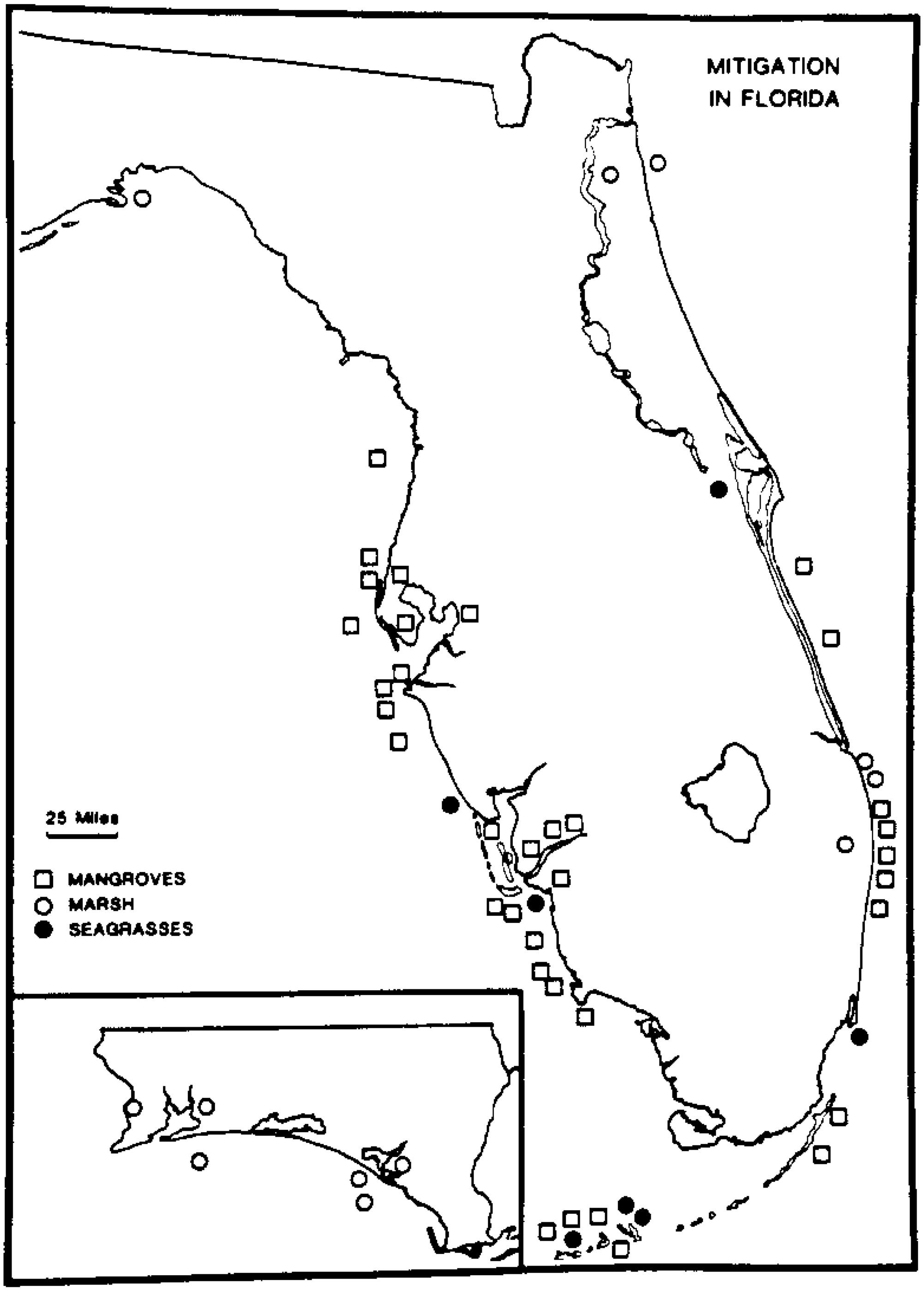


Figure 2a. Distribution of wetland mitigation recommendations made by the Panama City, Florida, field office of HCD from June 1981 to September 1984.

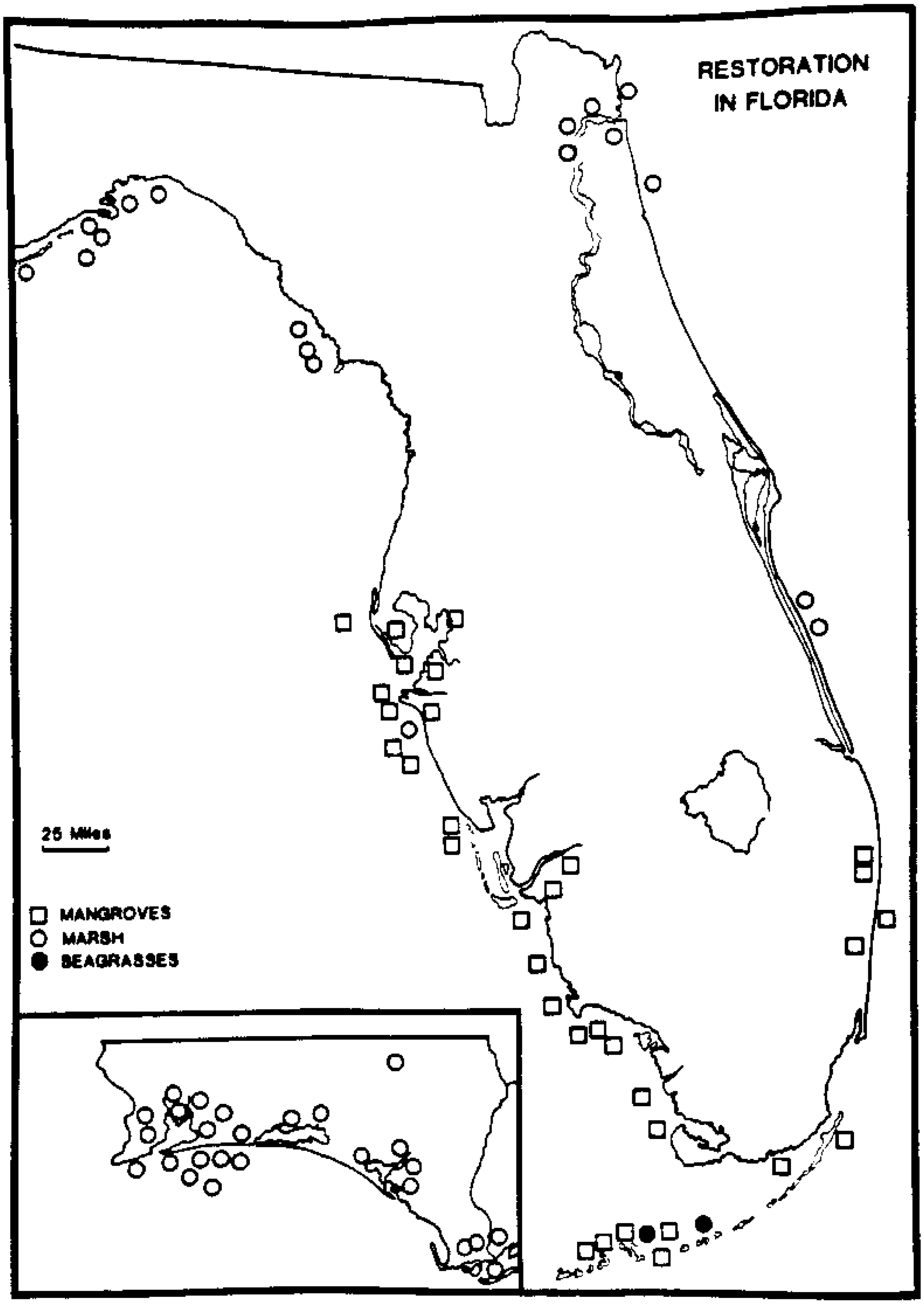


Figure 2b. Distribution of recommendations on restoring wetlands, resulting from unauthorized activities, from June 1981 to September 1984.

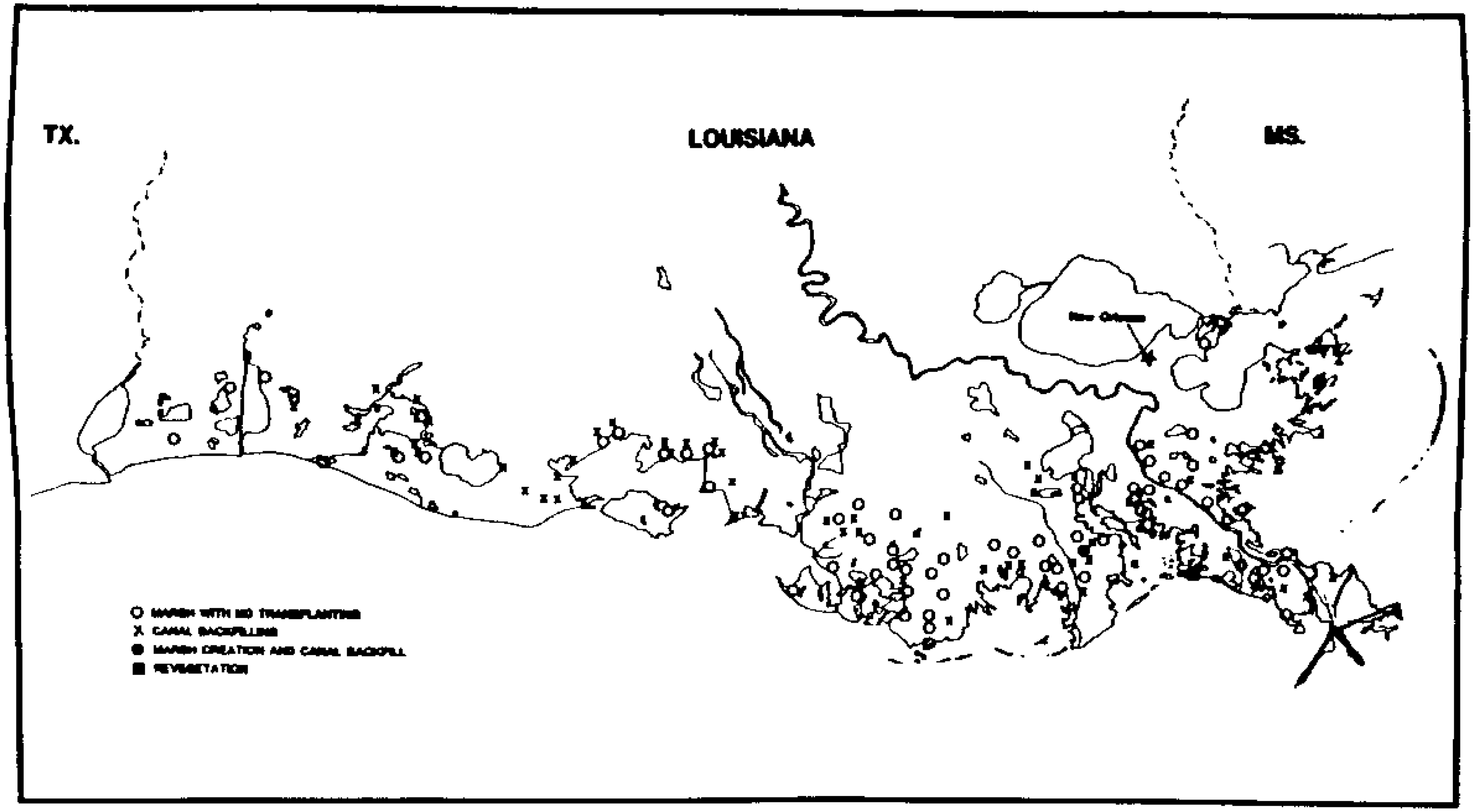


Figure 3. Distribution of recommendations on wetland mitigation made by the Galveston, Texas, field office of HCD from June 1981 to September 1984.

due to natural and man-induced subsidence are now shallow open water (Moore et al. 1985). It is anticipated that this procedure will help to replace subsiding marsh soils.

As can be seen in Figure 4, in Texas mitigation recommendations made by the Galveston area office pertain primarily to permit applications to alter salt marshes (1050 acres) and seagrass meadows (66 acres). Approximately 40 percent of the permit applications in which marsh mitigation was recommended called for transplantation of Spartina alterniflora (30) while the remaining applications generally requested removal of spoil or grading down of high ground to preproject levels and contours or both to allow for natural revegetation. Generally, in these cases, the grading sites are adjacent to natural marshes. The area office recommended the grading down of upland areas followed by the planting of Spartina for two federal projects--230 acres near Nueces Bay and 600 acres near Galveston Bay. As in North Carolina and Florida, seagrass restoration and generation projects are usually less than 0.5 acre (although there was a single 60-acre mitigation recommended for Laguna Madre). There has been an increased number of such projects in the past two years.

