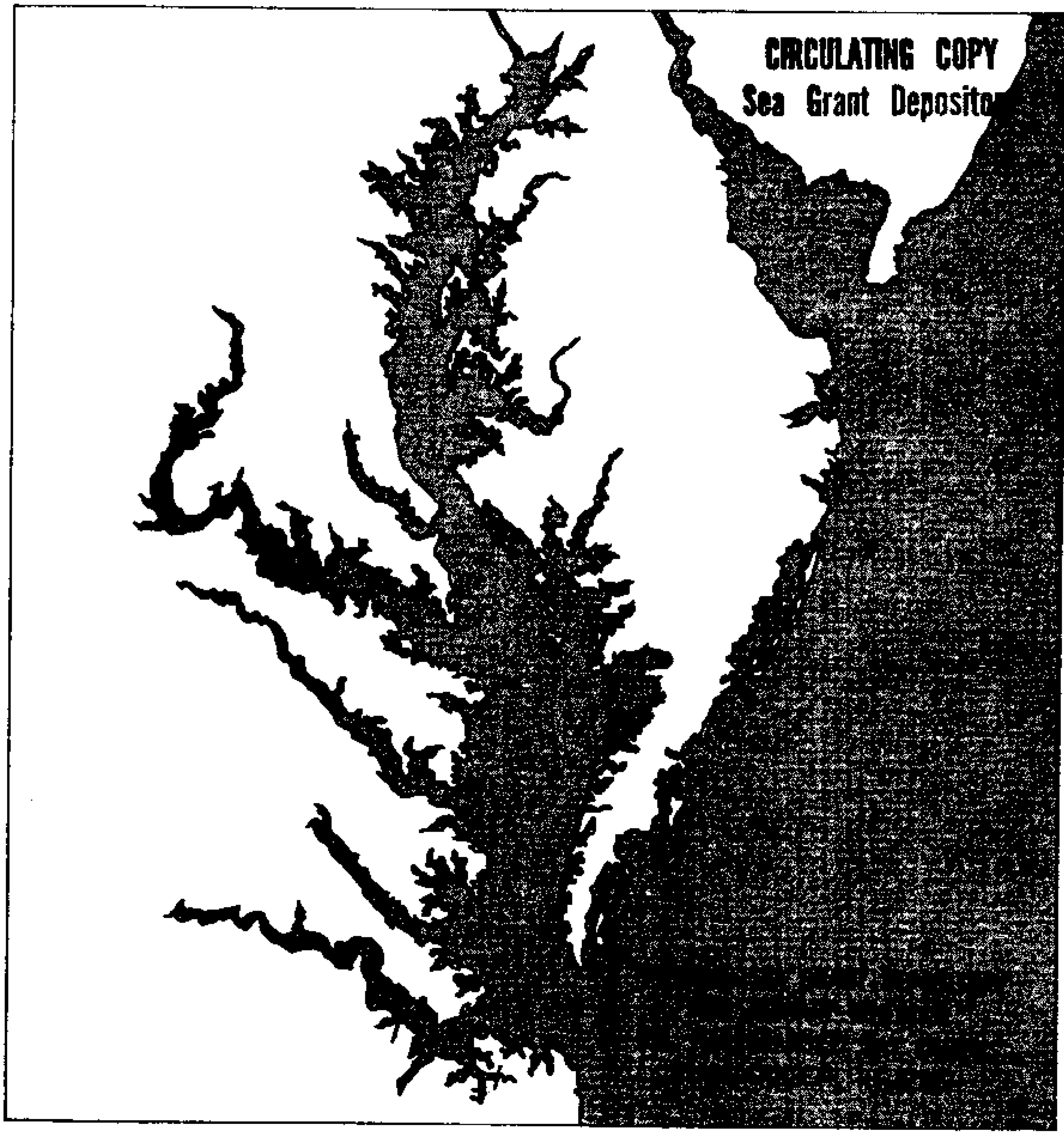
Background Papers On Chesapeake Bay Needs In Research and Related Matters



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University of Maryland

In Cooperation with the Chesapeake Research Consortium

Background Papers On Chesapeake Bay Needs In Research and Related Matters

Prepared at a
Workshop on Chesapeake Bay Research
September 21-23, 1981

Edited by
Chesapeake Research Consortium

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BACKGROUND PAPERS:
ON
CHESAPEAKE BAY NEEDS
IN RESEARCH AND RELATED MATTERS

Prepared at a
Workshop on Chesapeake Bay Research
21-23 September 1981

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INTRODUCTION

The uses of the Chesapeake Bay, already the most valuable estuary in the nation, will expand substantially in the future. While the ecology of the Bay is continually shifting in response to natural and man-made stresses, the competition among such different uses as shipping, recreation, development, mining, waste disposal and fishing can lead to conflict and a deterioration of the system. Our ability to manage the Bay so that its many users may continue to benefit will depend on how well we understand fundamental estuarine processes. Such understanding comes best from the organized efforts of research to increase our knowledge. Major research efforts are essential over the next decade and as long as a lack of understanding impedes our ability to balance the uses and protect the essential qualities of the great Chesapeake Bay system.

Available funds are, however, finite, and the kinds of research which will be of greatest value frequently require investment in expertise, specialized facilities and auxiliary support. Funds to be applied to activities related to the Bay must also provide for management activities, enforcement of laws and regulations, education and other important public functions. It is therefore necessary that the most significant research topics be identified.

These are the reasons why the Trustees of the Chesapeake Research Consortium directed that three documents be prepared:

Research Progress in Chesapeake Bay

Background Papers on Chesapeake Bay Needs in Research and Related Matters

Ten Critical Questions for Chesapeake Bay in Research and Related Matters

These have been developed about ten years after the volume The Chesapeake Bay - Report of a Research Planning Study was prepared by the consortium group as an overview of the principal needs.

New and unanticipated needs are certain to emerge in the future as problems change and as the best scientists and managers suggest fresh and innovative research to improve understanding and use of the Bay system. This document is therefore intended to be highly useful, but it cannot be an exclusive listing. New ideas must receive proper evaluation.

The emphasis in Background Papers on Chesapeake Bay Needs in Research and Related Activities is on the Chesapeake Bay and its tidal tributaries as a total and interrelated system. Only from this comprehensive perspective can we hope to understand the Bay's rich complexity. Scientists, managers, users and representatives of the public interest took part in the process of reviewing significant issues and reaching a consensus.

As preparation for the workshop which produced these papers, a broad-based list of research suggestions was culled from about twenty previous reports. The list was presented to a workshop group of scientists and managers who selected 241 questions, arranged by use or special topic. A questionnaire was then sent out to 135 pertinent agencies, groups, organizations and individuals who were asked to rate each question which was within their competence, as 1-Critical, 2-Urgent, 3-Desirable, 4-Minor, or 5-Unnecessary. The range of perspective was broad: Of the 123 persons who returned their ratings, 51 are considered "scientists," 45 "managers," 10 "users" and 15 "citizens."

Scores were tabulated, averaged and arranged in order of priority (Cronin and Rountree 1981, Chesapeake Research--Ratings of Suggested Questions, CRC Publ. No. 100). The needs for further research were emphasized by 165 additional research questions suggested by respondents, also listed in the report.

A second workshop was convened on 21-23 September 1981 at Windmill Point, VA, to draft these papers. The group of 31 scientists, managers and user-citizens drew upon ratings which had been assembled, the literature of the Bay region and their own expertise to select important problems and provide valuable supplementary material.

The resulting working papers have been used as the background for the selection of Ten Critical Questions for Chesapeake Bay in Research and Related Matters, which will be published as a companion volume under that title. Each question will be discussed thoroughly and a suggested approach to its solution outlined. This set of working papers, however, contains many useful evaluations and suggestions. They merit review by scientists, managers, user groups, legislators and the citizens interested in achieving the sustained best possible balance among users of the magnificant Chesapeake Bay system.

L. Eugene Cronin, Convenor
Director
Chesapeake Research Consortium

CHAPTER 1
FISHERIES AND WILDLIFE

Committee: William Jennings Hargis, Jr., Chairman,
John S. Gottschalk, Dexter S. Haven, W.P. Jensen,
Robert W. Lippson, Maurice P. Lynch,
Cranston Morgan, Virgil Norton

PREFACE

Organization

The report of the Committee on Fisheries and Wildlife deals both with research needs for fisheries and wildlife and with assessment needs by surveys and monitoring. Without adequate long-term, time-series data on all essential biological, chemical, geological, physical and socio-economic aspects affecting populations of species important to the fisheries, and to wildlife harvesters, significant understanding, prediction and effective advice are difficult, if not impossible.

Monitoring, the repetitive gathering of specific information, considered by some not to be "research," turned up in all of the categories of research needs. This emphasizes the point that the data and other products of such surveys or monitoring activities are of importance to "research" as well as to management.

We have separated needs into Fisheries, Wildlife and Monitoring, and have identified ten groupings for fisheries, one for wildlife and one for monitoring.

There are overlaps among sections of this chapter and with plans developed by other committees. This duplication is to be expected, since the biota contributing to fisheries production are ubiquitous and depend upon all other natural elements—chemical, geological and physical.

Research Needs for Fish and Fisheries

1. Evaluation of the Status and/or Management of Stocks
2. Seafood Production and Processing
3. Trend Evaluation

4. Economic Evaluation and Modelling
5. Synthesis: Development of White Papers or Monographs
6. Reproduction and Recruitment Research
7. Habitat Quality
8. Toxicity and Bioassay
9. Parasites, Pathogens, Diseases and Predators
10. Research on Survey and Monitoring Needs for Fishery and Wildlife Research and Management
11. Essential Fundamental Research

Research Needs for Wildlife

Wildlife Habit

Monitoring Needs for Fisheries and Wildlife

Monitoring Needs for Research and Management of Fisheries and Wildlife of the Chesapeake Bay

INTRODUCTION

Harvesting marine animals and plants is perhaps the oldest organized economic enterprise of the Chesapeake Region and the New World. North American aborigines are known to have engaged in fishing for personal use as well as for barter or trade long before Europeans arrived in America. Reports of the abundance of fishery resources and their possible development probably date to the early days of Spanish and certainly to the beginnings of English exploration. In the Chesapeake, commercial and sustenance-level fishing continue to be economically and politically important.

With the increase of leisure time, however, recreational or "sport" fishing in Maryland has actually come to exceed commercial finfishing. Though commercial landings of crabs, oysters and other molluscs probably outweigh those of recreationists, a significant percentage of the total catch in the northern part of the Bay is taken by unlicensed individuals. Many recreational fishermen sell their catches.

In Virginia, commercial fishing for all classes of fishery products (i.e., industrial and edible finfishes, crabs, oysters and clams) predominates, but recreational fishing for all but industrial finfish is also important and becoming more so, and may have greater economic value.