The Need for Follow-Up

Mitigation recommendations should be designed to compensate for unavoidable loss of resources because of man's activities after all realistic alternatives to avoid impacts have been evaluated (Ashe 1982). Wetlands and adjacent estuarine waters are integrally linked through biological, chemical, and physical processes, and provide critical habitat for fishery organisms during different life history stages. Thus, compliance to permit recommendations is of major importance to reduce the loss of habitat. Mitigation should not be used as an alternative in the planning process if it is used by applicants to justify the destruction of wetlands. This often occurs because the technology exists, and thus mitigation becomes a two-edged sword.

Numerous examples of both successes and failures have been documented (Teas 1980, Connell Associates, Inc. 1983, Phillips 1974, Getter et al. 1984, Shisler and Charette 1984, Fonseca et al. In press, Race 1985). Examples of both successes and failures of natural revegetation by wetland plants into down-graded and contoured upland or spill sites also exist (HCD, pers. comm.; authors, pers. obs.). The justification for considering marsh grass, seagrass, and mangrove mitigation through planting and transplantation is to enhance the productivity and refuge value of the degraded site sooner than would occur naturally. Many of the plant species are slow colonizers and may take an excessively long time to colonize and attain natural densities for the area. During the development period, which may take years, plant production and habitat refuge value are low. Often natural revegetation simply does not occur, and transplants often are not as successful as anticipated.

Mitigation procedures may be effective strategies to reduce the rate of wetland habitat loss, but available data on mitigated habitats (Cammen 1976 a,b, Kruczynski et al. 1978, Josselyn 1982) are not adequate to

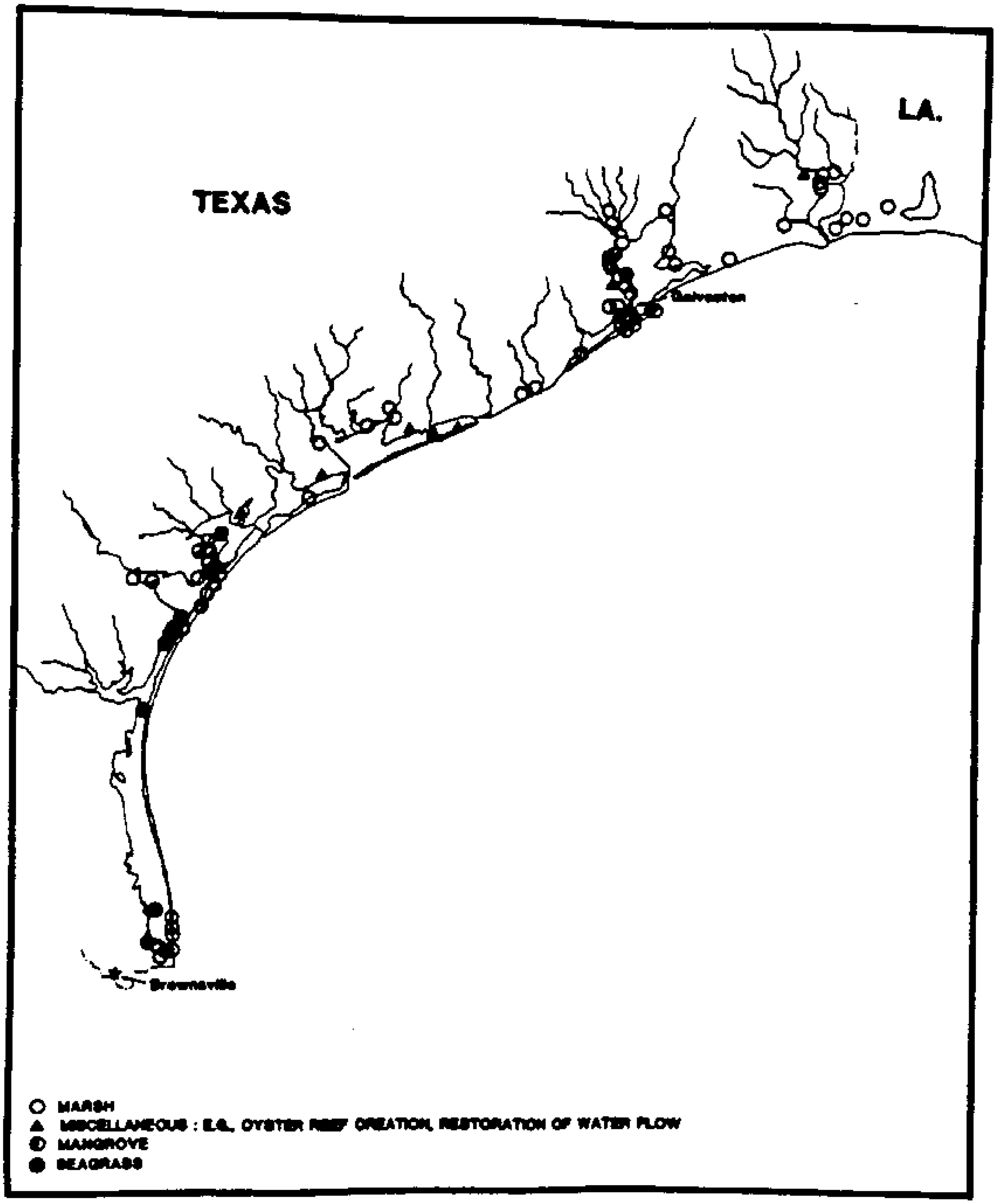


Figure 4. Distribution of recommendations on wetland mitigation made by the Galveston, Texas, field office of HCD from June 1981 to September 1984.

quantify the extent to which habitat mitigation compensates for loss of fishery habitat. HCD area offices do track permits to evaluate the final disposition by the Corps of Engineers. However, they track only a small subsample of what was actually altered and mitigated and cannot determine how successful the mitigation measures proved to be. Thus, the information provided in Figures 1-4 shows sites where recommendations for mitigations have been made. HCD area offices do not have the staff or funds to follow up on the majority of their mitigation recommendations. They must take the position that their recommendations are valid, that mitigation can help stem the loss of vital wetland, and that reestablished wetlands become fishery habitats based largely on assumptions and intuition drawn from ecological theories.

We are not alone in this predicament because other responsible federal and state agencies face identical problems. Small scale research efforts have been initiated by the Southeast Fisheries Center's Beaufort and Galveston laboratories to evaluate mitigation procedures and mitigated habitats, particularly as a function of food and refuge development. Similar efforts also are underway by state organizations and universities to evaluate aspects of mitigated habitats in Florida (D.W. Crewz, Department of Natural Resources, pers. comm.), New Jersey (Shisler and Charette 1984), California (Boyd 1982, Zedler et al. 1982, Race 1985), and Louisiana (Neill and Turner 1984).

Lessons Learned from Seagrass Mitigation

Because of the relatively high resistance to degradation in water quality by emergent marshes and mangroves, general ease of access to these areas, and their visibility there has been extensive development and subsequent testing of revegetation technologies for many marsh species on all coasts of the United States and for mangroves throughout their range. Some artificially created marsh and mangrove habitats are now over 80 years old, although most are younger. As noted earlier, revegetation efforts with marsh and mangroves have met with variable success. In contrast, research into the function of seagrass systems did not really begin until the late 1950s and only in earnest in the 1970s (Thayer et al. 1975, 1984, Zieman 1982). As a result, the technology for establishing these systems is only now emerging. Yet our ever increasing use and development of the coastal zone is resulting in a greater potential for loss of these critical nursery habitats (Thayer et al. 1975, Orth and Moore 1981). Consequently, we are observing a larger number of permit requests pertaining to seagrass meadows and a concomitant increase in recommendations by environmental agencies to mitigate the loss of seagrass.

Here are two examples of how mitigation management based on seagrass transplantation is evolving.

Example 1: In December 1983, the North Carolina Coastal Resources Commission (CRC) adopted a mitigation policy. This policy required that adverse impacts to coastal lands and waters be mitigated or reduced through proper planning, careful site selection, compliance with local standards for development, and creation or restoration of coastal resources. Shortly after promulgation of this policy, a project was submitted to the North Carolina Office of Coastal Management (OCM) that requested the removal of salt marsh and seagrass for construction of a marina. This project eventually was granted mitigation status by CRC, meaning that there was sufficient public benefit and water dependency to consider mitigation alternatives to compensate for the wetland loss.

By April 1984, the authors had been requested to participate as representatives of NMFS in a review of the seagrass mitigation plan and make recommendations not only on the plan but also on subsequent seagrass mitigation efforts. As part of this process, numerous meetings were held with state and federal agencies to aprise them of available data on seagrass restoration technology. These data were derived from a cooperative research program on the restoration of seagrasses between the National Marine Fisheries Service (Beaufort Laboratory) and the U.S. Army Corps of Engineers (Waterways Experiment Station, Environmental Laboratory).

At this point it became clear that though a policy had been adopted by CRC, no technical guidelines had been developed to implement the policy. In essence, CRC had stated that the concept of mitigation was acceptable, but no direction on specific and acceptable actions had been provided. The policy lacked specific directions concerning site selection criteria, acceptable resource trade-offs, performance and compliance standards, accepted methodology for monitoring, and reporting on the above. The lack of any such guidance on mitigation severely compromises the ability of state and federal agencies to enforce the Coastal Area Management Act, the Fisheries Conservation and Management Act, and the National Environmental Policy Act. This first mitigation proposal received by OCM had no guidelines by which to control the project. The agencies and the applicant then were forced to develop mitigation guidelines and a mitigation plan for the marina project at the same time.

The first problem that was encountered centered on the inadequacy of a resource inventory of the impact site. A cursory inspection by the applicant misidentified the seagrass species present (Halodule wrightii actually was present but Zostera marina was reported.). The spatial and temporal separation of these species in North Carolina strongly supports the argument that the meadows are not ecological equivalents. The restoration process for H. wrightii also is different than that for Z. marina. This point of ecological equivalency was contested by the applicant and, in one sense, rightfully so. Data simply do not exist on ecological equivalency among species of seagrasses.

The resource agencies, however, had to make a decision based on best available information and ecological principle. The fact that two seagrasses are separate species--with each one having distinct environmental requirements for growth (different seasons), different life histories, and different depth ranges and morphologies--supported the contention that unique ecological functions may be supported by each species in the estuarine system. The decision on the agencies' parts to promulgate this more conservative view was a statement that we must make ecological decisions based on ecological data, and lacking of those data, any action that may compromise the integrity of habitat function must be denied. Such an approach is totally consistent with the North Carolina mitigation policy that emphasizes ecosystem protection and enhancement (Clark 1984) and is emphasized by other work (Ashe 1982).

Another aspect of the ecosystem function concept arose when off-site mitigation was proposed for this project. The initial proposal called for on-site mitigation using an adjacent area at that time devoid of seagrasses. This site was rejected by the resource agencies after a time series of aerial photographs demonstrated a perpetual lack of seagrass cover. The applicant had claimed that the site was barren as a result of previous dredging of a channel, which was consistent with agency requirements of selecting a disturbed site for restoration. Since aerial photographs revealed that cover was absent prior to the channel dredging, it was concluded that the site was naturally and chronically without seagrass cover and any planting would run a high risk of failure. At best the plantings at the proposed site would be a temporary pulse in system productivity since they would likely fail, providing inadequate compensation for the impact site meadows that had persisted through many years (for parallel discussion on site selection, see Fonseca et al. In press).

Once species, acceptable sites, and transplanting procedures were verified and approved, it was quickly realized that there were no provisions for monitoring the site to ascertain performance and compliance with mitigation standards. In fact, there were no standards. Fortunately, there was research on seagrass restoration (Fonseca et al. 1982) in the area so that guidelines could be developed based on testable data.

Example 2: Examples of the use of research data on seagrass restoration to mitigate construction-related damage exist. One is the restoration of seagrass meadows (65.8 acres) that were damaged or destroyed during the construction of replacement bridges through the Florida Keys (Mangrove Systems, Inc. 1985). Regulatory agencies were provided with a thorough discussion of the value of the affected seagrass meadows. As a consequence, steps were taken to accurately determine the extent of damage and the technology available to restore these areas.

The project followed the four interrelated aspects that have been shown to be critical to the success of a mitigation effort: (1) site resource inventory; (2) transplanting technology; (3) site selection; and (4) monitoring and performance evaluation.

The site and resource inventory, which employed ground-truth methods to verify aerial photography, allowed the categorization of impact areas and non-restorable areas altered so as to no longer support seagrass. This categorization of restorable and non-restorable habitat was made based on environmental criteria important to the growth and development of the seagrasses used, particularly the criteria of sufficient sediment depth. Mitigation plans based on environmental requirements of the target species such as this one are rare and should be encouraged. Two areas of 30.5 and 35.3 acres were determined to be nonrestorable and restorable, respectively. The inventory also identified additional disturbed areas as planting sites that were unrelated to bridge construction but were available for seagrass mitigation. The availability of these sites (17.0 acres) may have gone unnoticed had the inventory effort not been made. As a consequence, the restoration ratio reached 0.8:1 as opposed to the 0.54:1 that would have occurred had these areas not been identified.