Since Colonial times, and the mid 1800s especially, there has been a growing realization of the necessity to manage both the living, renewable resources and the harvesters; more recently, we have come to recognize the importance of managing the environment on which resources depend. Since about 1875, science has become involved increasingly in efforts to understand the ways of resources and of the fisheries which depend upon them and to provide information and rational advice to public management and industry. Now, despite occasional disagreements, science is a regular part of the fisheries management efforts of the states bordering the Chesapeake. Scientific advice is usually sought, though it is often overshadowed by socio-economic or political factors in the decision-making process. Sometimes it is simply ignored. Nonetheless, science has contributed solidly to development of knowledge of the fish and fisheries and to their effective management. Scientists are called upon to make increasingly important contributions in fishery and environmental research (the development and marshalling of knowledge) and advisory services (the dispensing of factual information and objective advice based upon the results of original research, and/or of scientific organization, synthesis and analysis of facts).

Fishery and wildlife organisms and other elements of the biota on which they depend are of value and importance in several respects:

1. They are the raw products of the basis of commercially important fishery and wildlife harvesting activities of great economic significance, with an annual value of hundreds of thousands of dollars.
2. They are also the renewable basis of the socially and economically important recreational fisheries and hunting, which are growing.
3. Fishery and wildlife organisms and other ecologically important elements of the biota serve as indispensable indicators of environmental quality. Also serving the other recreational and economic interests dependent upon the clean waters of a health Bay, they are the "canaries of the Chesapeake" providing warnings of developing difficulties or evidence of troubles already present.
4. Fishery and wildlife organisms, and other ecologically important species on which they depend, also serve usefully as "guardians" of environmental quality. Water quality standards set the limits or objectives of water quality management programs. Quality criteria, and the standards based upon them, usually are established to meet the needs of important elements of the biota. As a result these standards, oriented toward fishery organisms and toward continuation of the fisheries and wildlife stocks, are usually higher than those required for other uses of the waters, and serve to assure preservation of good quality water and protect or favor the other uses which also depend upon waters of high quality.

The Necessity for Continuing and Additional Research

Scientific knowledge of the Chesapeake, its tributaries and its resources and amenities has grown rapidly since World War II, and it is diverse and extensive. Despite the great power of the scientific method and of the scientific knowledge now available, many fundamental and significant scientific questions necessary for effective management of the fishery resources and other ecologically important biota remain to be answered. "Applied" investigations are always required due to continually arising time-, site-, species- and fishery-specific questions.

For both basic and applied research, the continual acquisition and integration of specific data and synthesized information on the species involved and on the environmental factors which affect their abundance, distribution and availability are necessary. Scientific investigations of phenomena affected by short- and long-term changes require comprehensive data bases. Detection of significant natural phenomena, whether aperiodic or exhibiting cyclic periodicities of several years, can only be separated from "background" variations with long-term, time-series data, of sufficient resolution to allow statistically reliable identification. Because the search for correlations is continuous and requires proper data and analysis, scientific monitoring is critical in fisheries and wildlife research.

Effective management advice, planning and execution requires data of similar character. Hence, surveys and monitoring programs are also necessary. For this use, however, continued re-evaluation of the scientific effort is necessary. New knowledge, new correlations and new or improved techniques necessitate continuous review of plans for research, surveys, monitoring and their results. Thus, this effort to plan for research and monitoring selective to the fishery and wildlife resources of the Chesapeake Bay system is of special value and should serve other organizations that also conduct planning and review activities themselves.

The result of our analysis is an organized list of scientific research and monitoring issues which (1) have been found to be important in the past and still are or (2) have emerged recently as necessary for understanding the resources so that effective management planning can be developed.

The order in which the research needs and projects are presented does not imply priority.

NEEDS FOR RESEARCH: FISH AND FISHERIES

RESEARCH AREA 1
EVALUATION OF THE STATUS AND/OR MANAGEMENT OF STOCKS

PROJECT: Evaluation of the Status and Management of Stocks of Anadromous and Catadromous Fish Species in the Chesapeake Bay

Introduction

Shad, alewives, river herring, other alosids, as well as striped bass and white perch, migrate from the ocean or from saltier regions of the Bay to spawn in fresh or brackish water and may be classed among the anadromous species. Stocks of shad, river herring, striped bass and white perch have declined sharply since 1970, as measured by commercial catch statistics, reports of commercial catch and other indices. Populations of resident species have remained relatively stable, based on commercial catch statistics. Marine-sourced populations have increased in the Bay. Several species which are not harvested in Maryland or have no commercial value have increased dramatically, particularly young of year menhaden and adult gizzard shad.

Year-to-year fluctuation of fish populations is the rule rather than the exception. Patterns of periodicity can frequently be correlated with natural events or climatic conditions. Current-year landings of anadromous fish are approximately one-sixth of the 1969 landings, when the current phase of a longer-term, downward trend commenced; moreover, current landings are one-sixth of the long-term median values. Recreational catches cannot be so clearly measured but are thought to be equally reduced.

Analysis of the causative factor(s) is complicated by the widespread decline in reproductive success. The fundamental research required to understand the trends has not been conducted; nor has routine monitoring of the status of stocks been sufficiently detailed to identify the cause or remedies. Continuance of species abundance and diversity necessary to support major fisheries requires research on abundance and condition as a basis for understanding factors responsible for population fluctuations and, thus, maintaining fish populations.

The parameters to be measured and studied are similar for many species. Protection and management of fishery resources benefits from the results of virtually all scientific research conducted in the Bay.

A research plan for Chesapeake Bay anadromous finfisheries has value if the plan is relevant to actual problems, fosters compatibility among research projects conducted by institutions and agencies, provides results that are applicable throughout the Bay system, and maintains the integrity of institutional and agency capabilities to provide a continuous core of expertise and facilities. With these premises in mind, a Baywide anadromous fisheries research and monitoring program should be initiated, focusing on the following areas and problems:

1. Declining production of young of the year
2. Habitat degradations and loss
3. Predation
4. Fishing mortality effects
5. Larval transport
6. Effects of climate and weather on fishery stocks
7. Effects of parasites and diseases and other natural causes of morbidity and mortality

The project(s) will attempt to define the stocks of each of the species, evaluate the causative factor(s) for the decline of stocks and reduced reproduction. Initial needs appear to be information on life history, sex, size and distribution of catch (commercial and sport), juvenile index, catch per unit effort and environmental data sets.

The objective of the project(s) will be to identify the stocks, provide reasons for decline and form a basis for recommending implementation of measures to reverse the decline and optimize or maximize the catch and value of the stocks.

American eels are catadromous. Elver stage eels enter the Bay system during their first year and remain through their adult stage, reaching sexual maturity at about age 18 and leaving to spawn in the south Atlantic Ocean. American eels support two valuable fisheries, and the possibility exists for future aquaculture utilizing spawned elvers. Live eels from Chesapeake Bay and other East Coast areas are shipped to European markets. Small eels (6" - 18") are utilized for crab trotline bait and recreational fishing lures. In Maryland, the American eel fishery is estimated to be the second most valuable finfishery in recent years. In Virginia it is also significant.

No formal long-term study or research has been conducted on the American eel stocks in Chesapeake Bay. Limited catch reports have been maintained but are believed to significantly underreport the catch. An inventory and stock assessment project was initiated by the Maryland Tidewater Fisheries Administration in 1980. Anecdotal accounts indicate a declining abundance of eels available to commercial eelers. Japanese interests have indicated a desire to raise elvers for a specialty market product in Japan. Eeling is a single species fishery. The value of eels as forage for larger fish is unknown but considered signfificant.

One phase of the project will outline specifically the eel resource in the Bay and define the level of harvest, with the objective of managing the resource to increase the harvest and, at the same time, conserve the stocks so as to assure future availability. Specific areas of research will include the age, sex, composition of the stocks, elver transport and migration, the effect of harvest on reproductive adults, natural mortality rates and catch per unit effort in the fishery. Very little information is available on growth rates.

The approach must be Baywide since the fisheries are Baywide. For some, there is little basis for identification of separate Maryland and Virginia stocks at this time.

Costs for research on the anadromous species cannot be specified. The overall objectives should be adopted by each state management or research agency. Individual projects should be planned and conducted in the context of this objective. If they are, they will contribute as the momentum develops. The work must continue until the species and the fisheries dependent upon them are sufficiently understood to allow effective management and conservation.

For the eel research, estimated costs are $75K annually, to continue for a minimum of three years.

RESEARCH AREA 2
SEAFOOD PRODUCTION AND PROCESSING

PROJECT: Developing New Cost-Efficient Technology or Gear to Aid in Growing, Harvesting and Processing Oysters

State-wide production of oysters in Virginia declined from about 4 million Virginia bushels just prior to 1960 to about 1 million bushels during the 1978-79 season. Almost all of this decline was due to the absence of production from Virginia's 110,000 acres of leased bottoms. Increased costs since 1960 involved in growing, harvesting and processing have contributed largely to the absence of production from these leased bottoms. That is, growers are simply not realizing sufficient profit to encourage them to grow more oysters.

The increased costs have largely been the result of an industry failing to modernize and adopt cost-efficient means of growing, harvesting and processing oysters. They are still employing costly labor-intensive practices in use 100 years ago. Similar problems beset the oyster industry of Maryland.

Research is needed by a team of biologists and engineers to develop techniques and equipment for planting, harvesting and processing oysters that are demonstrably cost-efficient. If production costs can then be reduced, profits to growers would be higher and incentives created for encouraging higher levels of production that Bay waters remain capable of.

The approach would be to identify first the specific problems, then analyze existing techniques to determine where costs might be lowered or if a new approach is needed or possible. Finally, techniques or gear would be developed to meet the needs.

PROJECT: Development and Deployment of Disease-Resistant Progeny

Disease caused by pathogens remains a major problem affecting oyster production in the middle and lower reaches of the Chesapeake and its major southern tributaries.

A promising technique for allaying or reducing the effects of diseases on marine and estuarine populations, especially those under immediate stress of disease, was developed years ago by plant and animal scientists working with terrestrial populations. It involves the "planting" of disease-resistant stocks.

While marine science has recognized this possibility and undertaken preliminary research--several organizations have worked on the problem--the level of support has been inadequate to develop the work beyond the promise of its potential success.

This effort requires not only support for the research operations, but special culturing and rearing facilities, which are also important to management as well as to genetic research and to the understanding of basic disease-related mechanisms.

RESEARCH AREA 3
TREND EVALUATION

PROJECT: Analysis of Long-Term Data Sets on Species Abundance or Availability in Relation to Hydrographic Factors in the Bay and at or Near the Bay Entrance

Many research organizations have in their files long-term collections of data obtained from (1) surveys for juvenile fish or crabs, (2) commercial landing data for fish, crabs and oysters, (3) seasonal or long-term studies on oysters spatfall on test shells or on the bottom. Most of the data acquisition efforts resulting in such data sets could be termed monitoring. Frequently, these long-term data sets have not been related to possible causes by the individual conducting the monitoring.

Research is needed to analyze available long-term data collections in relation to available historical data on salinity, temperature, dissolved oxygen or other hydrographic and environmental factors. For example, variation in the circulation patterns in the Bay or at the entrance to Chesapeake Bay may be inferred from historical data on wind patterns, salinity and temperature, and is probably related to species distribution and abundance, particularly those which migrate into or out of the Bay at critical life-history stages. Further, setting of oysters should be examined against annual variations in temperature and salinity.

The objectives of these studies would be to develop predictive capabilities to forecast future abundance or distribution patterns.

The approach to the problem would be to review the files of various institutions and the published and unpublished data to determine where suitable long-term data sets exist and then, making use of those data, undertake detailed analyses of them. In addition to a computer, this project requires a time-series statistician and several biologists.

RESEARCH AREA 4
ECONOMIC EVALUATION AND MONITORING

PROJECT: An Evaluation of Minimum Data Requirements for Bio-Economic Modeling Designed to Provide Effective Management Information

Project Description and Significance

The importance of population dynamics and biological stock models for management and for evaluating alternative management and regulatory decisions has long been recognized. These models can be categorized as:*

Statistical

Surplus production

Yield per recruit

Population simulation

Interacting multi-species simulation

In recent years, complex bio-economic models have been generated to evaluate the implications of biological constraints as affected by economic objectives of fisheries. These models have employed steady-state and dynamic techniques for use on both single-species and multiple-species bases. The models have been made possible by advances in conceptual aspects of biology and economics and through new quantitative techniques, including computer facilities. They have provided important insights into management approaches and have greatly facilitated classroom teaching of the implications of increasing resource use-rates.

However, in the process of developing complex modeling approaches, inadequate attention has been given to the data demands of these models and the control variables actually available to management agencies. Therefore,

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* Martin Marietta has done this for the Maryland Tidewater Administration.

in a certain sense, model development has proceeded beyond the practical and useful stage into a theoretical stage in which data collection of the necessary data may be too costly and the various interactions included in the models (e.g., dynamic interactive effects) are perceived to be too complex to be utilized within the constrained options available to management agencies. Further, the degree of resolution available in the model may exceed the resolution of the data. The latter point may represent some lack of communication on the part of the modelers as well as on the part of the management decision-makers.

Therefore, the basic question is how to combine the enormous theoretical expertise that has developed over the past decade with the practical needs of management decision-makers, both constrained by the lack of certain historical data and the lack of funds to establish large data collection systems.

Objectives

1. To develop appropriate bio-economic models designed to evaluate pertinent management and regulatory alternatives for the commercially important species in the Bay.
2. To determine the trade-offs between data requirements and validity and reliability of predicted results.
3. To develop improved methods of estimating fishing effects and to determine methods of incorporating recreation effort into the models, recognizing the constraints implied by (1) and (2) above.

Approach

Interdisciplinary approach but with direct input from management agencies in order to determine key management and regulatory alternatives and to establish the likely availability of data sets.

Develop appropriate models.

Test predictive results and utility of models through joint efforts of scientists and management agency personnel.

Through an experimental process involving simulations and model adjustments, evaluate the trade-offs and implied statistical problems (i.e., model misspecification, serial correlation, etc.) involved in simplifying the data inputs. This will involve altering the models and adjusting degrees of freedom by deleting or combining variables, using surrogate variables, and making use of reduced observations for estimation of parameters of the models.

When the appropriate models have been specified, simplified computer programs for updating information and re-using the models should be provided to the appropriate management agencies.

RESEARCH AREA 5
SYNTHESIS: DEVELOPMENT OF WHITE PAPERS OR MONOGRAPHS

PROJECT: Develop Management or Synthesis Papers for the Commercially Important Species of Finfish, Molluscs and Crustaceans

Intelligent management of individual species in a commercial, recreational or combination fishery should be based on analyses of all available data. These analyses should be presented in single volumes for each species and/or for each single-species or multiple-species fishery to make them easily available to science and to management.

For the Chesapeake Bay, only a few such comprehensive recent reviews exist (i.e., the oyster industry of Virginia and Maryland). Many more are needed. Each volume should discuss such topics as life histories of the species, landings, spawning, range, age-structure of the stocks, predators and diseases, the impact of hydrographic conditions, effects of habitat characteristics, management strategies. Emphasis should be on those species and/or fisheries which are of commercial and recreational importance, those which exhibit wide fluctuations in abundance or theose which have shown long-term declines Examples are: Hard Clams, Soft Clams, Blue Crabs, Menhaden, Shad, Striped Bass and Croakers.

Such studies would be of major value to resource managers who would have a broad review of each species. Each study would be primarily a library review project, with emphasis on published data, technical reports, thesis material, unpublished and contract reports. No new experimental or ecological research would be involved in this project, though such comprehensive analyses would certainly indicate areas in which essential information is lacking and on which research and monitoring efforts are needed.

RESEARCH AREA 6
REPRODUCTION AND RECRUITMENT RESEARCH

PROJECT: Blue Crab (Callinectes sapidus) Larval Transport and Recruitment

The blue crab is a Bay-wide species of considerable commercial and recreational importance. Although landing statistics underestimate the total catch in Chesapeake Bay by some magnitude, an impressive average catch of 60-70 million pounds is reported annually.

However, drastic fluctuations are prevalent in the blue crab stocks. It is not unusual, therefore, to observe a severe decline in the adult stock one year followed by exceptional abundance the next.

Forecasts on the relative abundance of the blue crab are based on the numbers of juvenile crabs sampled by standardized means at set stations. Current research at VIMS focuses on the climate patterns and shows some promise. No attempt has been made to develop predictions based on the larvae (zoeae and megalopae).

The juvenile and adult life stages of the Blue Crab are generally understood in terms of their geographic distribution, relative growth rate, seasonal migration and over-wintering characteristics. Although there is much that is unknown concerning the juvenile and adult stages, almost nothing is known about the environmental and habitat requirements of critical larval stages and the larval-transport mechanisms.

It has generally been accepted that the adult female blue crab migrates to the higher salinity waters of the lower Bay and spawns during the late spring and summer months. The larvae that subsequently develop in the lower end of the Bay have been considered to provide the recruitment to the ensuing year class.

Recent work by scientists in Chesapeake and Delaware bays indicate the possibility that recruitment to the crab fishery may not entirely be from the lower-Bay spawning areas and that, in fact, a major portion of the recruitment may be contributed from adjacent Atlantic coastal waters. But this work is preliminary and much research is required before a definitive statement can be made regarding recruitment relative to lower Bay spawning grounds and adjacent coastal and offshore waters.

If significant recruitment does originate from coastal waters rather than the lower Bay, drastic fluctuations observed in the blue crab populations of the Chesapeake may be explained in part by information obtained on coastal currents, meteorological events, predation and the behavior of the larvae offshore and in the lower Bay and in transit.

Knowledge gained on larval transport and the importance of coastal water recruitment to the Bay fishery can have significant importance for making early predictions and improving the accuracy of those predictions.

Objectives

1. To determine the extent of adult and larval distribution and interchange in lower Chesapeake Bay and adjacent Atlantic coastal waters and the embayments and lagoons nearby.
2. To measure the effect of estuarine currents and high river flows on the displacement of crab larvae.
3. To assess the concentration of larvae in Atlantic coastal waters.
4. To learn the relationships between coastal currents and transport of larvae

RESEARCH AREA 7
HABITAT QUALITY

PROJECT: Degradation of Habitat

As the human population expands around the shores of Chesapeake Bay, the increasing demands and results of urbanization will be reflected in its water quality, fisheries stocks and shorelines. Communities distant from the

Bay, but located on or near its tributaries, are pressing for impoundment of those tributaries to provide flood protection, water supply and recreational lakes. In-place and proposed impoundments present blockages to the migration of anadromous fish such as shad and restrict access of these species to natal spawning grounds. In addition, the character of the wetlands, wooded swamps, fresh and brackish marshes, are being permanently altered, resulting in a loss of downstream export of nutrients.

Of deep concern to the health of the fisheries and supporting food organisms is the threat of chlorine and the related complex of halo-organics. To provide some understanding of the effects of these materials on the biota, bioassays are critically necessary, both in vivo and in situ, of the sensitive life stages of economically and ecologically important species.

Run-off (non-point sources) exacerbated by the construction of roads, housing tracts (urbanization) and industrial facilities and certain farming practices results in the conveyance of soil particles with sorbed chemicals, fertilizers and heavy metals. High turbidities result, which in time cause siltation of critical biotic growing areas and the need for maintenance dredging of navigation channels.

Nutrient enrichment, e.g., from fertilizers runoff, has been implicated in the occurrence of algal blooms, brown and red water, the resulting dissolved oxygen sags and possible toxic releases which in turn stress organisms. While not conclusively proved, such environmental stresses may be the cause of periodic fish kills on fish already weakened by disease and parasites.

Implicit in the concern for the health of Chesapeake Bay is the desire for maintenance of a mix of species suitable for harvest by man. In recent years there has been a serious decline of striped bass and an increased abundance of gizzard shad. While no implied cause and effect linkage is intended here, one wonders about predation on gizzard shad by striped bass. Has the gizzard shad increased because striped bass have declined? Further, over-all productivity of the Bay in terms of total biomass may not decrease even if the water quality declines and habitat is destroyed. But what species mixes will evolve and will that species complex be regarded as a source of economic wealth or will it be a signal of further degradation of the Bay? Will decline of commercially and recreationally important species and increase of so called trash fish lead to a neglect of water quality and ensure degradation of the Bay?

The entire topic of habitat degradation lends itself to a spectrum of monitoring strategies which will be addressed elsewhere.

Our recommendation for research beyond monitoring proposes a Center For Large Estuarine Area Research (CLEAR) on fish. A building designed to accommodate feeding and behavioral research on fish, prey-predator relationships, disease studies, energetics and physiology, life cycle studies and long-term chronic bioassays will allow a more appropriate analysis of in-field studies under controlled conditions than is now possible. This Center could be managed either by one institution or several. The research undertaken there could bring scientists much closer to understanding societal effects on species of economic and ecological concern.

RESEARCH AREA 8
TOXICITY AND BIOASSAY

PROJECT: Bioassay and Toxicity in Relation to Fisheries and Wildlife

Common bioassay or toxicity studies use LD50 studies to determine the impact of a given toxicant on a given species. Most of our information is from static tests. Some progress has been made in recent years through research on chronic (low level, long term) effects of toxicants on organisms challenged in flow-through systems. Unfortunately, our current criterion for effects is still primarily death or profound morbidity, i.e., visible impairment, from which there is no possibility of survival. In addition, most of the extant data involve adult forms, while larval or juveniles may be the most sensitive stages.