Transplanting technology and site selection were related to the site inventory. Observations made during the inventory suggested the need for suitable anchoring devices for appropriate species. Available technology was employed to meet these criteria (Fonseca et al. 1982, Derrenbacker and Lewis 1982). Selection of sites started with all available on-site (affected by construction) plantable areas. After these areas were eliminated as choices, other disturbed areas in the immediate vicinity were considered.

In this mitigation, site selection was made much easier since even the unrelated impact sites had either previously supported seagrass, or were contiguous with existing meadows. More important, each site had a definable source of impact that had since been alleviated.

An important aspect was the establishment of a comprehensive monitoring of the seagrass growth in both planted and control (unplanted) areas. Data were collected not only on survival of transplant units, but also on their rate of coverage. The use of a coverage criteria rather than other non-repeatable methods (e.g., leaf length) allowed verification of performance over time that was mutually beneficial to the contractor as well as to the agency determining compliance. The contractor was able to accurately estimate performance and, thus, efficiently plan for replanting or selecting alternative sites where needed. The monitoring agency was able to have a quantifiable (and more importantly, verifiable) means of determining compliance. By the end of August 1984, 47.54 acres of seagrass had been planted with almost 73 percent at acceptable coverage levels. This overall success and coverage is, in large measure, the result of proper site evaluation and application of techniques appropriate both for the sites and the plants used.

Finally, the cohesive nature of these four actions (site survey, site selection, appropriate technology, and monitoring program) has provided an information set that has proved repeatable in other areas. The ability to apply this information elsewhere in other unrelated projects has enhanced the original value of the project significantly by adding to guidelines for planting on a wider geographical basis.

In both these examples, trading a natural system for a human-propagated system has been accepted as a means of mitigating wetland loss. The first example utilized the "up-front" approach in that an equivalent meadow needed to be created on a human impact site before destruction of the natural meadow would be permitted. But the policy was implemented before guidelines could be developed, and it is our opinion that only the fortuitous existence of local data bases used to develop these guidelines prevented the initiation of a series of irrevocable wetland habitat losses. In the second example, a clear public interest requirement delegated wetland restoration to an after the fact activity. In this case, however, resource inventories, site selection, species selection, transplanting technology, and monitoring and performance evaluation were clearly identified prior to the execution of the project. The difference between the two approaches points out the need to consider fully those elements in order to adequately control the mitigation process. Finally, it must be emphasized that only incorporation of basic ecological data on wetland systems during decision processes can promote their effective restoration.

Acknowledgments

We express our thanks to HCD area office personnel who spent many hours gathering the mitigation data and generating the map information used: Beaufort--Larry Hardy and Ronald Sechler; Panama City--Edwin Keppner; Galveston--Donald Moore, Peggy Keney, and Rick Ruebsmen. Andy Mager in the Southeast Regional Office also made significant contributions to both the data and discussion.

References

Ashe, D.M. 1982. Fish and wildlife mitigation: description and analysis of estuarine applications. Coastal Zone Manage. J. 10:1-52.

Boesch, D.F. and R.E. Turner. 1984. Dependence of fishery species on salt marshes: the role of food and refuge. Estuaries 7:460-468.

Boyd, M.J. 1982. Salt marsh faunas: colonization and monitoring. pp. 75-79 in M. Josselyn (ed.). wetland restoration and enhancement in California. California Sea Grant College Program, Rep. No. T-CSGCP-007.

Cammen, L.M. 1976a. Abundance and production of macroinvertebrates from natural and artificially established salt marshes in North Carolina. Am. Midl. Nat. 76:487-493.

Cammen, L.M. 1976b. Macroinvertebrate colonization of Spartina marshes artificially established on dredge spoil. Estuarine Coastal Mar. Sci. 4:357-373.

Clark, W. 1984. North Carolina's mitigation policy: a new challenge. Natl. Wetlands Newsletter, Nov.-Dec. 1984: 13-16.

Connell Associates. 1983. Port of Miami seagrass monitoring project, Task 8, Final Report, Phase 1, Survival. Connell Associates, Coral Gables, Fla. 41 p.

Derrenbacker, J.A. and R.R. Lewis. 1982. Seagrass habitat restoration, Lake Surprise, Florida Keys. pp. 132-154 in R.H. Stoval (ed.), Proceedings of the 9th Annual Conference on Wetlands Restoration and Creation. Hillsborough Community College, Tampa, Fla.

Federal Register. 1983. Habitat conservation: policy for National Marine Fisheries Service (NMFS). Federal Register 48(228):53142-53147

Fonseca, M.S., W.J. Kenworthy, H. Homziak, and G.W. Thayer. 1979. Transplanting of eelgrass and shoalgrass as a potential means of economically mitigating a recent loss of habitat. pp. 279-326 in D.P. Cole (ed.), Proceedings of the 6th Annual Conference on Restoration and Creation of Wetlands. Hillsborough Community College, Tampa, Fla.

Fonseca, M.S., W.J. Kenworthy, and G.W. Thayer. 1982. A low-cost planting technique for eelgrass (Zostera marina L.). U.S. Army Corps of Engineers Coastal Engineering Research Center, Fort Belvoir, Va. Coastal Engineering Technical Aid No. 82-6. 15 p.

Fonseca, M.S., W.J. Kenworthy, G.W. Thayer, D.Y. Heller, and K.M. Cheap. 1985. Transplanting of the seagrass Zostera marina and Halodule wrightii for sediment stabilization and habitat development on the East Coast of the United States. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report EL-85-9. 14 p.

Fonseca, M.S., W.J. Kenworthy, and G.W. Thayer. In press. The use of ecological data in the implementation and management of seagrass restorations. Proceedings of the 36th Annual Conference of the American Institute of Biological Science. University of Florida, Gainesville.

Fredette, T.J., M.S. Fonseca, W.J. Kenworthy, and G.W. Thayer. In press. Seagrass transplanting: Ten years of U.S. Army Corps research. Proceedings of the 12th Annual Conference on Wetlands. Hillsborough Community College, Tampa, Fla.

Getter, C.D., G. Cintron, B. Dicks, R.R. Lewis, III, and E.D. Seneca. 1984. The recovery and restoration of salt marshes and mangroves following an oil spill. pp. 65-113 in J. Cairns, Jr. and A. Buikema, Jr. (eds.). Restoration of habitats impacted by oil spills. Butterworth, Boston, Mass.

Goforth, H.W. and J.R. Thomas. 1979. Planting of red mangroves (Rhizophora mangle L.) for stabilization of marl shorelines in the Florida Keys. pp. 297-230 in D.P. Cole (ed.), Proceedings of the 6th Annual Conference on Restoration and Creation of Wetlands. Hillsborough Community College, Tampa, Fla.

Josselyn, M. 1982. Wetland restoration and enhancement in California. California Sea Grnat Program, Rep. No. T-CSGCP-007. 110 p.

Kruczynski, W.L., R.L. Huffman, and M.K. Vincent. 1978. Habitat development field investigations. Apalachicola Bay Marsh Development Site, Apalachicola Bay, Florida. Summary report. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Miss. Technical Report DMRP D-78-32. 39 p.

Lewis, R.R. and C.S. Lewis. 1977. Tidal marsh creation on dredged material in Tampa Bay, Florida. pp. 45-67 in R.R. Lewis and D.P. Cole (eds.), Proceedings of the 4th Annual Conference on Restoration of Coastal Vegetation in Florida. Hillsborough Community College, Tampa, Fla.

Lewis, R.R. 1981. Economics and feasibility of mangrove restoration. pp. 88-94 in P.S. Markovits (ed.), Proceedings of the Workshop on Coastal Ecosystems of the Southeastern United States. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80-59.

Lindall, W.N., A. Mager, G.W. Thayer, and D.R. Ekberg. 1979. Estuarine habitat mitigation planning in the southeast. pp. 129-135 in G.A. Swanson (tech. coord.). The Mitigation Symposium. U.S. For. Serv. Rocky Mtn. For. Range Exp. Stn. Gen. Tech. Rep. RM-65.

Lindall, W.N., Jr. and G.W. Thayer. 1982. Quantification of National Marine Fisheries Service habitat conservation efforts in the southeast region of the United States. Mar. Fish. Rev. 44:18-22.

Mangrove Systems, Inc. 1985. Combined final report, Florida Keys restoration project. Florida Department of Environmental Regulation, Tallahassee. 73 p.

Mason, H.L. 1980. Techniques for creating salt marshes along the California coast. pp. 23-24 in J.C. Lewis and E.W. Bunce (eds.), Rehabilitation and creation of selected coastal habitats. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80/27.

Moore, D., P. Keney, R. Ruebsamen, and J. Lyon. In press. National Marine Fisheries Service activities to reduce adverse dredging impacts in Louisiana coastal marshes. In C.F. Bryan, P.J. Zwank, and R.H. Chabreck (eds.), Proceedings of the 4th Coastal Marsh and Estuary Management Symposium. Louisiana State University, Baton Rouge.

National Marine Fisheries Service. 1983. Statistics on the importance of NMFS' Habitat Protection Program's involvement in the Corps of Engineers' Section 404 Regulatory Program under the Clean Water Act and habitats of importance to living marine resources. National Oceanic and Atmospheric Administration, Washington, D.C. 9 p.

National Ocean Service. 1985. Draft report on availability and status of coastal wetlands alteration data. Strategic Assessment Branch, Ocean Assessment Division, National Oceanic and Atmospheric Administration, Rockville, Md. 12 p.

Neill, C. and R.E. Turner. 1984. An evaluation of backfilling canals as a means of mitigating the environmental impact of canals in south Louisiana: atlas of backfilled canals. Interim report (Phase III) to the Coastal Management Division of the Department of Natural Resources, Baton Rouge, La. 180 p.

Nixon, S.W. 1980. Between coastal marshes and coastal waters, a review of twenty years of speculation and research on the role of saltmarshes in estuarine productivity and water chemistry. pp. 437-525 in P. Hamilton and K.B. MacDonald (eds.), Estuarine and wetland processes. Plenum, New York.

Orth, R.J. and K.A. Moore. 1981. Submerged aquatic vegetation of the Chesapeake Bay: past, present and future. Trans. N. Am. Wildl. Nat. Resour. Conf. 46:271-283.

Peters, D.S., D.W. Ahrenholz, and T.R. Rice. 1979. Harvest and value of wetland associated fish and shellfish. pp. 606-617 in P.E. Greeson, J.R. Clark, and J.E. Clark (eds.), Wetlands functions and values: the state of our understanding. American Water Resources Association, Minneapolis, Minn.

Phillips, R.C. 1974. Transplantation of seagrasses with special emphasis on eelgrass, Zostera marina L. Aquaculture 4:161-176.

Phillips, R.C. 1980. Planting guidelines for seagrasses. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va. Coastal Engineering Technical Aid No. 80-2. 28 p.

Race, M.S. 1985. A critique of present wetlands mitigation policies based on an analysis of past restoration projects in San Francisco Bay, Calif. (U.S.A.). Environ. Manage. 9:71-82.

Race, M.S. and D.R. Christie. 1982. Coastal zone development: mitigation, marsh creation, and decision-making. Environ. Manage. 6:317-328.

Reimold, R.J. 1980. Creation of a southeastern United States salt marsh on dredged material. pp. 6-22 in J.C. Lewis and E.W. Bunce (eds.), Rehabilitation and creation of selected coastal habitats, proceedings of a workshop. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80-27.

Seneca, E.D. 1980. Techniques for creating salt marshes along the east coast. pp. 1-5 in J.C. Lewis and E.W. Bunce (ed.). Rehabilitation and creation of selected coastal habitats, proceedings of a Workshop. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80-27.

Shisler, J.K. and D.J. Charette. 1984. Evaluation of artificial salt marshes in New Jersey. N.J. Agric. Exp. Stn., Publ. No. P-40502-01-84. 159 p.

Teas, H.J. 1977. Ecology and restoration of mangrove shorelines in Florida. Environ. Conserv. 4:51-58.

Teas, H.J. 1980. Mangrove swamp creation. pp. 63-90 in J.C. Lewis and E.W. Bunce (eds.), rehabilitation and creation of selected coastal habitats, proceedings of a workshop. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80-27.

Ternyik, W.E. 1980. Salt marsh creation in the Pacific northwest: Criteria, planting techniques and costs. pp. 25-34 in J.C. Lewis and E.W. Bunce (eds.). Rehabilitation and Creation of Selected Coastal Habitats, Proceedings of a Workshop. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80-27.

Thayer, G.W., D.A. Wolfe, and R.B. Williams. The impact of man on seagrass systems. Am. Sci. 63:288-296.

Thayer, G.W., H.H. Stuart, W.J. Kenworthy, J.F. Ustach, and A.B. Hall. 1979. Habitat values of salt marshes, mangroves, and seagrasses for aquatic organisms. pp. 235-247 in P.E. Greeson, J.R. Clark, and J.E. Clark (eds.), Wetland functions and values: the state of our understanding. American Water Resources Association, Minneapolis, Minn.

Thayer, G.W. and J.F. Usatch. 1981. Gulf of Mexico wetlands: Value, state of knowledge and research needs. pp. 1-30 in D.K. Atwood (convener). Proceedings of a symposium on environmental research needs in the Gulf of Mexico (GOMEX), Vol. 2B. Atlantic Oceanographic and Meteorological Laboratories, Miami, Fla.

Thayer, G.W., W.J. Kenworthy, and M.S. Fonseca. 1984. The ecology of seagrass meadows of the Atlantic coast: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-84-02. 147 p.

Thayer, G.W., M.S. Fonseca, and W.J. Kenworthy. 1985. Restoration of seagrass meadows for enhancement of nearshore productivity. pp. 259-278 in International Symposium on the Utilization of the Coastal Zone. Planning, Pollution, and Productivity, Rio Grande, Brazil, 1982.

Thorhaug, A. 1974. Transplantation of the seagrass *Thalassia testudinum* Konig. Aquaculture 4:177-183.

Thorhaug, A. 1980. Techniques for creating seagrass meadows in damaged areas along the east coast of the U.S.A. pp. 105-116 in J.C. Lewis and E.W. Bunce (eds.), Rehabilitation and creation of selected coastal habitats: proceedings of a workshop. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-80-27.

Tiner, R.W., Jr. 1984. Wetlands of the United States: current status and recent trends. U.S. Fish and Wildlife Service, Washington, D.C., 59 p.

Zedler, J., M. Josselyn, and C. Onuf. 1982. Restoration techniques, research, and monitoring: vegetation. pp. 63-72 in M. Josselyn (ed.), Wetland restoration and enhancement in California. California Sea Grant College Program, Rep. No. T-CSGCP-007.

Zieman, J.C. 1982. The ecology of the seagrasses of South Florida: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-82-25. 124, 26 p.

WOOING THE PRESS, WINNING THE PUBLIC, AND WIELDING INFLUENCE: KEYS TO CITIZEN INVOLVEMENT

Linda Weimer
University of Wisconsin, Madison

It is fashionable these days to portray the average American as self-absorbed, materialistic, cynical, and unwilling to get involved.

At the University of Wisconsin-Madison, I hear our students characterized as preoccupied with getting good grades; uninterested in causes outside the classroom; and bent on getting jobs that pay $40,000 a year and enable them to dress for success.

But the fact is, we have over 300 organizations to which our students volunteer time and energy. Thousands of them are active in the community tutoring fellow students, being companions to elderly people in Madison, working with learning-disabled children, and contributing in countless other ways.

The difference between reality and the perception of reality is not too great when one looks at our society as a whole.

Virtually all of us have a good deal of leisure time--far more than people of past generations. Survey researchers have shown that, aside from work, sleep, and time spent on personal and family activities, people have about 38 hours of free time each week. That accounts for about 23 percent of their time. Leisure time, combined with the general affluence of our society and the number of causes to which one can devote time or money, has made this the age of citizen involvement, belying the stereotype of the isolated, self-absorbed citizen. In fact, the challenge for many citizen groups is to compete with other volunteer and charitable organizations that are vying for public attention.

To illustrate the point, let's look at an imaginary neighborhood in Everytown, USA, where you might live. Right on your own street, you have a Mother Against Drunk Driving, a Daughter of the American Revolution, a Big Brother, and a Citizen for Better Environment.

Your next-door neighbor is working feverishly to reelect your least favorite state senator (you try not to talk politics over the back fence), and his wife is busy setting up candidate forums for the League of Women Voters. Across the street lives the chairman of the board of your local public television station and her husband who is active in Rotary Club and the local Red Cross chapter.

You, too, are an active volunteer--a founding board member of an organization some wag has dubbed the Committee on Wetlands Preservation in Everytown, or COWPIE for short. Wetlands have been vanishing at an alarming rate around Everytown for the past 25 years, but a proposal to reroute a state highway through the last and largest wetland area in the township has galvanized you and your colleagues to become active and form this new organization.

You and your board face many challenges. Apart from finding a name for your group that carries a slightly classier acronym, you need to make the citizens of Everytown aware of your cause and gain public support. Beyond that, you want to solicit members, contributions, and volunteers. Finally, you hope to influence the decision makers whose judgments will affect the wetlands in question and others in the township.

But how does one go about making the public aware of an issue or an organization? For that matter, how do people get their information? How can the organization engage media interest, and what influence will that have on people's attitudes and the decision-making process?

It has been said that the press is the lifeblood of every environmental battle. Unless citizen activists can obtain fair, accurate, frequent, and in-depth media coverage on an issue, nine times out of ten the battle will be lost.

The mass media clearly plays a most important role in raising public consciousness about a given issue although media coverage is less influential when it comes to persuading an individual to form an opinion about that issue or to change his or her behavior.

However, the first step toward public involvement is awareness, and the most efficient means of raising public awareness is to rely on the mass media--namely, newspapers, television, radio and, to a lesser extent, magazines and other periodicals.

Is any one of these more effective than the others? The answer depends on what one is hoping to achieve. If it is merely to reach the greatest number of people, television might be best; if it is to obtain in-depth reporting on a subject, newspapers and magazines have more to offer. All are important.

Leo Jeffres, in his book Mass Media: Processes & Effects, soon to be published by Waveland Press, looks at how much of our leisure time we Americans spend paying attention to the media versus engaging in other activities. Although the level and form of our media consumption varies depending on our age, he notes that we spend about 47 percent of our free time on media consumption. Incidentally, we spend another 10 percent on organizational activities -- another indication of citizen involvement.

Not surprisingly, more leisure time is devoted to television viewing than to all other forms of media combined. The average American spends two to three hours a day in front of the TV set, and much of that time is spent watching entertainment programming. On an average weekday, five-sixths of the adult population in this country watches TV.

In looking at how to use the media effectively, our primary focus is on programs that have news and editorial content, although environmental themes lately have found their way into films and prime time TV shows. But news has become such a profit center for commercial television stations now that almost three-quarters of those watching television see one or more news programs.

Local news shows are far more popular than national news shows. Jeffres cites one survey in which almost half the daily television news viewers polled watched only local newscasts. People aged 35 and up tend to watch more TV news than those in younger age groups, with TV news consumption increasing as age advances. TV documentaries on PBS and shows such as "60 minutes" are heavily watched and have proved good ways of raising the public's environmental awareness.

Radio is also an important vehicle for news delivery. Ninety-five percent of the public listen to the radio at some point during the day; 49 percent of adults hear a radio newscast daily. The highest listenership occurs during "drive time," when people are tuned to their radios while going to and from work.

Clearly both TV and radio play an important role in informing the public, but there are drawbacks to relying on them to convey substantive information. Apart from the TV documentary or radio talk show, any message to be presented, be it a news item or a public service announcement, must be kept short (to have 45 seconds is a luxury). And in the case of television the subject must be visual.

Such constraints don't come into play so much when it comes to newspapers. With the growth of radio and television, and more recently the growth of new technologies like cable TV and home computer information networks, there have been dire predictions of the demise of the newspaper. There has been some decline in newspaper readership, but newspapers prevail as the nation's largest medium of communication in terms of news and editorial content, employment, advertising, and sales revenue.

Jeffres reports that 68 to 80 percent of American adults read a newspaper on an average day. As in television news viewing, readership rises as one advances up the age scale. Almost all readers page through the full newspaper but they actually read about one-fifth of it. Unlike broadcast messages, information found on the pages of a newspaper is not ephemeral. It can be clipped and saved and shared with friends and family, and that kind of sharing is very influential in opinion formation.

There is also evidence that in communities where there is a weekly newspaper but no local daily paper the weekly community newspaper is considered the more important and credible source of information. A friend of mine is fond of saying that people read the dailies but they memorize the weeklies.

Magazines and periodicals--like newsletters--are also important communication vehicles although the average American does not spend as much time on these as on other information sources. But Jeffres reports the greatest reading of magazines occurs among an important group from an environmentalist's standpoint: college-educated professionals, age 18 to 44, with household incomes of $30,000 or more. These publications are usually less timely in their reporting of events and less likely to focus on issues of very specific interest, but they do allow for reporting in much greater depth.

Looking at these various mass media options, how can we then use them to our advantage in Everytown's wetlands preservation campaign?

Since these papers are designed to help implement estuarine management strategies, it may be productive to spend some time on practical advice in dealing with the press.

If I were on the COWPIE board, I would begin by searching for a local Mina Hamilton Haefele to help us out. Haefele is a former Associated Press (AP) and Newsweek reporter who became active in environmental causes in the mid-1970s. I am no doubt biased, but I think the first step for any environmental organization or program is to find a good communicator.

Writing in the Friends of the Earth tabloid, Not Man Apart, Haefele once gave some classic advice on how to deal with the media in an article entitled, "How to Fascinate the Press."

Her advice, by the way, is as relevant to a large, long-standing institution like the University of Wisconsin-Madison as it is to a brand new citizen environmental group. Borrowing from her article and based on my own experience in environmental communication and media relations, here are some suggestions for dealing with the press.

The bread and butter of a public information campaign is the press release. Above all it should be substantive; there must be something of public interest to say. Apart from that, packaging is quite important. The release should be engaging but straightforward, neatly typed, free of grammatical and typographical errors, and accurate to a fault. That press release, in a reporter's or television news director's hand, is the embodiment of your organization, and that sheet of paper should reflect well on you.

As Haefele writes, "Any environmental organization that sends out smudgy, mimeographed statements flawed by typos and sentence insertions deserves what it gets -- oblivion."

Sometimes it may be hard for a small, newly formed group to develop credibility with, and get press releases picked up by, the media.

Haefele suggests one consider joining forces, temporarily, with an established organization that is already known. If it is one whose aims and philosophy are generally consistent with those of your own organization, this might be a good way to build press contacts and public awareness.

The content of anything issued by a citizen involvement group, whether it be a press release, brochure, statement, or public service announcement, should not only be substantive but scrupulously accurate. The three most important rules of journalism are accuracy, accuracy, and accuracy.

Never make statements that cannot be substantiated, never make comments off the record (to a reporter, nothing is off the record), never personally attack those who oppose your cause, and don't be tempted into making a statement that is a half-truth. To the press, a half-truth is as good as a whole lie.

Be sure to target your mass media message to the general public. Don't get too technical or complex, but don't talk down to your audience either. Explain things to a reporter as you would explain them to a friend who works in a different field. Hard statistics and examples that illustrate your points are valuable communication tools.

Try to cultivate personal relationships with the reporters who are covering the issues with which your organization is involved. Take the time to introduce yourself at hearings, community meetings, or press conferences and be available to that reporter when he or she calls. Always return calls to members of the press as soon as you can, even if you think you will face some tough questions. One option if you know what the call is about is to jot down some notes and have them in front of you when you return a call.

Be mindful of press deadlines. Morning papers have late night deadlines; afternoon papers have a final deadline of about noon. TV stations need time to prepare for the six o'clock news, and if you want a story to escape media attention, call a press conference for late Friday afternoon.

Remember that reporters and editors are human and that they sometimes err in reporting the news. If that happens, don't call the editor or news director to complain loudly about the poor coverage; write an unemotional letter, setting the record straight. As politicians say, never pick a fight with someone who buys ink by the barrel.

By the same token, if a newspaper editor or respected reporter believes in the goals of your organization, you might garner more press attention than your organization might otherwise merit. Editors are influential members of the community, and reporters often write editorials on the subjects they cover.

Try to be different and creative in getting your message across to the media and the public. Sponsor interesting events: tours of the wetlands, canoe trips, a benefit craft fair. These might be more appealing to reporters and the public than would a press conference, a scientific symposium, or a technical report. Journalists deal constantly in words. Charts, maps, photographs, and unusual events provide a refreshing change of pace.

Use the press conference judiciously. Call one only if you have real news to report and do so at a time that is compatible with press deadlines. Have one person, or at most two people, speak for the organization. He or she should be articulate, poised, and knowledgeable about the subject. That person represents your organization and will help shape its image before thousands of TV viewers and radio listeners. Once you have such a spokesperson, be alert for opportunities to put him or her before the public through radio and television talk shows, community meetings, or public hearings.

If a controversial situation comes along, be aggressive. Seize the high ground; don't be put on the defensive by your opponents. If necessary, raise their arguments yourself first, and then do your best to answer them.

As discouraging as it can sometimes be, the press thrives on controversy. It is the lifeblood of the profession, and to an editor's mind it is what sells papers and gets people to tune into the six o'clock news.

Because of the shallowness of coverage on most issues, which is probably related to time and space constraints and the short attention span of many reporters, the media often present the situation of the black hats versus the white hats. Good fights evil, even though our own life experiences tell us that things are never that simple.

Knowing this tendency, one can try not to become the black hat in a controversy even if all one can do is point out the shades of grey. Members of the public and the press need not necessarily support a position, but it can be very damaging if they actively oppose it and disheartening if they oppose it not knowing the facts.

Don't expect instant results. It may take months or years to build your relationships and credibility with the press. By being patient and creative and employing a variety of media strategies, an organization will eventually find its way into the public consciousness and win supporters.

Finally, the key element in any communication program--know your audience and develop strategies to appeal to them. Identifying people who are likely to seek out more information on your organization and perhaps contribute support or volunteer their time is not an easy task, but it is a crucial one.