Great need exists for development of improved techniques of bioassay on both economically and ecologically important components of the biota of the Bay.

Coordinated projects are necessary which will involve the following:

1. Studies of the cellular level or with a physiological orientation which will enable us to determine when a toxicant is beginning to affect an organism.
2. Determination of the most sensitive stages of important species (e.g., larvae, juveniles) to toxicants.
3. Careful re-evaluation of presently known toxicants or potential toxicants in view of results of (2).
4. Complete toxicity and bioassay studies on the stages of each economically or ecologically important species which occur in Bay waters.

General Requirement

No laboratory or institution within the Chesapeake Bay system is set up to routinely challenge commercially important species or organisms on which these species depend with known or suspected toxicants. Consequently, laboratory capability will have to be developed in one or more of the research institutions and development of such facilities should be accorded high priority within the area. Research should be coordinated among participating institutions.

RESEARCH AREA 9
PARASITES, PATHOGENS, DISEASES AND PREDATORS

PROJECT: Research on the Impacts of Parasites and Pathogens on Species of Importance to the Fisheries

Parasites and pathogens, obligate and facultative, are ubiquitous in estuarine and marine waters, lurking in wait to attack natural and cultured populations alike.

While it is increasingly well established that parasitism affects populations, questions persist on the degree to which parasitism and changes in patterns of pathogenicity compete with and affect other mortality-causing factors such as harvesting, aging, catastrophic natural events, exposure to toxicants, nutritional shortages and diseases.

Chlamydans, rikettsiae, viruses, bacteria, dinoflagellates, fungi, protistans and thousands of metazoans have been discovered in many finfishes, crustaceans and molluscs. Some cause debility, reduce fecundity or bring about death--even under natural conditions. Stress caused by lowered water quality, natural catastrophic events and other abnormal conditions can cause severe epizootics or epidemics with massive mortalities. Additional and continuing research is required to understand the actual role they play and what can be done, if anything, to mitigate their effects in nature and under culture.

Normally benign parasites and facultative pathogens can become terrible scourges when actual or potential host populations are stressed by natural phenomena, man-caused changes or under conditions of culture. The economic effects and impacts on fisheries as well as scientific programs can be great but relatively little is known of the interaction between stress and pathogenicity. This field has shown significant promise, however. Research on striped bass in California has shown their susceptibility to parasites when stressed by pollution. Additionally, much evidence clearly connects stresses caused by salinity effects and crowding to disease-caused mortality in the Chesapeake and elsewhere.

Also, the presence in numbers of certain parasites and pathogens may be useful as indication of stressful conditions in fishery populations; thus, interactions, too, should be considered.

Sub Project

Organized research efforts which will uncover and/or elucidate the various parasites and pathogens which can infect the several species of economic, ecological or aesthetic importance in the Chesapeake are needed. Of special importance is research to provide details of life cycles, routes of infection, actual or potential pathogenicity, and mechanisms of control of the most important species. Necessary also are studies to examine the environmental, natural and man-induced interactions and the several key parasites and pathogens acting upon the socioeconomically and ecologically important species.

This should be a concerted effort among institutions and specialists concerned with Chesapeake Bay phenomena.

PROJECT: Research on the Impacts and Possible Control of Predators on Species of Importance to Fisheries

That predation affects fishery (and wildlife) populations is well-established; however, despite the availability of considerable data on predation in the Chesapeake system, evidence is incomplete on its relative importance in population dynamics of important species of molluscs, crustaceans and finfishes, especially the former. Regarding significant predators known to influence production of oysters and clams, long sought, control measures have not yet been developed. As is common in fisheries and wildlife research, the focus of research frequently shifts as new pressures emerge; such is the case of work on the predators of important fishery stocks. For more than a decade research on such important ones as the oyster drills, Urosalpinx cinerea and Eupleura caudata, has stagnated, creating a serious hiatus in the efforts to understand and develop effective control measures.

Questions persist on the degree to which predation and changes in pathogens compete with other mortality-causing factors such as harvesting, aging, catastrophic natural events, depredation and alteration of habitats, nutritional shortages and diseases. These questions need to be answered to permit more effective modelling and management.

Research and monitoring efforts should be undertaken or resumed which will fill this important gap in the current knowledge of the oyster drills and other important predators such as bluefish and striped bass and their impacts on the prey or forage species, and vice versa.

While controls on bluefish or striped bass are obviously not desirable for reducing their impacts on prey species, it is important to understand their roles in the dynamics of other commercially or recreationally important organisms and also their dependence with their prey. Controls are desirable for the oyster drills to reduce their adverse effects upon oyster production. At the same time it is important to understand the possible ecological impacts of controlling them.

RESEARCH AREA 10
RESEARCH ON SURVEY AND MONITORING NEEDS FOR FISHERY AND WILDLIFE RESEARCH AND MANAGEMENT

PROJECT: Improved Sampling Techniques for Determination of Population Stocks and Evaluation of Factors Affecting Management of Fish Stocks

Introduction

The availability of increasingly sophisticated analytical capability and the development of mathematical models to analyze and understand fisheries population dynamics have underscored serious problems in information gathering. Many specific bits of information are not available and some parameters have not been adequately sampled or measured. The result is an inability to make use of available analytical capability to its fullest. Further significant questions persist about the results obtained with such severely limited information.

Collection of information and samples is time-consuming and, therefore, expensive. However, it is clear that improved, cost-efficient sampling techniques must be developed if the complexity of environmental variables are to be understood and fisheries managed for optimum values. Lack of information on stock characteristics and life history was most often cited as the reason for lack of greater modeling efforts (Review and Evaluation of Fisheries Stock Management Models, MD DNR, Tidewater, 1980).

Analysis and adoption of fishery conservation and management options often involves non-biological considerations. Even though biological measurements are often available and can be analyzed in an uncomplicated fashion, they may not be sufficient. Such analyses often do not result in a full formulation of management strategies directed at multiple-use goals. Although the thrust of this project is to improve sampling techniques for determination of population stocks, sampling of all relevant non-biological fctors must also be efficiently conducted and improved in order to utilize them in the evaluation.

Sub Project

The objective of the project is to improve biological and non-biological sampling techniques and to obtain information cost-efficiently.

The approach will be to select a multi-species fishery that involves a wide array of information needs, diverse perceptions of the values of the stocks and non-biological constraints (e.g., gill net fishery). The hierarchical importance of each bit of information will be organized beginning with formalization of objectives and proceeding through a matrix of the entire range of information and sampling required.

RESEARCH AREA II
ESSENTIAL FUNDAMENTAL RESEARCH

PROJECT: Identification of Food Chains

Organisms ingest food but what they eat and which foods are optimal are questions largely unanswered. Countless studies on predator species have been conducted to determine food items of importance. However, we know very little about the complex food chains which support the hierarchy of prey species.

The Atlantic oyster and blue crab, while well-studied, are relatively unknown in terms of their food requirements in the wild. We know little about bacteria-phytoplankton-zooplankton speciation in the Chesapeake. We know little of the requirements of fish larvae, molluscan larvae and crab larvae relative to bacteria-phytoplankton-zooplankton.

There is critical need to begin long-term, fundamental research on the systematics of unicellular organisms.

Recent research on phytoplankters and changes in speciation strongly indicate that some net-phytoplankton species under pollution stress give way to nanoplankters. Traditional chlorophyll a and photosynthetic measurements suggest that productivity continues at the same level but studies of phytoplankton feeders demonstrate significant reduction of feeding on nanoplankters.

In this time of accelerating multiple-use demands on the estuary, of non-point source runoff and resultant water quality change, we must begin to identify at least the basic organisms of the food web complex, determine their environmental requirements and discover what second-, third- and fourth-order organisms feed upon.

PROJECT: Nutritional Requirements of Economically Important Shellfish

Research on the nutritional requirements of the larval stages of hard clams and oysters under laboratory culture has received much attention, and the various species of dinoflagellates and algae which give optimal growth and survival are well known. Additional studies have shown that various amino acids and lipids are important nutritional requirements. None of these studies, however, has resulted in the development of an artificial food for larvae which is as satisfactory as algal cells or dinoflagellates.

We are lacking a basic understanding of the nutritional requirements of adult oysters and clams. While these two species may be cultured in the laboratory using algae, growth is less than in the natural environment; and the volume of algae necessary to maintain even 2-3 bushels of oysters is enormous. No artificial diet has been developed.

One important aspect of growth which is frequently ignored in artificial feeding studies of adults is meat size or meat quality. Frequently, oysters of the same shell size (length) may exhibit major differences in the size of the meats. Those of low quality are watery in appearance, and have a low glycogen content; those of high quality are larger, rich in glycogen and the most desirable from a commercial aspect.

The basic cause of this variation in meat size is poorly understood. It can be affected by the presence of diseases, crowding or fouling, but research at the Virginia Institute of Marine Science and elsewhere indicates that particulate and perhaps dissolved carbohydrates are of major importance in nutrition. Corroborative data from the field, however, is lacking.

There is a need to know more as to why oysters from one estuary may consistently produce high quality oysters and those from another grow only thin watery meats which, from a commercial aspect, have little value. Known causes such as disease, fouling and crowding, explain only part of the differences.

There also is a need to know more about the nutritional requirements of adult oysters and hard clams for other reasons. This knowledge would enable scientists to understand and perhaps even predict rates of growth and meat yields of adults in the field. Also, it would be of major benefit to those who wish to grow these two species on known diets in the laboratory.

The first approach to the problem would be a series of field studies which would measure the volumes of dissolved and particulate carbohydrates in estuaries in relation to growth of oysters (shell), meat size and glycogen content. Following this would be laboratory studies which would attempt to develop an artificial diet based on the results of field studies.

NEEDS FOR RESEARCH RELATED TO WILDLIFE

RESEARCH AREA
WILDLIFE HABITAT

PROJECT: Study of Wetland Values

While there is general recognition that certain species of wildlife are dependent upon wetlands for all or part of their subsistence, in general the ecologic relationships are not well understood. Further, the magnitude of contributions of nutrients of tributary Chesapeake Bay wetlands to the productivity of the Bay is largely conjectural.

Before far-reaching and environmentally important decisions about wetlands use can be made as the basis for comparison of benefits gained or lost in the life system of the Bay, more knowledge of wetlands and their role in the Bay system must be secured. Furthermore, the kinetics of energy transfer mechanisms of marsh-estuarine systems, while they have been studied in some areas, have not been developed for the Chesapeake Bay. Until this information is obtained, there can be no rational determination of the relative values of the various components of the natural system of the Chesapeake Bay.