If you win over the press, and the public becomes generally aware of your group and its goals, you will have won a battle but not the war. The public may become accustomed to your face, so to speak, but that's no guarantee that they will like you or support you.

To achieve the goal of wetlands preservation, for example, people must be motivated to enlist in the cause, especially people who may be influential in the decision-making process. Though others will probably address this issue, I'd like to close with a few observations based on research that has been done on environmental communication and how it affects attitudes and behavior.

Many studies have shown that environmental concern is most prevalent among people who are white, middle-class, college-educated, liberal in their political views, young, cosmopolitan, and appreciative of aesthetic and rural values. These are the people who, having been exposed to an issue, are most likely to seek out more information and, perhaps, become involved.

Studies also show that serious environmentalists do not rely solely on the mass media for environmental information. Booklets, magazines, newsletters, and seminars may be more effective communication tools. Again, the information transferred should be clear and accurate.

Apart from those already predisposed to become involved in environmental causes, another group can be tapped for citizen involvement--those with some special interest in the cause. In the case of Everytown's wetlands preservation effort, several groups can be identified: duck hunters, bird watchers, native plant gardeners, local teachers who use the wetlands as an educational tool, people who own property around wetlands and want to keep it from being developed, and homeowners who would be adversely affected by the construction of the proposed highway. All have some self interest in supporting the group; special mailings, seminars, personal visits, or meeting presentations are good ways to communicate with them.

University of Maryland researcher James Grunig recently completed a study showing that the general environmental public and these special interest publics, as he calls them, are composed of high-involvement, information-seeking people. He likens them to parishioners who are already in church on Sunday morning.

He has found that these people generally believe that change is possible, and they desire action-oriented information to help them achieve that change. When one encounters general public indifference to an issue, Grunig says it's usually because individuals feel a lack of power to make changes, whether it be saving the whales, protecting the oceans from pollution, or preserving a wetland area.

But the record of achievement on these issues over the past ten years suggests that citizen involvement is important, that change can be effected, and that public opinion does have a strong influence over how resource decisions are made. Persuading members of the press to publicize and support a cause like wetlands preservation is no panacea for shaping public opinion, but in Everytown, your town, and my town, the environmental battles cannot be won without them.

References

Grunig, J. 1983. Communication behaviors and attitudes of environmental publics: two studies. Journalism Monographs 81:1-47.

Jeffres, L. In press. Mass media: processes & effects. Waveland Press, Prospect Heights, Illinois.

Haefele, M. H. 1978. How to fascinate the press. Not Man Apart. Friends of the Earth, Washington.

Udell, J. 1985. Trends and the competitive outlook for U.S. newspapers. Paper delivered at fall conference. Wisconsin Newspaper Association, Madison, Wisconsin.

PROTECTING THE NATION'S ESTUARINE RESOURCES: THE ROLE OF CITIZEN ACTION

James T.B. Tripp,
Environmental Defense Fund
New York, New York

The United States has a large number of productive estuaries--complex mazes of barrier islands, coastal waters and wetlands, beaches and coastal rivers, and floodplains. Despite a number of federal and state statutory and regulatory programs, these resources continue to be under assault. A local citizen group that is able to focus on the issues of a specific estuary and take effective advantage of the expertise of national environmental organizations, academic scientists, and state and national resource agencies is critical for protection of that estuary.

The largest estuaries have attracted vast and growing urban populations and major port facilities--New York and northern New Jersey, Baltimore and Norfolk, Tampa, New Orleans, Galveston and Houston, and San Francisco. Along much of the Atlantic and Pacific coasts, citizen groups with particular interests in specific estuaries are reasonably effective. Similar citizen efforts must be strengthened in estuarine areas, such as coastal Louisiana and other Gulf coastal estuaries.

Types of Assaults on our Estuaries

What is the role of citizen action in estuarine protection? What can a citizen group do particularly well? For any particular estuary, a wide spectrum of stresses degrades it, and a large number of federal and state laws and regulations control it. However, no one government agency--federal, state or local--is in a position to look at the entire estuarine system. The range of influences on estuaries--such as the Hudson River estuary, Chesapeake Bay, coastal Louisiana, Galveston and Corpus Christi Bays in Texas, and the San Francisco Bay and delta system in northern California--shows how vital it is to have local citizen groups that are equipped to work on estuarine-wide issues.

In the upper Hudson River estuary, electric utility pumpback storage, coal conversion proposals, and water supply projects--including Hudson River floodskimming, which the Corps of Engineers (COE) has proposed as part of the Northeast Water Supply Study--have been major concerns. In the lower estuary, including the upper and lower harbors and the New York Bight, major past and future problems include dumping of contaminated dredged materials, sewage and sludge, indirect discharges of improperly pretreated toxic industrial wastes through municipal sewage treatment plants, and filling of coastal waters and wetlands in the Hudson River for the Westway project. In the Hackensack meadowlands these stresses include residential and commercial development, New Jersey Turnpike expansion and expansion of the Sports Complex in estuarine wetlands.

In the Chesapeake Bay estuary, the U.S. Environmental Protection Agency (EPA) has documented a variety of residential, commercial, and agricultural sources of nutrients and toxic chemicals that have contributed to loss of seagrass beds and other plants. In addition Soil Conservation Service (SCS) projects and private agricultural and commercial developers have destroyed wetlands. Acid sulfur deposition, furthermore, may be contributing to perturbation of tributaries of the Chesapeake and affecting anadromous fish reproduction. In the lower part of the bay, in the tidewater Virginia watershed, several municipalities are proposing construction of water supply dams on tributaries of the York and James Rivers. Such dams will affect the flow of fresh water to oyster nurseries and other bay resources and destroy wetland resources.

Along the Gulf coast, the Mobile estuary faces enormous stresses, including loss of shallow bay bottoms and tributary riverine bottomland hardwood wetlands, in the face of Corps of Engineers navigation projects. In coastal Louisiana, the most tormented estuarine resource in the country, the pressures are massive. They include construction of canals and other works and discharges of dredged materials associated with navigation, oil and gas and flood protection projects, loss of wetlands because of agricultural conversion in floodplains of the Mississippi, Atchafalaya, and Red Rivers, and residential development in coastal wetlands. These stresses also take the form of substantial loads of toxic metals and organic chemicals from industrial, agricultural, and urban sources that enter the coastal wetlands and littoral waters and inevitably affect fish, shellfish, and wildlife resources, and, in turn, human health.

In Galveston Bay, the port authority of Galveston continues to consider construction of a deep channel for use by super oil tankers. The Corps of Engineers, the Bureau of Reclamation, and Texas municipalities are considering expansion of the Houston Ship Channel and main ship channel to Texas City, the Bayport ship channel in the western part of the bay, and water supply projects on tributary rivers, such as the Wallisville Dam on the Trinity. Major development proposals have been made for western Galveston Island, which would destroy hundreds of acres of estuarine marsh and impose further stress on Galveston Bay. In Corpus Christi Bay, the Galveston District is considering a Clean Water Act Section 404 permit application for a nine-acre bay fill for commercial development.

Finally, on the Pacific Coast, the San Francisco Bay and delta system has been subject to severe environmental perturbations. Recent projects that could further degrade this system include Bureau of Reclamation proposals to discharge salt-laden agricultural drainage wastes into the bay, proposals to withdraw additional amounts of fresh water from the bay's Sacramento and San Joachin tributary rivers for agricultural and municipal use, and development projects that will fill wetlands. Further north on the Pacific Coast, in Grays Harbor estuary in the state of Washington, the port authority of Grays Harbor has proposed filling portions of the Bowerman basin--the major stop over point for migrating Pacific flyway shore birds between San Francisco and the Alaskan panhandle--for industrial development. The Corps of Engineers is considering channel enlargement.

In addition to direct physical stresses, many coastal estuaries are affected by regional atmospheric pollution in the form of atmospheric sulfur and nitrogen oxide deposition. Further, in response to rising concentrations of carbon dioxide and trace gases, the warming of the earth's atmosphere--the greenhouse effect--is slowly causing a rise in the level of the world's oceans. Even states with relatively strong coastal wetlands protection programs are ill-equipped to deal today with the long-term consequences of sea level rise for estuarine resources.

It should be evident from this litany of recent and proposed actions that the nation's estuaries are subject to a wide range of unending stresses. Many of these stresses relate to land use issues. Local citizen groups can play a unique role in terms of understanding such a complex array of issues and working with the different local, state and federal institutions that affect these stresses.

Effect of Citizen Action

For a local citizen group to be effective in understanding these stresses and promoting useful institutional responses, it must possess a high degree of citizen action capability. It is useful to identify some local or regional citizen groups that have the capability to influence what is happening to an estuary.

The upper Hudson estuary has enjoyed a remarkable degree of protection in this century, in part because of some very generous private donations of land and maintenance of numerous large estates. In the late 1960s, several Hudson Valley conservation groups, including Scenic Hudson and the Hudson River Fishermen's Association,, began to take aggressive political, legal, and scientific action in response to particular pending projects, such as the proposed Hudson River Expressway (which would have filled in hundreds of acres of the river near Tarrytown) and Con Edison's Storm King pumpback storage project. Lawsuits to stop these projects were successful. These groups have technical staffs that work on a wide range of projects.

Recently, Scenic Hudson has participated with the Environmental Defense Fund (EDF) in two New York state Department of Environmental Control (DEC) adjudicatory hearings dealing with utility sulfur-in-fuel standards, stack heights (where the concern is local contributions to acid sulfur deposits within the Hudson highlands), and aesthetic impoverishment. In addition, the Hudson River Foundation, now with assets of some $20 million, has been established as a result of a settlement agreement affecting several Hudson River legal actions involving Con Edison, General Electric, Exxon, the state of New York, and citizen groups, including NRDC.

In the lower Hudson estuary, no one citizen group is clearly identified with the protection and restoration of this remarkable estuary. Numerous groups, including Clean Ocean Action, the Natural Resources Council of Staten Island, and local Sierra Club groups (with assistance from the National Wildlife Federation and EDF) are engaged in efforts to end open ocean disposal of contaminated dredged materials and sewage sludge and to strengthen industrial pretreatment regulations. The Sierra Club and other New York City groups have recently successfully protected the lower Hudson River from the filling of some 200 acres for the Westway highway project. Progress overall is slow.

In the Hackensack estuary in New Jersey, a citizens group, the Hachensack River Coalition, has just been formed. With the support of this coalition, in August 1985 EDF completed a report urging EPA Region II and the Corps of Engineers to undertake a comprehensive Clean Water Act Section 404 wetland jurisdictional determination in the Hackensack meadowlands and to prepare a programmatic environmental impact statement (EIS) to consider alternatives to the development plan of the Hackensack Meadowlands Development Commission, Sports Complex, and New Jersey Turnpike Authority.

In the Chesapeake Bay, the Chesapeake Bay Foundation has a scientific staff that has played a major role in educating the public about the environmental stresses affecting that estuary. It has been working with EPA in its comprehensive scientific investigation of the causes of the bay's dramatic decline and pursuing implementation of state action plans.

Both the Mobile estuary and the Louisiana coastal zone lack a similar citizen action group. While the Mobile Audubon Society is active on Mobile estuarine issues, no individual works full time on these issues. Similarly, in coastal Louisiana, several individuals and groups--including Oliver Houck of Tulane Law School, Michael Halle and Joan Phillips of the Sierra Club, the Ecology Center of Louisiana, scientists from the LSU Center for Wetland Resources, EDF, and others--pay attention to coastal Louisiana issues. But no one or more individuals is in a position to keep after the Louisiana coastal zone office of the state Department of Natural Resources, the state Department of Environmental Quality, (DEQ), the New Orleans District Corps of Engineers, EPA Region VI, and other pertinent agencies and to press for an aggressive coastal protection, restoration, and pollution control program. Certainly the citizen action capability is woefully inadequate relative to the scope of estuarine problems in the Louisiana coastal zone.

As for Galveston Bay, the Sierra Club, which spearheaded the legal opposition to the Galveston deep water port project, appears to be the most active citizen group advocating bay protection, although no one is employed on a paid basis by any group to work full time on these issues. In Corpus Christi, a recent fight to protect Nueces Bay against use as a disposal area for dredged spoils from a COE project was led by the Coastal Bend Audubon Society under the aegis of then president Ted Jones who knew how to take advantage of legal and scientific expertise, to raise money, and to use the media. A recent coalition has been formed to fight a commercial development project in Corpus Christi Bay. Texas, like Alabama and Louisiana, lacks a properly funded citizens group which can support at least one full time individual to work on coastal issues.

In the San Francisco area, several groups, including the Save the San Francisco Bay Association and the EDF Berkeley office, have paid legal and scientific staff who work on bay and delta water quality and habitat protection issues.

We can mention two other examples where individual citizen activists working full time have made a significant difference for estuarine protection and management. David Ortman, a Northwest representative for Friends of the Earth in Seattle, Washington, has effectively worked with other conservation organizations to block a proposal to fill in hundreds of acres of the Bowerman basin for port-related industrial development and has formulated an alternative plan that the Grays Harbor Estuarine Management Task Force is considering.

Throughout the Suwannee River basin and estuary in Florida, Helen Hood, a full time volunteer for Florida Defenders of the Environment, working with EDF, numerous academic scientists, and other groups, is cajoling EPA, the COE, the Florida Department of Environmental Regulation, the Nature Conservancy and other agencies and groups to protect that remarkable riverine and coastal resource.

From those examples, we can reasonably conclude that a citizen action group with resources spearheaded by at least one full time advocate--who is capable of effectively using the scientific, legal, and political resources of conservation organizations, universities, and agencies such as the Fish and Wildlife Service and the National Marine Fisheries Service and their state counterparts--is essential (although by no means sufficient) for a moderate degree of protection of an estuary with prevention of the worst abuses.

Citizen groups should recognize by now that enactment of state or federal environmental laws and regulations, no matter how strong on paper, is only a small step in the direction of effective estuarine protection. The involvement of a focused local citizen organization in the relentless, day-to-day overseeing of the implementation of these programs (as well as local land use programs) as they affect each individual estuary is critical.

An Ability to Use Federal and State Laws and Regulatory Programs

The nation now has numerous federal laws and regulatory programs designed in part to protect estuarine resources. Many coastal states have comparable laws and regulatory programs. A local citizen group must be able to understand the interrelationship of these programs and to take advantage of them to be effective in protecting an estuary. Since a local citizen organization will typically not have on staff the requisite legal expertise to use all these programs, it must have the skills to attract and use efficiently the legal, as well as scientific, expertise of national environmental organizations and private and academic lawyers. A recitation of the federal laws that can be used to protect estuarine resources indicates that the citizen challenge is to learn how to integrate these programs.

The potentially most powerful regulatory tool for protecting estuaries, including their wetlands, from physical disturbance is Section 404 of the Clean Water Act, 33 U.S.C. §1344. In theory, under the EPA 404(b) guidelines, 40 CFR Part 230, estuarine and coastal riverine waters, including wetlands, should be protected from the physical onslaught of dredged and fill material associated with non-water-dependent activities.

In recent years, the Office of Chief of Engineers (OCE) and Department of the Army have been relaxing their interpretation of the Section 404(b) guidelines alternatives analysis and mitigation policy to authorize issuance of permits for non-water-dependent activities. Fortunately, EPA Region I has invoked the Section 404(c) process in the face of issuance by OCE of permit to a shopping mall developer to fill in and dredge a 50-acre swamp in southeastern Massachusetts.

Unfortunately, EPA Region VI, with responsibilities for Louisiana and Texas, has shown little inclination to promote effective implementation of the Section 404 program. A major agenda item for citizen groups in Louisiana and Texas should be to reeducate EPA Region VI about the virtues of wetlands protection.

Maintaining and restoring water quality in the broadest sense in coastal riverine and estuarine areas is an essential component of proper management of estuarine resources. Indeed, it is important for the health and well-being of people who consume estuarine resources and enjoy recreation in estuaries. Numerous federal and state programs are designed to control water pollution. Under Section 303(c) of the Clean Water Act, states must adopt, subject to EPA approval, water quality standards for all waters, including coastal waters. In turn, these standards can be used to limit discharges of waste waters beyond technology requirements and to be a basis for managing non-point sources of pollution. States are supposed to review and revise these standards every three years. The Louisiana DEQ has recently revised the state's water quality standards.

In general, coastal states have not adopted quality standards important for estuaries, including salinity, eutrophication, and toxic organic chemical levels. Although both salinity and eutrophication are hard to formulate, citizen groups should insist on their inclusion in estuarine water quality standards.

In California, the state Water Resources Board has a salinity standard for San Francisco Bay/delta waters specified by maximum chloride levels at key points. Since that board under state law now has legal control over withdrawals of water from the delta, the salinity standard in effect regulates those withdrawals, i.e., flows of fresh water into the estuary.

In view of problems with coastal salt water intrusion, Louisiana and Texas both need standards that specify allowable salinity ranges throughout the coastal region. A citizen group could initiate this process. The Sierra Club in Texas is planning to take legal action against EPA for its improper approval of that state's water quality standards. More citizen attention to this program is essential.

Other Clean Water Act programs important in protecting estuaries from discharges of toxic metals and organic chemicals are the Section 402 permit and industrial pretreatment programs and state counterparts. Introduction of large quantities of industrial toxic metals and of organic chemicals directly and indirectly through municipal treatment plants into these estuaries is a major source of degradation. EPA has slowly been promulgating effluent limitations that restrict discharge of toxic metals and organics by many industries. Citizen action is essential if EPA and the states are to implement these restrictions aggressively.

The Coastal Zone Management Act (CZMA) provides for federally supported state programs that, on paper, should contribute to the protection and restoration of coastal resources. While no coastal states other than Louisiana have established comprehensive new regulatory programs under this act, states have established new policies and have integrated existing programs that citizen groups can use.

Another federal program that affects coastal resources is the federal Flood Insurance Act of the Federal Emergency Management Administration. Local, state and federal environmental groups are apt to give little attention to implementation of this program. The result is a relatively ineffectual resource protection program. Local groups should understand this program since it provides another means for local citizen groups to press for restrictions on development in sensitive, low-lying coastal areas. With sea level rise, this program will become increasingly important.

Other federal programs that citizen groups can use to provide some degree of legal protection to estuarine resources are the Coastal Barrier Island Resources Management Act, the CZMA estuarine management program, and the national seashore and scenic and wild river programs.

Finally, local citizen groups can use the National Environmental Policy Act (NEPA) EIS process to comment on effects of Corps of Engineers and Bureau of Reclamation water resource development and other federal projects that typically have devastating long-term adverse effects on estuarine resources in or near coastal areas.

National environmental groups have a long and difficult task--to maintain or strengthen all of these federal programs that affect estuarine resources. Strong federal programs alone will not assure adequate protection of particular estuarine resources. Only a local citizen group, with a minimum of one full-time person supported by experts from state and national citizen organizations and academia, can aggressively support effective and coordinated implementation and enforcement of these federal programs and state counterparts to protect a particular estuary. Two other ingredients for effective citizen action to protect estuaries are essential: an ability to mount legal action and a capability and willingness to formulate affirmative, alternative strategies to economic proposals that degrade estuaries.

Legal Action

A local citizen group should be able to take administrative and political advantage of the federal and state regulatory programs that affect use of estuarine resources. However, to enhance its credibility, it must have a willingness and ability to initiate legal action. Since it may lack the resources to take such action by itself, it should draw selectively on the talents of national groups or pro bono lawyers.

While federal courts are becoming increasingly conservative in the sense that they are predisposed to uphold decisions of federal administrative actions, citizen groups have in fact enjoyed a number of recent triumphs in federal court--either in the form of outright successes or of judicial rejection of agency decisions.

The First Circuit Court of Appeals in Sierra Club v. Marsh, 769 F. 2d 868 (1st Cir. August 9, 1985), held that a cargo port and causeway that the state of Maine proposed to build at Sears Island, Maine, would have significant environmental effects so that the COE must prepare a full-scale EIS before granting a permit. The Second Circuit, Sierra Club v. United States Army Corps of Engineers, 772 F. 2d 1043 (2d Cir. 1985), has recently affirmed in substantial part the district court decision in the Westway case that the COE failed to explain the change in its draft EIS finding that the impact of a 200-acre Hudson River fill on the striped bass fishery would be significant. In early 1983, the Fifth Circuit, reversing the district court, found the Galveston District's EIS for the port of Galveston's proposed deep-water channel to be inadequate because of its inclusion of multi-port benefits without disclosure of multi-port environmental costs and its failure to present a worst-case analysis. See, Sierra Club V. Sigler , 695 F. 2d 957 (5th Cir. 1983).

Recently, the Fifth Circuit rejected the finding of the New Orleans District that its permitted shell dredging operations would have insignificant effects on Lake Pontchartrain and Atchafalaya Bay and remanded the matter to the COE to reconsider whether a full-scale EIS would be required. See, State of Louisiana v. Lee , 758 F. 2d 1081 (5th Cir. 1985). In October 1985, the Fifth Circuit in Fritiofson v. Alexander, No. 84-2592 (5th Cir. Oct. 7, 1985), found that the COE failed to conduct an analysis of cumulative impacts of past, proposed, and future residential development on Galveston Island wetlands as the CEQ regulations at 40 CFR Section 1508.7 and Section 1508.27(b)(7). The court therefore remanded the matter to the Galveston District to reconsider its decision whether or not these cumulative impacts were significant so that a full EIS must be prepared.

This record of judicial achievement is quite remarkable. In each of these cases local citizen organizations built a strong political organization and effectively solicited legal assistance. However, with few exceptions, such as the Westway project, these favorable judicial decisions at most buy time and create an opportunity for full public review of an agency decision through the NEPA process. Ultimately, for such legal action to lead to long-term estuarine resource protection, citizen groups must have the capacity and imagination to fashion and advocate an alternative strategy for managing the resource and addressing the underlying economic need and pollution source.

Formulation of Alternative Management Strategies -- A Citizen Responsibility

Estuarine resources are threatened when private or public investments are designed in a manner that involves the loss or misuse of the wetlands. Citizen groups interested in protection of particular estuarine resources have both a need and responsibility to assist in formulating alternative investment strategies for several reasons. First, if they can propose reasonable alternatives, the private or public developer may be compelled to modify its plan in response to NEPA and other regulatory requirements. Second, a positive program of action often wins political acceptance. Third, in some situations, citizen groups may devise alternative strategies that are economically or financially advantageous to the applicant or its constituents. Finally, some alternatives -- including use of estuarine management, scenic and wild river, national seashore, and Section 404 (c) programs--may provide a basis for long-term institutional protection of an estuarine resource.

Thus, an effective local citizen group must have the capability to formulate a bold conceptual view of the management of the estuarine resource that is the subject of its special concern. While this view may entail, by way of example, no more dredging in coastal Louisiana, no more dumping of sludge and contaminated dredged materials in the New York bight and no more withdrawals of freshwater out of the San Francisco Bay delta system, it must also have a positive dimension to it. In many cases, the capability to present and advocate positive alternative strategies will require effective cooperation between the local group and experts in academic institutions, national environmental organizations, and state and federal resource agencies.

Some examples of efforts by environmental groups to propose a positive agenda designed to accomplish reasonable economic objectives in a manner protective of estuarine resources should be mentioned. In New York and New Jersey, several groups, including Clean Ocean Action, the Natural Resources Council of Staten Island, EDF and others, were frustrated at the progress that the New York District of the COE was making in pursuing alternatives to open ocean dumping of dredged materials from the the lower Hudson estuary in the context of a five-year study.

During 1984, they put together a report entitled "An Alternative Strategy for Disposal of Dredged Materials from the Greater New York Harbor Region: A Citizen's Proposal" (October 1984). In Grays Harbor estuary, David Ortman of Friends of the Earth put together an alternative plan for management of that estuary, including alternative sites for port development that are now the subject of serious consideration by a governmental task force.

In California, the EDF Berkeley office--through EDF economist Dr. Zach Willey and lawyer Tom Graff--has formulated an alternative solution to the agricultural drainage problem which obviates the need for the highly expensive San Luis drain, a federal proposal to carry off toxic San Joachin Valley agricultural drainage water and dump it into the San Francisco Bay and delta. They have recently had success in persuading key political decisionmakers in California and irrigationists, including the Westlands Irrigation District, to pursue this alternative strategy. Similarly, EDF will be participating in the next round of state Water Resource Board hearings on water quality standards, including salinity standards, for this estuarine resource.

Damage to estuaries can come from many types of projects. Government agencies are often ill-equipped to develop and advocate alternatives. Citizen groups should have that capability.

The Louisiana Coastal Zone Need for Local Citizen Action

What do these concepts of effective local citizen action mean for the Louisiana coastal zone? This vast, highly productive but disintegrating estuarine system has inadequate citizen representation. It needs a single citizen group with at least one full-time person to be a voice for its protection and restoration. In the absence of funding to employ one person full time in this capacity, it would be worthwhile to form an informal association--a Louisiana coastal resource citizen action council--of individuals who are active on coastal issues.

This council should be prepared to coordinate its work with one or more national environmental groups and academic scientists who have the requisite skills to assist this council. With such assistance, it must plan and press for implementation of a bold alternative ecological, legal, and political strategy for this remarkable coastal zone. With such a voice articulating a vision for this resource--a vision that no other institution can present--and demanding action, such a council may become a forum for reformation in the conduct of dredging, filling, and sediment-distribution practices so disruptive of coastal Louisiana's wetlands.

CITIZEN INVOLVEMENT: A CASE STUDY ON COASTAL WATER MANAGEMENT

Joseph A. Phillips
North Carolina State University, Raleigh

I would like to relate an experience involving citizen groups aimed at solving a water management problem in the coastal area of North Carolina. I will discuss the problem, how it was handled, and the follow-up measures taken to date.