Substantial areas of Bay wetlands have been impaired by pollution or deposition of solid wastes; and even greater amounts have been destroyed by dredging and by the utilization of wetlands as locations for deposition of fill materials, usually urban wastes, surplus earth from construction projects, or filling deliberately carried out to provide building sites for homes, industry and other human pursuits. In many situations the affected wetlands have been of relatively small size. Consequently, little attention has been given the cumulative effect of dozens of relatively small acts of destruction. Yet the net effect may be highly significant to estuarine and wetlands dependent resources and to large portions, if not all, of the Chesapeake Bay.

It has been postulated that marshlands in general, and tidal wetlands in particular, are among the most productive of all the elements of natural ecosystems. Various interpretations have been derived from the data available, ranging from hypotheses that the bulk of wetlands fertility is converted in time to hydrocarbons to conjectures that the net biomass is increased only indirectly and at rates that vary with temperature, salinity and other environmental factors. There is little doubt, however, that the estuarine-dependent species (those which use the Chesapeake Bay throughout their entire lives or at some stage of their life-cycle development) are dependent on the wetlands for food and other essential habitat elements. The wetlands are especially important to many species of fish, crustaceans and molluscs, all of great direct and indirect value to mankind, in addition to their roles in the total ecosystem. The same is true for amphibians and reptiles, as well as those which contribute to the efficient functioning of the total ecosystem but have negligile visible value in commerce or recreation.

As a principal wintering area for several hundred thousand wild ducks, geese and whistling swans, the Chesapeake Bay is of international significance. These birds, as well as most of the other birds that live in the Bay and its wetlands, are protected from excessive hunting by international treaty;

each country (Canada, United States, Mexico, Japan and the Soviet Union) has committed its government to encourage protection for habitat. A manifestation of this high-level concern may be found in the six national wildlife refuges located on the Bay or its tributaries. In addition, both Maryland and Virginia have set aside substantial wildlife conservation areas in the wetlands of the Chesapeake.

Because of the aforementioned factors and despite the advances in scientific knowledge and management capability, additional scientific effort is required. Several research areas are important.

Sub Project 1. Significance of Chesapeake Bay Wetlands to Resident and Migratory Wildlife

Objective

To determine the significance of Chesapeake Bay wetlands (fresh swamps and marshes, and tidal marshes) to resident migratory wildlife.

Approach

A series of test plots will be established in a representative series of wetlands from the upper to lower Bay. Data required will include not only qualitative and quantitative determinations of plant and animal life and remains, but also a complete series of data related to the physical and chemical character of each wetland and its accessory drainage or flooding system. The most advanced system of data comparisons will be employed to derive the final estimates of productivity. Simultaneously, descriptions of energy transfer through the food-web and associated reduction and elaboration systems in each biome will be identified, characterized and qualified in terms of each component and the whole.

Costs and Direction

This project will require a minimum of 10 years with the first two years devoted to project design, implementation and critique; five years to field and laboratory study and experimentation; and three years for analysis of data and report preparation.

In addition to a project coordinator responsible for the direction of the total program, there should be about five principal staff membrs, two of whom will be supervisory ecologists, one each plant and animal ecologists, and one experimental design and data management specialist. the functional field staff will vary from six to fifteen; support staff will consist of approximately twelve sub-professional assistants, seven clerical and five maintenance and support personnel. First-year costs are estimated to be $750,000.

Sub Project II. Effect of Cumulative Destruction of Wetlands

Objective

Determination, qualitatively and quantitatively, of the significance to resident and migratory wildlife of the incremental destruction or impairment of Chesapeake Bay wetlands.

Approach

This will utilize a computer model to be developed simultaneously with Sub-Project I but with a separate, integrated staff. In practice, the areas and production indices will be determined and evaluated by Sub-Project I. As that work is developing, a small, sophisticated staff of about five professionals would begin the tentative design of a Bay wetlands model. By the fifth year data will be flowing from the parent project and will be programmed into a computer. Continual refinements will be made in the manner in which the data may best be stored, programmed and retrieved, in order to eliminate to the maximum extent the necessity for modifications when the actual data begins to come on line.

Meanwhile both staffs will be interacting with respect to acquisition and selection of data, recognizing that the essentiality test must grade not only the natural significance of the information but its susceptibility to automatic processing.

Once a critical threshold of data has been obtained by Sub-Project I, this project will begin to process not only the historical experience, but variable projections in character, location and area of wetlands, at time intervals optimal for planning and for decisions related to wetlands protection.

The development, analysis and interpretation of these data will permit useful estimates of losses and gains, first approximations of the possible courses of effects on wildlife, and efficient design of the research required to comprehend the processes involved and determine the courses of various effects.

MONITORING NEEDS FOR FISH AND WILDLIFE

MONITORING AREA I
MONITORING NEEDS FOR RESEARCH AND MANAGEMENT OF FISHERIES AND WILDLIFE OF THE CHESAPEAKE BAY

PROJECT: Monitoring Needs for Research and Management

Monitoring--the continual, repetitive sampling, analysis, recording and reporting of selected features which are of importance to the phenomenon under study or control--is extremely important to science and to management. With renewable natural resources, subject to the many interactive influences over time of nature and man, our understanding of the ecological, economic and socially relevant "parameters" is vital to both.

Understanding of the factors affecting fishery stocks and the fisheries and wildlife populations and the users requires the ability to measure the essential natural and man-influenced processes involved in each, to detect changes, distinguish significant factors, separate long-term from short-term effects, distinguish aperiodic from periodic events and determine relationships. Thus, fishery and wildlife scientists must have access to the products and services of useful monitoring programs.

To manage fishery and wildlife harvesting, processing and selling activities effectively, preserving the stocks for posterity and yet allowing maximum use, requires understanding of the important factors, recognition of causes-and-effects, recognition of change and its direction, reliable anticipation or prediction, and the ability to determine through appropriate feed-back mechanisms the effects of management and development measures.

Monitoring then is an activity important to fishery and wildlife science and to management. It must not be ignored in the development of any effective research program designed to improve scientific understanding and management of fishery and wildlife resources and of the harvesting and production activities dependent upon them.

To be most useful to science and management, monitoring activities must (1) cover the important features of the populations involved, (2) cover the key organisms that affect those populations, (3) include the critical aspects of their habitats, (4) incorporate observations of essential factors of management, harvesting and production, and marketing efforts, and (5) be planned and executed. Adequate provision for quality-control, standardization, data management, review and revision must be included in any large-scale, large area monitoring program. For most Chesapeake fishery and wildlife activities, the area involved would be quite extensive covering the entire Bay and its tributaries and the critical approaches and other influential adjacent areas.

Several organizations must be involved in any Bay-wide monitoring effort. There could be many users or customers of the output of such efforts whose needs should be considered. Consequently, careful joint planning, standardization of methodologies, measurements and reporting, intercalibration of instruments, sampling and analytical techniques, compatibility of data, data processing and rapid availability of useful information must be assured. These criteria must be applied to populations of fishery and wildlife species (i.e., species of economic and social importance), to populations of organisms on which those fishery and wildlife stocks depend (i.e., species of ecological importance)*, of all important man-affected and natural environmental features and of the production activities dependent upon them. They may also have to cover important relevant economic and sociological parameters. They should cover the essential features required to allow understanding and effective management; thus, large-area and synoptic efforts will likely be involved.

Initially, <u>surveys</u> may be required to determine the nature and extent of anticipated monitoring activities, especially for new projects. Monitoring programs must be properly designed, to minimize costs and avoid collection of useless data.

For some purposes monitoring may be a relatively short-lived activity and can be discontinued when basic requirements have been met. For many pur-

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* Definitions: 1. Species of economic importance are those of significance in commercial and recreational catches. 2. Species of ecological importance are those of significance to maintenance of economically important species and continued functioning of important estuarine processes.

poses, however, it will require a long-term effort due to the dynamics and essential complexities of the features being studied or managed. Many relationships can be determined only after decades or even centuries of observations.

Sub-Projects

1. General - Monitoring needs related to migratory species or wild stocks.

   a. Distribution, abundance and condition of juvenile populations of economically and ecologically important species, such as:

      Eels - Anguilla rostrata

      Shad - Alosa sapidissima

      Herring - Clupea harengus

      Menhaden - Brevoortia tyrannus

      Striped Bass - Morone saxatilis

      White Perch - Morone americana

      Croaker - Micropogon undulatus

      Spot - Leiostomus xanthurus

      Weakfish - Cynoscion regalis

      Speckled Trout - Cynoscion nebulosus

      Summer Flounder - Paralichthys dentatus

      Forage Species - Anchoa mitchilli, Dundulus heteroclitus, Menidia menidia, Menidia beryllina and Cyprinodon variegatus

      Blue Crabs - Callinectes sapidus

      Oysters - Crassostrea virginica

      Hard Clams - Mercenaria mercenaria

      Soft Clams -Mya arenaria

      Others - Sea nettle, waterfowl, other birds, reptiles, mammals.

   b. Distribution, abundance and condition of adult populations of economically and ecologically important species (as listed).

   c. Distribution and abundance of important food organisms, competitors or predators.

   d. Distribution and abundance of important parasites and pathogens.

2. Monitoring Needs Related to Environment of Fishery Organisms and to Other Economically or Socially Important Uses and Users.

   a. Monitoring of the production and/or use by industrial operators of chemical products of actual or potential toxicity to both economically and ecologically important species.

b. Monitoring of point-source contaminants from industrial, municipal and domestic outfalls of importance to fishery organisms and other key elements of the biota.

c. Monitoring of non-point source contaminants of importance to fisheries organisms and other key elements of the biota.

d. Monitoring of key biological, chemical, geological and physical parameters of ecological importance to fisheries populations (and other key elements of the biota) including:

Salinity

Temperature

Oxygen, BOD, COD

Insulation

Transparency

Nutrients, (Orthophosphate, ammonia, nitrates--nitrites)

Meteorological and climatological events

Productivity (Chlorophylls a + b, biomass, key autotrophs, heterotrophs, phytoplankters, zooplankters, nectonic and benthonic species)

Blooms and red or mahogany waters

Submerged aquatic vegetation, including algae

e. Monitoring of wetlands, shorelines and bottom modifications via permits and regular inventories.

f. Tracking of oil contaminants from shore facilities and vessels.

g. Monitoring of distribution and abundance of important bacteria and fungi.

3. Special--Applies to organisms under economic levels of "culturing" or farming, i.e., oysters and clams, especially oysters.