The problem arose from conflicts among farmers, foresters, fishermen, and wildlife interest groups in the coastal area of North Carolina. The Albemarle-Pamlico peninsula and surrounding counties are currently the location of extensive land clearing and drainage--mainly for agriculture and forestry. Small areas in the headwaters of the estuaries of the peninsula provide nursery areas for the young fish that support the fishing industry. Land clearing and drainage affect the habitat of the abundant wildlife of the area, and drainage canals that outlet directly into nursery areas bring fresh water intrusion that alters the salinity on which the young fish depend.

There is, then, some conflict between the interests of agriculture and forestry on the one hand, in clearing and draining more land, and of fisheries and wildlife on the other, in trying to maintain productive saline nursery areas and wildlife habitat.

In order to gain a clear picture of the problem and proposed solution, I would like to present a capsule version of a task force report and the follow-up that took place.

The coastal resources of North Carolina provide the base for numerous economic and recreational opportunities for the citizens of the state. The natural beauty of the area attracts visitors who support active and growing tourist and recreational industries. The natural productivity of the land supports lucrative agriculture and forestry industries. Economically important sport and commercial fishing industries depend on some of the nation's most productive coastal estuarine systems for finfish and shell-fish populations. All of these activities are economically important not only to this geographical region but to the economic well being of the state as a whole.

Perpetuation of these economic activities is dependent on the resources on North Carolina's coastal system. But, because the economy, environment, and lifestyle of the area are dependent on portions of a total system, competing uses and interrelated impacts can be anticipated. For example, those engaged in agriculture and forestry must remove excess water in order to use the land effectively. As a consequence, those interested in the fish and wildlife are concerned over the impact of this artificial movement of water -- from considerations of quality, quantity, and timing. Water management problems are a primary concern, both to those whose livelihoods depend on, and to those interested in, the resources of the area. Unless careful thought and planning are undertaken, the impaired use of certain coastal resources may have a dramatic impact on the continued viability of important economic activities in the area.

In response to this need, an ad hoc committee was appointed by Governor James B. Hunt, Jr., in May 1981. The purpose of the Governor's Coastal Water Management Task Force was to bring together those interested in agriculture, fisheries, forestry, and wildlife so they could reach a mutual understanding of the problems faced by each group. The task force was directed to formulate a balanced approach that would allow agriculture, forestry, fishing, and wildlife to develop in a manner acceptable to all interests.

The 30-member task force was chaired by Joseph A. Phillips, Assistant Director, North Carolina Agricultural Extension Service. The task force was composed of three distinct groups. Representatives of the agriculture, forestry, and fishing industries formed group I or the users' group. The wildlife interests were added to the users' group during the deliberations of the task force. This group's primary responsibility was to assist in identifying problems and suggesting solutions acceptable to each of these industries.

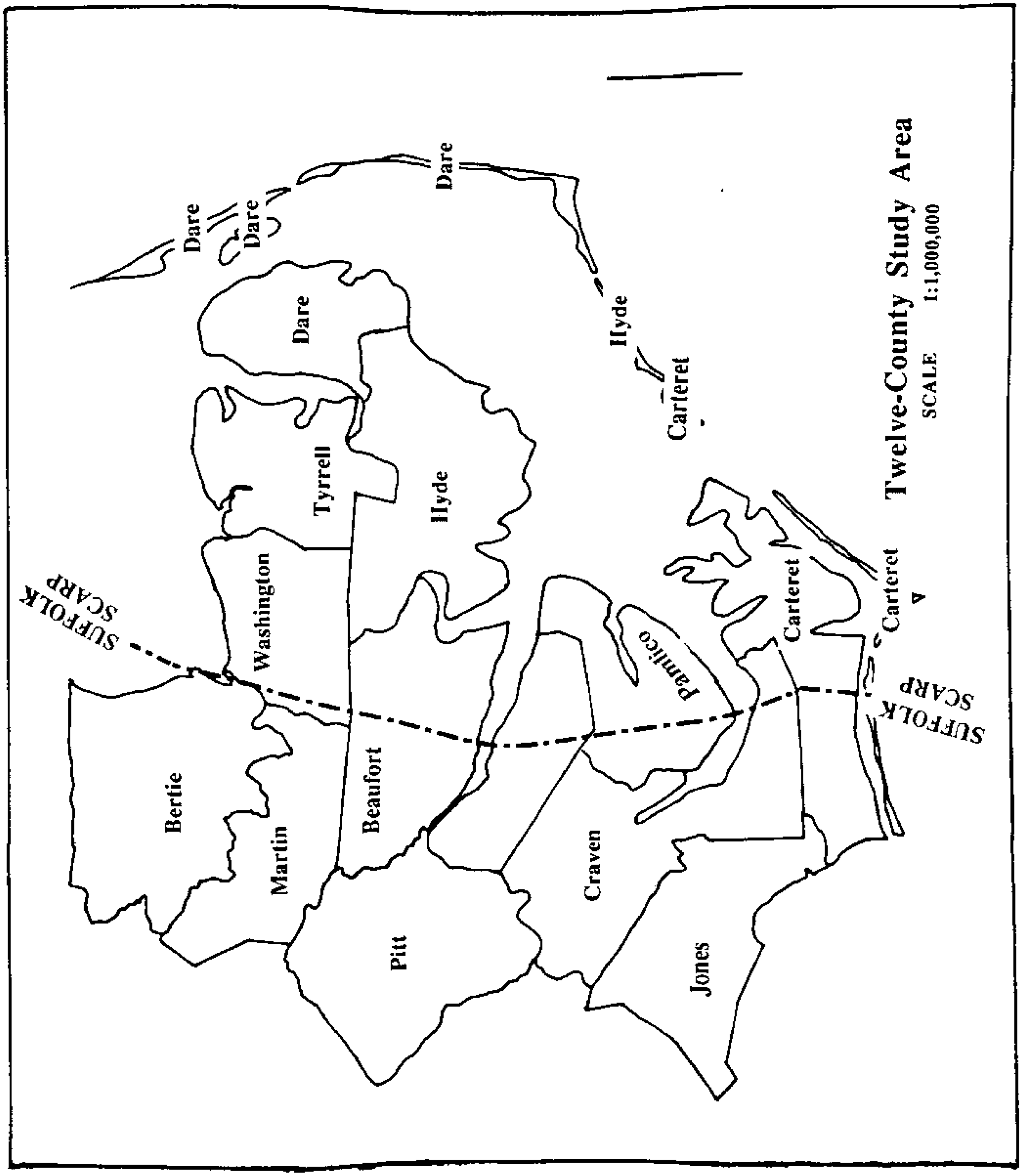
The technical advisory group, group II, was directed to provide scientific and technical data, offer guidance, and assist in identifying alternative solutions. Members in group II were from various disciplines interested in the topics considered by the task force.

Group III, or the advisory group, comprised representatives of programs within the department of Natural Resources and Community Development (NRCD) that have an interest in this area. In addition to providing support, this group was requested to ensure that any recommendations made by the task force would by consistent with state policy and regulations administered by NRCD. The Division of Soil and Water Conservation was asked to provide staff support and to coordinate the activities of the task force.

The study area was limited to a 12-county area in the east central portion of the coastal region (see Figure 1). Counties in the study area are Beaufort, Bertie, Carteret, Craven, Dare, Hyde, Jones, Martin, Pamlico, Pitt, Tyrrell, and Washington.

The area was limited to these 12 counties because they represent a predominantly rural area, and the most productive area from the standpoint of the fisheries industry. A small study area was defined so that the efforts of the task force could be manageable. The northern and southern regions of the coastal area were excluded because the southern coastal region's problems are associated with residential and urban pollution, and the northern region's present problems in the Albemarle Sound are receiving separate attention from state and other agencies.

In general, lands west of the Suffolk scarp drain into streams and rivers, while lands to the east drain more directly into Albemarle Sound or Pamlico Sound. Drainage from lands west of the Suffolk scarp tends to become a part of the "big wedge" effect of freshwater intrusion in the


Twelve-County Study Area
SCALE 1:1,000,000
Dare
Dare
Dare
Dare
Dare
Hyde
Carteret
Tyrrell
Hyde
Washington
SUFFOLK SCARP
Bertie
Martin
Beaufort
Pamlico
Carteret
Carteret
SUFFOLK SCARP
Craven
Pitt
Jones

coastal rivers, while drainage from the east more often contributes to the "little wedge" effect on nursery areas.

Agriculture is a primary industry in the study area. It includes row crops as well as livestock, and ornamentals as well as vegetables. The better-drained upland soils are used predominantly for high value crops such as tobacco and peanuts, while corn and soybeans are the main crops grown in the large flat fields of the drained swamplands. In the 12-county area, total cash receipts from crops in 1980 were 16.5 percent of the total for the state. This represents only a small fraction of the total agricultural contribution to the economy of the area. Land, buildings, and farm equipment make up a large part of the tax base of most counties. Related service industries such as grain elevators, tobacco warehouses, and farm supply businesses contribute significantly to the tax base as well as providing employment for many people. The economic well being of most of the 12 counties depends on agriculture.

There are several factors that have contributed to the past agricultural interests. First is the land itself. The area has a high proportion of very productive soils located on a landscape adapted to large scale agriculture. In addition, the climate is favorable for many crops, the area is near major markets, and land is still available for agricultural development. This combination of factors creates an especially desirable agricultural area.

The 12-county area can be divided into two agricultural sections: a better-drained section west of the Suffolk scarp where drainage is a relatively minor problem, and the other section east of the scarp where drainage is all-important. Both sections need water management. Accelerated runoff is a problem in both sections, and the eastern section cannot produce crops profitably without drainage. Most crops grown throughout the study area are water-sensitive, and will be damaged if the soil is waterlogged for only a few hours. Farmers consider the removal of excess water a major necessity.

The agricultural community believes that water management is ultimately in their best interests. At present, excess water is removed with no provision for storage and reuse. (It is ironic that drainage now thought to harm saltwater nursery areas was originally installed using the best available technology of the time and with the aid of government programs). Public money will be necessary to correct past errors in judgment and to build new systems that meet public as well as private needs.

A traditionally important aspect of the coastal economy in North Carolina is the fishing industry. In the context of this report, both shellfish and finfish are considered collectively as the fishing industry. The fishing industry includes both commercial and recreational fisheries.

The primary reason for the vitality of the fishing industry in coastal North Carolina is the productivity of the estuarine environment. The estuarine system in North Carolina is the largest on the Atlantic Coast, and occupies approximately 2,327,000 acres of marsh, wetlands, creeks, rivers, and open sounds.

A number of factors combine to give estuaries their high productivity: tides, salinity, shallowness, and abundant flats and salt marshes. Estuaries support an extraordinarily rich community of life, from microscopic algae and plankton to the largest game fish. Within the estuary, there is a critical zone of intermediate salinity serving as the primary sanctuary and feeding area for the juvenile stages of finfish and shellfish. This zone is referred to as the estuarine nursery area. The most critical breeding areas have been identified and are referred to as primary nursery areas. Initial growth and development occur in the nursery areas because of favorable food, protection, bottom type, and salinity.

The 12-county study area is considered one of the most productive areas in the state for the fishing industry. In the area, Pamlico Sound and the eastern portion of Albemarle Sound are estuarine systems that serve as the center of the fishing industry in the region.

The fisheries industry is an important part of the economy in this study area. But current land clearing and drainage in the area may damage the resource base for this industry. As land is drained for agricultural and forestry production, impairment of the fisheries may result. Impairment results from the flux of freshwater during critical periods in the life cycle of the fish in the nursery areas. Degraded water quality from point and nonpoint sources also has a pronounced effect on this industry. These problems result not only from local drainage, but also drainage from entire river basins.

Conservation of marine resources is an essential element in protecting present and future fisheries productivity. Certain fishing techniques and overfishing can be destructive or wasteful of many economically important species. Ensuring substantial marine stocks will require development and adoption of fishing methods that eliminate the discarding of one species while harvesting another species, excessive destruction of bottom habitat, and over-harvesting of existing populations. In order to realize progress in marine conservation, it is suggested that the Marine Fisheries Commission be more aggressive in these fisheries activities.

As with agriculture and fishing, the forestry industry is an important part of the economy of the study area. The land in the study area is attractive to the forestry industry and the agricultural industry for many of the same reasons. The rural nature, topography, and soil type all contribute to the importance of this area to the forestry industry.

Water management in this area is essential for satisfactory tree growth and wildfire control. Yet as with agriculture, potential impacts of forestry on the fishery resource are a concern. Hydrologic changes resulting from forest water management are minimal. Reduction in water table depth is necessary only during the harvest/regeneration period. The ability of established stands to tolerate saturated soils for several days provides an opportunity for storage and slow release of water pumped from agricultural areas. An adequate forestland base should be maintained, not only to provide timber needs, but to facilitate water management and to safeguard environmental quality.