Spatfall monitoring (Bottom and collectors)

Adult monitoring (Bottom and collectors)

Monitoring of yields (Bushels, meats, condition index)

Monitoring of distribution and abundance of predators, parasites and pathogens of oysters

4. Improvement of Techniques

Every monitoring effort must be carefully designed and appropriate research may be required to assure that the collection method, schedule of sampling, location of stations and specific observations obtained are appropriate and adequate for the uses to be served.

As an example, it is recommended that a complex multi-species fishery, such as the pound net or gill net fishery, be selected and critically studied. Formal objectives should be stated, including development of effective techniques for monitoring, and full consideration must be given to the seasonal, compositional, environmental and economic aspects of the monitoring design. A matrix should be developed and used, including the entire range of information needed and sampling required.

CHAPTER 2
TRANSPORTATION

Committee: A.E. Robinson, Chairman,
Waldon R. Kerns, Karl Kuhlman

PREFACE

This chapter represents the effort of a three man work group. None of the members of the group are experts in transportation; thus, the information contained here represents a consensus of understanding based on the study of materials available at Windmill Point, Virginia, their previous associations with experts in the field, as well as their own experience. It is not intended as a comprehensive thesis on research needs, but is, rather, a primer on those needs.

INTRODUCTION

In the Chesapeake Bay area, people and goods are transported by railroads, airplanes, highways and the waterway. All of these have, in some manner, an influence, direct or indirect, on the vitality of the Bay's social, economic and environmental values. While the use of the waterway for waterborne commerce and recreational boating apparently affects Chesapeake Bay the most, only waterborne commerce will be discussed here; recreational boating will be included in other sections of this report. (In addition, a complete description of waterborne commerce is included in the Corps of Engineers Existing Conditions Report and Future Conditions Report).

Since the founding of the nation, waterborne commerce has been the subject of much interest and sometimes controversy. This has been manifested in the institution of a number of research projects concerned with the development of more efficient dredging processes, methodologies to predict socio-economic and environmental needs and outcomes, investigations of the effects of the dredging process, and investigations oriented to solving the perplexing problems associated with the placement of dredged materials.

Research on socio-economic concerns has been rather limited with most of the activity taking place within governmental agencies or educational institutions. In some instances, such as government structure, only a few case studies have been done or the analyses have been part of reports focusing on other issues. For instance, research to provide background information on resource use tradeoffs among competing and conflicting uses is only in its infancy.

The research associated with dredging operations focused on two areas: the development of less costly dredging techniques and methods for minimizing environmental disruptions. This has been a world-wide effort with nearly all major nations making important contributions. The dredging industry is in the process of adopting many of these new techniques. It is anticipated the research of this type will continue, with much of it being done by the private sector.

The Corps of Engineers Waterways Experiment Station completed in 1978 a comprehensive dredged material research program. This program addressed many questions related to defining the water quality and biological effects of open water, upland and wetland dredged material placement; improving the effectiveness and acceptance of confined land placement where it is a desirable alternative; testing and evaluating concepts of wetland and upland habitat; and developing and testing concepts of dredged material as a productive resource. In addition, there have been specific efforts by the Chesapeake Bay scientific community associated with the investigations necessary to obtain permits for dredging and during the studies of the feasibility of deepening the channels leading to Baltimore, Hampton Roads and other bay area ports. Some of these investigations made use of the Chesapeake Bay Model.

RESEARCH NEEDS

It appears, at this time, that much of the basic waterborne commerce related research has been addressed, at least in a framework context. This does not mean, however, that no future research is needed. Quite the contrary is true. The approach of some of the previous work has been too generalized; consequently, little attention was sometimes paid to site specific problems. In addition, there are studies where no final conclusions could be reached, or substantiation for the conclusions was weak. It is the opinion of the work group that future waterborne commerce related research in the Chesapeake Bay should strive to fill these data needs and should be oriented to providing the site specific information necessary to make intelligent management decisions. Examples of this type research include the following projects.

PROJECT: Development of a Better Understanding of the Hydrodynamics of the System (High Priority)

Chesapeake Bay has been characterized as a partially mixed estuary. The physical process which control its hydrodynamics include astronomical forces (tides), freshwater inflow, temperature, density differences and wind. It is the ultimate culmination of these forces which creates the environment upon which the life cycle of many of the species that live in the estuary are dependent. Although there have been many productive studies, there is still only a partial understanding of the hydrodynamics of the bay and its interaction with the biota.

The key to gaining these understandings is prototype study supplemented by studies on the Chesapeake Bay Hydraulic Model and numerical models, as well as laboratory work. This work should be approached from a Bay-wide perspective oriented to synoptic sampling over periods of time sufficient to allow the segregation of the various driving forces. Inherent in this is the development of automated instrumentation that can be left unattended by significant periods of time.

The C&D canal is a special case involving a particularly complex situation. This should receive early attention that takes precedence over other hydrodynamic related work. This research project would be a multi-million dollar effort extending over several years.

PROJECT: A Better Understanding of the Properties of Dredged Materials (High Priority)

Prior to dredging, it is important to know the types of materials expected to be removed, as this can be a critical factor relative to the choice of the equipment and methods to be used in disposing of the materials. The field work involved would consist of hydrographic surveys delineating the boundaries of various type materials and the taking and analysis of bottom samples. Critical factors which should be evaluated include:

Soil type (clay, etc.)

Specific gravity

Settling rate

Presence of contamination

Processes involved in the takeup and release of contaminants by soil particles

Form and toxicity of the pollutant under various conditions (aerobic, anaerobic, etc.)

Factors contributing to flocculation

Although this project could be approached from a Bay-wide perspective, perhaps it would be better to concentrate opportunistically on those areas where dredging is imminent. In this manner, the time expended could be limited to several years and the cost to several tens or hundreds of thousands of dollars. It should be noted that the studies for most of the projects now being undertaken in the Bay already include many of these analyses.

PROJECT: A Better Understanding of the Biology of the System (High Priority)

Both the process of dredging and the placement of the resulting materials could have adverse consequences to the organisms and plants which reside in the Bay. To predict these consequences, a better understanding of the biology of the system is needed; included in this are:

Factors involved in the transport of species

Interaction of species

Systems for measuring the health of the system

Indentification of indicator organisms

Causes of and methods for controlling leaking of contaminants in disposal areas

Some of these problems are addressed in more detail by other work groups.

PROJECT: Develop Refined Methods of Making Socio-Economic Projections which Incorporate Existing Scientific Information (High Priority)

Population and econimic projections exist, but models must be developed which allow for incorporation of these projections with scientific information and ultimately provide for getting the information into the decision process: What impact will various types and quantities of commodities have on transportation needs? What economic conditions/parameters influence channel dredging and port expansion? How can socio-economic projections be modified to reflect demand for competing uses of water resources as alternatives to expanded transportation uses? What are the important scientific factors or indices which are needed to resolve conflicts among economic interests in the Bay?

PROJECT: Develop Effective Means of Facilitating Communications Between the Private and Public Sectors (High Priority)

Most transportation activities have off-site impacts. Also, these activities take place in both the private and public sectors and often seem to be in conflict. What are the factors which influence activities (such as increased coal shipments) in each sector and how can these factors be controlled? What types of institutions with respect to organization and operations are most effective, most efficient and politically viable within each sector? What process will allow for decisions on allocation of limited resources between increased transportation and alternative uses within each sector?

PROJECT: Develop Traffic Control Patterns that Mitigate the Effect of Congestion in Water Systems and Port Support Facilities (High Priority)

Increased vessel size and number and large transportation services will add to traffic congestion and surface use conflicts. This is a site specific problem and has become critical in some estuarine areas. What level and location of port support facilities are consistent with other water and land area activities? What is the best form of traffic control for reducing conflicts.

PROJECT: Monitoring (High Priority)

It is suggested that monitoring programs be established to assess the social, economic and environmental consequences of dredging projects. The work must begin several years before the dredging is started so that baseline conditions can be established. It should then continue through construction and beyond. Representative parameters which should be monitored include:

Turbidity

Salinity

Species numbers

Leaking of materials at disposal areas

Water quality

Ground water

Shoaling rates

In some cases, methodologies for monitoring will have to be developed.

PROJECT: Better Understanding of the Sources and Transport of Sediments (Medium Priority)

One of the primary causes of the need for dredging is the maintenance of existing channels. If it were possible to prevent the shoaling of these channels, this need could be minimized. Site specific work is needed to identify the sources of sediment and the factors involved in its transport. Once these are known, investigations should be undertaken to develop methods to prevent or minimize shoaling.

This project would be a field oriented one involving the tagging of materials and the tracing of their movement. A long-term record would be required. Once the prototype is better understood, a numerical transport model would be helpful in analyzing a variety of conditions. Each site specific project would involve several man-years of work and expenditures approaching hundreds of thousands of dollars.

Although much research has already been done, studies oriented to determining the effectiveness and economic efficiency of alternative structural and nonstructural measures to control erosion should continue.

PROJECT: Productive Uses of Dredged Materials (Medium Priority)

Much research has been done in an attempt to find productive uses for dredged material. Unfortunately few feasible proposals have resulted other than the use of the material as landfill. However, this type of research should continue and should include in addition to technical processes, the marketability of any resultant products.

PROJECT: Alternatives to Growth in Transportation Needs in the Bay System (Medium Priority)

One alternative in meeting increased transportation needs is to identify and develop alternatives to meet those needs. What would be the impact of comprehensive development of solar power, coal power and other energy sources on the need for transportation in the Bay? Identify foreign and other geographic area dependent activities that could be developed closer to the consumption area and thereby decrease transportation needs in the bay. Identify alternative shipment routes so as to lessen demand for transportation and port facilities. Identify and evaluate alternative recreational activities to lessen surface use demand.

PROJECT: Analyze Impact of User Fees on the Transportation Industry and Recreational Traffic in the Chesapeake Bay (Medium Priority)

On some rivers, user fees have been employed to pay for various water resources development projects and to manage various resources such as barge traffic. Research is needed to determine the impact on transportation of different kinds and levels of user fees. Research is needed to determine the feasibility and effectiveness of using fee receipts to mitigate damages from transportation activities or to finance research into other bay problems.

PROJECT: Develop Procedures to Mitigate the Effects of the Marine Environment and Organisms on Commercial and Military Vessels (Medium Priority)

Better methods of removing organisms from vessels and preventing clogging of intake pipes and structures are needed.

PROJECT: Develop Better Methodology to Evaluate Alternative Methods of Transportation (Low Priority)

One method of offsetting the impact of an increase in demand for transportation and port facilities is to develop more efficient transportation systems and port facilities. Alternative methods include such types as barges, rail, highway, bulk vessel traffic, inland navigation and trucking. Research to correlate the impact of new and improved alternatives on other uses of the waters is needed to facilitate efforts to implement more efficient (in terms of environmental quality) alternatives.

PROJECT: Research on New and Better Types of Vessel Propulsion Systems and their Impacts on Water Quality and Wake Control (Low Priority)

Vessel propulsion systems and the way they are used have a major influence on water quality and wake damage. Much work is underway on propulsion systems but scientific evidence of the impact on water quality and wake control could influence the adoption of new systems.

PROJECT: Research to Formulate a Regional and National Overview of Transportation Needs which Weigh the Advantages and Disadvantages of One Geographical Area Relative to Other Areas (Low Priority)

This research would consider all appropriate economic, social and environmental factors.

CHAPTER 3
WASTE PLACEMENT

Committee: Robert J. Huggett, Chairman,
David Correll, David A. Flemer, Kenneth E. McElroy,
John Roland, N. Bartlett Theberge, Harold Marshall, Frank O. Perkins

INTRODUCTION

Waste generation and placement are serious and complex problems facing those interested in the proper management of the Chesapeak Bay. To a large degree these problems are associated with increased population growth and commercial activity. A great deal of progress has been made in understanding the effects of wastes discharged into the Bay from point and non-point sources and much legislation has evolved to address water pollution problems.

Under federal water pollution legislation the ultimate goal is the restoration and maintenance of the physical and biological integrity of the nation's waters. The Water Pollution Control Act as amended contains regulations on specific abatement time frames, point source effluent limitations (K301), certain nonpoint source controls (K208), toxic and pretreatment standards for municipalities and industries, oil and hazardous waste provisions (K311), marine sanitation controls (K312), general prohibitions against pollutant discharge, unless by permit (K402), and control over dredge and fill activities. Problems associated with toxic substances and solid wastes have been addressed under the federal Toxic Substances Control Act and the Resource Conservation and Recovery Act. Under these acts the development, manufacture, marketing use, transportation and ultimate disposal of such wastes are subject to stringent regulation. In addition to federal legislation, states have developed programs under federal aegis and through independent state action.

Although numerous state and federal programs addressing waste problems have been developed, there remain many gaps in understanding how various wastes impact the Bay. Also, as might be expected, there are attendant uncertainties as to the management or control of certain wastes.

The generation of wastes is related to increased population and commercial activity. Population in the Bay area is projected to increase from a 1970 figure of 7.9 million to 12.1 million in 2000 and 16 million in 2020 (Chesapeake Bay Future Conditions Report, Vol. 1). As population increases, so does the total amount of water for human consumption. Concomitant with increased population is increased human waste and sewage outfall. Also associated with increased population is increased development and urbanization leading to higher rates of sedimentation. Areas subject to construction and development contribute 50 to 100 times as much sedimentation as would rural or forested land (Chesapeake Bay Existing Conditions Report, Vol. 9. Sediments also play a role in the introduction of other pollutants into the system. In the past sedimentation has ranked above sewage, industrial waste and chemicals as a major cause of water pollution (Chesapeake Bay Future Conditions Report, Vol. 1). The natural processes of sedimentation ultimately create a dredged spoil disposal problem of significant magnitude. Chesapeake Bay has some of the nation's most important ports. The maintenance of these channels to meet shipping needs is vital to local, state and national economies.

Manufacturing activities, often associated with chemical pollution, are expected to increase 219% from 1969 to 2000; water use by industry is expected to increase 229% during this period (Chesapeake Bay Future Conditions Report, Vol. 1). Nutrients largely associated with human population growth and agricultural practices are expected to increase significantly during the near future.

The following categories of wastes have been identified as being subject to research priorities with the full understanding that it is impossible and perhaps improper to isolate one category from another, except for purposes of discussion and analysis:

1. Chemical Wastes
   (a) Organic
   (b) Inorganic
2. Sediments
3. Microbes
4. Nutrients

In addition to the selection of these categories of pollutants as areas deserving research priority, another research area deserving priority has been identified. Further research into bioassay techniques is needed if we are to fully understand and properly control the impacts of pollutants upon the marine environment of the Chesapeake Bay.

Research dealing with these issues will enhance understanding of the effects of certain wastes on the Bay and by so doing aid the development of waste placement criteria--a sorely needed management tool.

CHEMICAL WASTES

PROJECT: A Data System for Xenobiotic Organic Chemicals in the Chesapeake Bay

Project Significance and Description

Perhaps the most difficult chemical pollutants to work with in aqueous systems are in the xenobiotic organics. This is because of the large number of organic compounds present in a sample and the difficulty, and therefore expense, of analysis of such complex mixtures. Partly for these reasons, most research along these lines in the Chesapeake Bay has centered on relatively few compounds such as chlorinated pesticides, phthalate esters and PCBs. Analytical techniques were developed which excluded as many as possible of the other non-sought and possibly interfering substances. Obviously much information was lost. Technology is now available to help alleviate this problem. With the development of capillary columns for gas chromatography and computerized data systems--to name two--the vast amount of data generated can be stored, manipulated and recalled. The organic content of one sample can be compared with others. Trend analyses can be performed on compounds which are unidentified, yet present. The key to such a system is the use of a standard relative retention index for gas chromatography and gas chromatography-mass spectrometry. There are several such indexes in existence. The present need is to come to a consensus as to which is best and develop the software to allow the data systems of one laboratory to communicate directly with those from other laboratories. The advantage of such a system would be to expand the organic data base immediately and give all investigators and managers ready access to all the data.

Objectives

1. To determine the best relative retention index scheme to use for gas chromatography, gas chromatography-mass spectrometry.
2. To develop the computer software to link different data systems from different laboratories with the goal of a regional network if anot national.

Cost and Duration

The estimated cost is $200,000-$300,000 for 2 to 3 years.

PROJECT: The Fates and Effects of Chlorine and Organohalogens from Sewage Treatment Plants and Facilities Requiring Antifouling Treatment of Cooling Waters

Project Description and Significance

Oxidizing agents, particularly chlorine, have been and are being used as biocides in sewage waste and cooling water. The benefits of such usage are the protection of public health for the former and efficiencies of heat exchangers for the latter. If the compounds are used in excess, the potential for toxic effects on the biota of the receiving waters exists. A considerable effort has been and is still being expended on the fate and effect of chlorine and chloramines in fresh and estuarine waters. Less has been done on the organohalogens which are produced by the action of chlorine on organic compounds present in the waters being treated. Organohalogen compounds which have been detected in the receiving waters around power plants and sewage plants in the Chesapeake Bay system include: chloroform, trichloroethane, trichloroethylene, bromodichloromethane, dibromochloromethane, tetrachloroethylene and bromoform (Bieri et al. 1981).

The relatively high toxicities of chlorine and its ammonia derivatives, chloramines, to estuarine species have been established. Fortunately, their residence times in natural waters are relatively short. Therefore, control strategies to protect the Bay's inhabitants may be possible with our existing knowledge. However, the fates and effects of the organohalogens are less understood. With the probable future increase in human population density in the Bay region, it is likely that the introduction of these compounds will increase. Therefore, research is urgently needed to assess the existing and potential impact of organohalogens from waste and cooling waters on the Chesapeake Bay.

Objectives

To determine fate and effect of organohalogens on the biota of the Chesapeake Bay system would include the following:

1. A chemical understanding, including kinetics, of the formation of these compounds in sewage wastes and cooling waters.
2. An understanding of the transport and storage phenomenon for the compounds in estuarine waters including solution and sorbed phases.
3. An understanding of the chemical and biological half-lives of these compounds in estuarine waters.
4. An understanding of the toxicities of these compounds to the Bay's inhabitants.

Costs

It is estimated that such a project would run between $300,000 and $500,000.

Related Studies

1. Adsorption-desorption studies
2. Bioassays

References

Bieri, R.H., P. deFur, R.J. Huggett, W. MacIntyre, P. Shou, C.L. Smith, and C.W. Su. 1981. Organic Compounds in Surface Sediments and Oyster Tissues from the Chesapeake Bay. Final Report to the U.S.E.P.A. Chesapeake Bay Program. Grant No. 806012010.

PROJECT: Trace Metal Research Needs in the Chesapeake Bay

Project Description and Significance

In the past two decades, a large body of data has been accummulated on trace metals in the Chesapeake Bay system. This was brought about, in large part, by the development of new, more sensitive analytical instrumentation such as the flameless Atomic Absorption Spectrophotometer. But until the last few years most work centered on a few elements such as copper, cadmium, zinc, lead and mercury. This may have been due to the ease of analysis as well as public health reasons. Now, data on many more elements are being generated. The list is expanding to include such elements as arsenic, silver and selenium. It is probable that research reports now being written under the U.S. EPA Chesapeake Bay Program will greatly aid our understanding of these elements in estuarine waters. However, more research may be needed on these substances relative to their fates and effects in the Bay.

A subset of the trace metals that has been largely ignored is the organometallic compounds. Such substances as tetraethyl lead and butyl tine are toxic. They are entering the Bay system from automobile emissions in the case of tetraethyl lead and antifouling paints in the case of the organo tins. We know very little about them.

Research is needed to determine the present state of the Bay relative to organometallics, which includes the persistence, transport mechanisms, storage sites dna biological effects in estuarine systems.

Objectives

1. Development of analytical techniques to determine the organometallics in sediemnt, water and issues.
2. Determination of the transport and storage mechanisms including the solution and sorbed phases.
3. Determination of the chemical and biological half-lives of the compounds.
4. Determination of the toxicities of the compounds to marine and estuarine organisms.

Costs:

It is estimated that this project will cost between $500,000 and $1 million.

Related Studies

1. Adsorption-desorption studies
2. Bioassays

SEDIMENTS

PROJECT: Determine the Principle Roles of Sediment in the Storage, Transport, Release and Effects of Nutrients in Different Physical/Chemical/Biological Zones of the Bay

Objectives

1. Determine the different roles that sediments play within the Bay system with regard to sorption/desorption rates, suspension/resuspension

and long-term sinks for various zones of the Bay including but not limited to:

a. Tidal fresh tributaries

b. Zones of maximum turbidity

c. Lower tributary subestuaries

d. Oligohaline zones

e. Mesahaline zones

f. Small coastal embayments of varying salinity

g. Other zones as appropriate

2. Interpret these results to aid management in nutrient control strategy decisions.

Related Studies

The EPA Chesapeake Bay Program has not completely determined what role the sediment component plays in nutrient dynamics within different zones of the Bay. Their work should be continued and extended to better define the involvement of sediment in the nutrient enrichment process beginning as a first priority with those zones of the Bay that are currently demonstrating over-enrichment problems or have had problems in the past.

PROJECT: Characterization of Sediments in Potential Dredging Zones Focusing Primarily on the Tributaries and Heavily Used Transportation Areas within the Chesapeake Bay Proper

Objectives

1. Define the physical and chemical characteristics of the sediments in the described areas.

2. Develop indices for interpretation of the potential hazards of the various sediment types defined.

3. Interpret results for managers so that wise dredge material placement decisions can be made.

Related Studies

The EPA Program has characterized the sediments from the main stem of the Bay. Whether this data will be carried forward to an indexing strateby is not known at present. This effort should be undertaken with the inclusion of sediment compositon definitions in the tributaries.