The study area is considered one of the most productive regions in abundance and diversity of wildlife. The richness, abundance, and variety of wildlife species result from the quality and diversity of the habitat. The broad floodplains of the Chowan, Roanoke, Pamlico-Tar, Neuse, and White Oak Rivers transecting this area; the vast marshlands of the estuaries; the low flatlands that were the floor of the Atlantic Ocean; and higher elevations of uplands of the coastal plain all create a mixture of ecological systems unsurpassed in richness, diversity, and complexity anywhere in the state.

Fish, wildlife, and a generally high quality environment are the basic resources that help attract tourists, hunters, and fishermen to the study area. Fisherman and hunters spend approximately 2 million man-days in recreational activities annually and contribute to the economy through lodging fees, food services, travel expenditures, user fees, guide services, and state and local taxes.

The clearing of large acreages of forested lands and other development activities has and will continue to have a significant impact on wildlife habitats, both in quantity and diversity of type. Waters and aquatic habitat can be degraded by pesticides and excessive nutrients. These habitat losses will result in losses to certain fish and wildlife populations and losses to some aesthetic and economic values of the natural resource base.

The task force was directed to identify the problems faced by each industry in the study area. Problems identified were to be actual conditions that could be substantiated by technical data. Once the problems were identified, the task force was charged with developing acceptable alternatives based on available knowledge to optimize agricultural, forestry, fisheries, and wildlife production. Recommendations could not be considered unless they were technically possible, economically feasible, socially and legally acceptable, and multi-resource responsive. If they met these four conditions, they were eligible for inclusion in the recommendations of this report.

In reviewing specific directives for the task force to consider, the governor further requested that the users' group, with the advice of the technical advisory group and the advisory group, formulate long-range goals for water management in the 12-county study area. Also, the governor hoped the task force could identify some short-range goals that could be achieved during his administration. Some examples of these short-range goals were possible clarification, modification, implementation, or cancellation of any regulations; development and implementation of a state-financed project that would demonstrate the benefits of innovative water management; and development of a specific study, for which the background information is currently available, either to identify water management problems in the area or to identify alternative to solve agreed-on problems. In addition, the governor hoped the users' group could arrive at a consensus on the problems, with the advice of the technical advisory group and the advisory group, and then take their report to the general public, local government officials, and state legislators for comment.

In an effort to identify specific concerns and problems of each interest represented on the task force, four subcommittees were established. The groups were also asked to identify causal relationships, remedial actions, trade-offs, and recommended actions. Initially, these subcommittees thoroughly reviewed and identified problems facing each interest group. An introductory presentation on problems was made by a representative of each group; the task force then devoted several months to charting these findings. Although each group identified several problems specific to its interest, task force members noticed that recognition of conditions (problems and consequences) in the study area was very similar among the groups. Using the results of the deliberations, six problem categories were identified:

1. Water Management - excess water on the land for agricultural and forestry production;

2. Freshwater Intrusion - reduction of salinity levels resulting from the influx of freshwater;

3. Information Transfer - lack of understanding among all interests of effects on the area and the need to improve information to promote greater awareness by the general public;

4. Water Quality - impact of point and nonpoint source pollution on water quality in the area;

5. Land Alteration - changes in land use activities that result in loss of habitat for certain species, and in reduction of the forest land base;

6. Regulations - confusion about existing regulations that apply to the area.

High rainfall, high water table, poor internal drainage of soils, and slow runoff (inadequate natural drainage) make artificial drainage necessary for most soils in the study area if agricultural and forestry operation are to be profitable. The most common methods of drainage are canals and ditches, which allow the water to move from the land rapidly enough to provide proper aeration of the root zone.

Since the 1700s, artificial drainage has been used in coastal North Carolina. Land was originally drained to aid timber removal, and later to aid agriculture. Swamp lands were considered more fertile than upland soils, and agriculture. Swamp lands were considered more fertile than upland soils, and agricultural successes at Lake Phelps and Lake Mattamuskett in the early 1800s encouraged the state to drain swampland so that more land could be put in production. Today, artificial drainage is used on a large percentage of the total land area, and its use could be extended much farther.

According to a 1978 study, approximately one-third of the land area in 17 coastal counties is drained for farmland or forestland. In addition, that study estimates that 40 percent of the land that is not adequately drained is suitable for drainage. As the demand for wood products, food, and energy increases it can be expected that additional drainage systems will be installed in the future.

Artificial drainage systems for timber management and agricultural crop production differ because field operations in forestry and agriculture are conducted differently. Even so, the primary reason for drainage is the same--productivity. For forest land, a managed plantation on a drained site is up to 13 times more productive than the pond pine that naturally occurs on undrained peat soils. Tracts in the coastal area can produce trees 80 to 85 feet tall in 25 years on drained sites that are intensively managed. For agriculture, wet soils must be drained if they are to be cultivated successfully.

Freshwater intrusion into saltwater nursery areas is considered the most critical problem facing the fisheries industry. The two main effects of freshwater intrusion on estuarine productivity are altered salinity regimes and pollutant loadings. Because water quality is considered separately, pollutant loadings will be discussed later in this section.

In the study area, lowered salinity levels primarily affect Pamlico Sound, as compared with Albemarle Sound, since Pamlico Sound has historically been a more saline system. The upper reaches of the tributaries of Pamlico Sound function naturally as nurseries. Nurseries are those areas where initial growth and development take place because of favorable food, protection, bottom type, and salinity. Unstable salinity conditions, resulting from a flux in freshwater, place a physiological strain on marine organisms. This problem is particularly acute because there is only a limited number of nursery areas available for estuarine production. As freshwater runoff reduces salinity, less nursery area is available and estuarine productivity declines.

Several factors are directly attributed to the influx of freshwater. The factors result in either chronic or acute effects. A chronic effect, the "big wedge," is the consequence of variations in river discharge. Land development upland in the major river basins can increase the rate of runoff into rivers. This "big wedge" effect influences both long-term and short-term processes of reducing salinity levels in the estuaries by altering natural stream flows. On the other hand, consumptive after-use in the river basins results in decreased river discharge. Any long-term change in river discharge would affect the "big wedge" and produce very complex, long-term changes in the system, ultimately affecting the water balance, subsequent discharge, and fishery production. It should be pointed out that natural fluctuations in rainfall may affect river discharge more significantly than either accelerated runoff or consumptive water use.

The acute effect, "little wedge," of pulses of freshwater directly into the nursery areas is the result of activities in the 12-county area itself. One such activity is the artificial drainage of farm and forest land. Because drainage systems speed the release of water from the land, those systems adjacent to nursery areas release water directly into the nurseries over a much shorter period of time than under natural conditions. The resulting reduction in water retention time on the land causes unstable salinity conditions in the estuaries. The problem is compounded by the fact that removal of surface water from crop and forest land is most critical in the spring and early summer. This is also the most critical time for adequate salinity levels in the nursery areas.

Hyposalinity has an impact on both shell and finfish. Shrimp production in the nursery areas and shrimp harvest are directly related to salinity regimes. Oyster production has been affected by lowered salinities in some areas. The effects on finfish are more subtle, but there is a demonstrable effect. Studies done in Pamlico Sound indicate a reduction in overall numbers of juvenile finfish produced in a nursery area receiving drainage, compared with one experiencing little or no drainage. As a result, there is a measurable impact on quantity and value of seafood production.

Throughout the problem identification phase of this study, it seemed that the need for increased information and education was very apparent. Two broad educational needs were identified: increased understanding among various interest groups as to their needs, and increased understanding by the general public.

The need for information transfer among the various interest groups results from the natural difference of views among the groups. For example, the economic incentive of efficient agricultural and forestry production may not be considered by those in fish and wildlife management. Conversely, the needs of fish and wildlife populations may not be understood by those engaged in activities such as agriculture and forestry.

Probably the most critical lack of information is with the general public. Public understanding and awareness of existing regulations, natural resource management, and technology are all identified needs. In addition, increased educational effort directed toward resource users is an identified need. For example, educational programs associated with agricultural nonpoint source pollution could greatly increase best management practices (BMP) adoption. Also, efforts directed toward fishermen about fisheries populations and harvesting techniques could reduce pressures on some species and areas.

A general awareness and appreciation by the public in the study area of the environment could lead to reduced pressure on finite resources.

Point and nonpoint source water pollution can have a dramatic effect on water use, wildlife, and the fishing industry in the study area. Activities both in the upper reaches of the drainage basins and in the vicinity of the study area contribute to water quality problems. For purposes of this study, water quality conditions resulting from activities in the area are the primary area of concern. Because the study area is predominantly rural, nonpoint sources, such as the offsite effects of agriculture and forestry and of septic tanks, are the main area of concern.

Any water quality degradation in the area can have a significant effect on water use, wildlife, and the fishing industry. Pollutants of primary concern are sediment, nutrients, bacteria and pesticides. The general consensus seems to be that increased adoption of BMP through current programs will improve water quality. Because BMP are not necessarily efficient for the landowner or land user, the task force members decided that some type of financial incentive is needed.

Conversion of forests to agricultural land reduces the available production area for forest products. At the same time, habitat selection for forest species of wildlife is reduced while habitat for field species increases. Certain BMP, such as buffer strips of wildlife plantings and windbreaks, can increase habitat diversity.

The agricultural and forestry industries are concerned about the apparent lack of clarity in the regulations related to Section 404 of the Federal Water Pollution Control Act. (Section 404 is the "Dredge and Fill" section of the Federal Water Pollution Control Act, As Amended, P.L. 92-500.) There was general agreement by the task force on the problems associated with this lack of clarity. One of these problems was the interpretation of existing regulations. Another major problem was the lack of a clear definition and classification of wetlands. There was agreement that soil type, vegetation, and proximity to water should be considered in defining wetlands. In addition, it was suggested that wetlands be classified according to value relative to other lands and attention be focused on high priority, critical areas. Another suggestion was that regulations be enforced fairly and that regulations be based on technology, economics, and a comprehensive management plan for the area. A final suggestion was that user groups be allowed to contribute to the process of issuing permits.

The lower coastal region of eastern North Carolina is under pressure from many activities stemming from the development of its resources. The purpose of the task force was to formulate a balanced approach that will allow agriculture, forestry, fishing, and wildlife to develop in a manner acceptable to all interests and at the same time maintain a satisfactory environment. Individuals and groups engaged in these major pursuits are concerned with the long-term effects resulting from such activities as land clearing and drainage.

In making recommendations for these problems, the task force acknowledged that water quality problems experienced in the primary saline nurseries and sounds in the study area have their origins throughout the drainage basins emptying into the sounds. In addition to freshwater intrusion, nutrient over-enrichment is recognized as a water quality problem in the study area. These nutrients come from industrial, residential, urban, municipal, forestry, and agricultural discharges and runoff in upland and coastal areas, as well as from septic tanks.

The task force also recognized that there are still many unknowns about the long-range effects of management decisions on the resources of the area. However, even with many unknowns, several recommendations can be made, based on current knowledge, for the resources of the area. The following recommendations include both immediate recommendations based on existing information, and general recommendations for overall future guidance.

After 18 months of intensive study and discussion, the task force made 10 recommendations to the governor. They can be summarized as follows:

1. An inventory and classification of land and water resources should be made immediately.

2. This inventory and classification should be the the basis for determining whether or not drainage permits will be granted. (New drainage outlets into primary saline nursery areas are already prohibited by CAMA regulations.) Drainage should be toward fresh water where feasible. Some changes in Section 404 permitting are also recommended.

3. A demonstration project of comprehensive water management should be designed and carried out.

4. The state should assume the ownership, management, and proper maintenance of the outlets of all major canals draining into primary saline nurseries.

5. The state should develop a comprehensive water management Plan for the 12-county area.

6. The state should encourage best management practices on forestry and agricultural lands, and encourage the development of resource management systems.

7. Government agencies with wildlife responsibilities should work with agriculture and forestry user groups to promote wildlife management practices. Tax incentives should be used to encourage establishment of wildlife habitat. Acquisition of unique natural areas should be encouraged.

8. The state should continue to encourage and strengthen a program of environmental education in the school systems.

9. Research and monitoring are needed. (Nine research projects were identified and recommended.

10. The state should take the initiative to obtain funds to implement recommendations 1 through 9.

Citizen involvement was not limited to participation as members of the task force; at each of the meetings held in Raleigh many citizens came and participated in the task force deliberations. Other meetings were held in the field with county commissioners and local leaders.

The final report was presented to the governor and he directed the task force to form a committee to follow up on the recommendations and report back to him. A status report on the implementation of the recommendations was issued in 1984. Each recommendation was addressed report back to him. A status report on the implementation of the recommendations was issued in 1984. Each recommendation was addressed noting progress as well as strategies to implement those where significant progress was not evident.

The North Carolina General Assembly provided funds in 1984 in two important areas that are supporting the recommendations. First, they provided funds for a study currently underway to measure the effect of freshwater intrusion into primary saline nurseries and how it might be managed. Second, there was significant funding for three targeted nutrient-sensitive areas to reduce nonpoint sources of pollution from agriculture that drain into the study area.

The most important outcome of the project has been the commitment of the user groups to come together, reason together, and begin to work together to solve these problems. The way is slow but with commitment and support of the state and local governments, the legislature, the technology available from the support groups, and the local people the job can be done.