PROJECT: Develop a Sediment Transport Model for the Bay Including Its Tidal Tributaries

Objectives

1. Identify the sources of sediment to the system and their relative contributions.
2. Route the sediment throughout the system. This will require a major effort to obtain estimates of rates of sediment flux through the tributary turbidity maxima and river mouths. A better understanding on Bay mouth flux may be needed.
3. Determine the sedimentation rates throughout the Bay system.
4. Interpret these rules for managers to:
   a. Predict dredging needs at various important locations throughout the Bay and provide a tool for long-range planning.
   b. Provide data to decision makers on the best locations for new channels.
   c. Provide the vehicle for management of sediment associated toxics and nutrients within the system.
   d. Provide the basis for decisions concerning land runoff control strategies.
   e. Provide a predictive tool for baseline sedimentation rates and during episodic events such as 100 year storms.

Related Studies

The EPA Chesapeake Bay Program will have completed a circulation model of the Chesapeake Bay and tidal tributaries upon which a sediment transport component can be built.

PROJECT: Determine the Role of Sediments in Transporting, Storing and Releasing Selected Inorganic and Organic Chemicals in Important Areas of the Bay

Objectives

1. Prioritize those areas or types of areas within the Bay where baseline data indicate that significant (in terms of hazard or risk) levels of specific chemical contaminants exist or potentially might exist in the future.
2. Develop the necessary coefficients and relationships for sorption/desorption and suspension/resuspension to provide data on the bioavailability of the material within the system.
3. Interpret these data to aid managers in making source control decisions.

Related Studies

The EPA Bay Program will have developed general relationships of sediment contaminant (primarily selected inorganics) flux in the system. Site specific work is needed to build on this information.

PROJECT: Determination of the Distinction Between Natural and Anthropogenic Sources of Sediment to the Chesapeake System and the Respective Relative Loadings

Objectives

1. Determine the sources of sediment to the system and relative contributions of each.
2. Develop the necessary relationships between man's activities and natural processes regarding sediment inputs.
3. Interpret results for managers so that responsible and meaningful control strategies can be developed.

SOLID WASTES

Solid wastes have reference to a wide-range of substances that include dredge spoils, sewage sludge, fly ash, and various industrial and manufactured products typically placed in land fills and dump sites. Many of these products may themselves represent potentially toxic substances, or convey such substances, or conditions, that may be hazardous to the health of humans or biota in the local ecosystem. Solid wastes are also significant in the use of these materials in landfill operations.

PROJECT: Reduction or Prevention of Leaching of Hazardous Materials from Solid Waste Placement Sites (Highest Priority)

Objectives

1. To improve the effectiveness of specific physical methods for increasing ponding or settling time in containment areas.
2. To improve containment techniques around spoil sites and landfill areas to reduce the leaching of materials into the surroundings and the Bay.

Approach

1. Conduct field investigations to improve the effectiveness of various consolidation techniques within the region.
2. Identify long-term needs for disposal placement in the Bay with the location of appropriate disposal sites.

Duration and Cost of Study

The majority of the above studies would require 12 to 24 months to complete at estimated costs that would range between $50,00 and $100,000.

PROJECT: Feasibility Study on Utilizing Sanitary Solid Wastes as Construction Material for Man-Made Offshore Islands

The technology for constructing man-made offshore islands has been well established. New offshore islands can reduce the impact of storm surge on the shoreline, reduce coastal erosion, induce acretion in some locations and provide new land sites for recreational or industrial usage. Specific questions that need to be answered would include: What is the engineering and economic feasibility of using sanitary solid wastes material as a major component of construction material for offshore islands.

Approach

Assemble a team of one or more each of engineers, physical oceanographers, waste management specialists and industrial economists to undertake a three-year feasibility study culminatng in a report on what would be involved in bringing such a project to fruition, if it appears to be feasible.

Duration and Cost of Study

The estimated costs include salaries for 5 to 6 professionals conducting the study over a 36-month period, travel, secretarial and support needs. Total estimate is $125,000.

Related Studies

1. Research directed at source reduction practices for solid wastes. To change manufacturer's practices and consumer habits to reduce the volume of solid wastes generated.
2. To investigate the reuse of sewage sludge or to remove harmful substances from waste stream before sludge is generated.
3. To investigate various recycling methods for fly ash and other solid wastes in relation to the abundance of these most common wastes within the bay region.

MICROBES AND VIRUSES

PROJECT: Determination of the Roles of Sewage-Derived, Viral Pathogens in the Marine Environment

It is well-known that sewage-derived viruses have a disturbingly long residence time in estuaries. Since they can accumulate and some can cause diseases, it is of importance to know to what extent they represent a threat to marine organisms and to humans. Since viruses are being observed to cause diseases and mortalities in a full phylogenetic range of marine organisms, it is important to know whether they are sewage-derived or whether their expression is related to the presence of other pollutants. The human viral pathogens may or may not be host specific and, therefore, must be regarded with suspicion.

The marine environment can clearly serve as a reservoir of human viral pathogens which can reinfect humans via shellfish consumed by humans; therefore, methods for detection of such viruses and knowledge of their residence times and the threat they represent must be developed.

Approach

Since detection of pathogenic viruses is accomplished utilizing metazoan cell lines in culture, the methods are expensive and time-consuming and thus do not lend themselves readily to ecological studies. Better detection methods are needed. If use of cell lines is to be the only method, then identification of more appropriate cell lines utilizing marine organisms is necessary. Such a shift in methodology would be particularly significant in studies of sewage-derived viruses on marine organisms. With such techniques available the researcher could better assess whether viruses are involved in diseases of marine organisms.

Methods for detecting the presence of sewage-derived pathogenic viruses which cause diseases only in humans need to be improved because, as stated above, the present methods are too expensive to be readily applied to ecological studies. If adequate methods are made available, then assessments of tolerable limits of sewage pollution could be made, for example, size of buffer zones around marinas as the zones relate to shellfish harvesting, levels of fecal coliform bacteria in shellfish or shellfish growing waters as they relate to numbers of viruses. Such studies have been conducted in the past; however, they have been hampered by the lack of ability to detect many viruses and by the small sample sizes which could be examined due to the expense involved.

Cost and Duration

It is difficult to estimate costs and duration, because the attempt to improve methodology is a high-risk venture. At least $300,000 and three years could be regarded as an approximation. Once the methodology is acceptable, the other research projects could begin; however, costs and duration are not possible to estimate.

PROJECT: Determination of the Roles of Sewage and Other Forms of Chemical Pollution in Expression of Microbially-Induced Diseases

Associated with sewage pollution are marine organisms in a diseased or stressed condition which can be traced to a microbial agent, usually of bacterial etiology. The question is whether the sewage provides the disease microbes directly or the sewage provides favorable physicochemical conditions for expression of the disease. It has been suggested that various chemical wastes such as agrichemicals cause the expression of protozoan diseases. While there is no evidence that such is the case, the charge cannot be disregarded because of the management and political implications. Therefore, studies should be conducted to resolve the issue.

Approach

Microbial disease agents should be identified and methods for control of their transmission and expression as agents of disease need to be developed. Selected pollutants, particularly those from the petrochemical and agrichemical industries as well as from sewage, should be applied to host organisms to determine if such pollutants in ecologically-significant concentrations do affect expression of diseases.

Cost and Duration

Since it is difficult to set limits on the research effort, it is difficult to estimate costs and duration. A reasonable starting project would consist of $200,000 and three years.

NUTRIENTS

Much relevant research was conducted in the 1970s on the biological effects of nutrient enrichment, the transport, deposition and biotransformation of nutrients in estuarine ecosystems, and the relative and absolute sources of key nutrients. These relate respectively to the impact, dynamics and sources of nutrients. However, we still lack an understanding adequate for management needs of all three of these aspects of nutrients in estuarine systems. General agreement exists that the key mineral nutrients are, in descending order, nitrogen, phosphorus and silicon.

Fixed nitrogen and phosphorus in various forms are widely used in agriculture and in residential areas as fertilizer. Both are also generated in large quantities by urgan populations (sewage) and livestock concentrations. Nitrogen oxides are also released in large amounts in the combustion of fossil fuels and returned to the system as nitrate. Nitrogen oxides and ammonia are also released to the atmosphere in significant amounts from croplands and "natural plant communities" impacted with high nutrients in land drainage. Weathering of soils is another major source of phosphorus, nitrogen and silicon compounds. The rate of these processes has been increased significantly by urban and agricultural development.

The application rates of fertilizers have increased rapidly with increased intensity of agricultural practices, primarily since World War II. The discharges of nutrients in sewage effluents have also increased due to population growth and the introduction of such consumer products as polyphosphate conditioners in detergents. Emissions due to fossil fuel combustion have increased rapidly and continue to increase. Increased emissions of nitrogen oxides from uplands due to denitrification are surmised in recent years due to increased agricultural fertilization rates. So-called fluvial inputs due to weathering no doubt increased a great deal in colonial days due to land clearance, but not in recent years.

The most important value of additional nutrient research would be the approach to the ability to provide the Bay with an optional level of nutrient enrichment to maintain high productivity of useful species but prevent over-enrichment. Certain aspects of our knowledge are presently inadequate to attain this goal.

PROJECT: Phytoplankton Responses to Increased Nutrient Enrichment

What are the responses

1. With respect to species composition?
2. With respect to growth rates?
3. In various parts or zones of the Bay?
4. With respect to different nutrients or ratios of nutrients?

The need is to answer these questions with the full gamut of potentially important species rather than in "pure cultures" or mixtures of a couple of species. Without these studies, models will not predict the answers we need.

The approach might be a variant from so-called "chemostat" experiments in which a steady stream of ambient Bay plankton and a separate stream of nutrient test liquid would be pumped through the appropriate hardware.

Cost and Duration

Probably several sites should work for several years with funding of $50,000 a year for each investigation.

Related studies might include examining various locales in the Bay which happen to be enriched in the desired manner, then test what plankton populations prevail seasonally.

PROJECT: How are Key Nutrients Transported and Transformed in the Tidal Waters of the Bay?

1. How do various nutrients partition on suspended particulates?
2. How are nutrients precipitated from the water column?
3. What factors control benthic regeneration rates?
4. Which forms of nitrogen and phosphorus accumulate in various parts of the system?

We need to understand how salinity, temperature, sediment type and organics affect nutrient partitioning so that we can construct useful models of water column and bottom sediment nutrient dynamics.

The objective is development of conceptually correct, useful simulation models. The approach would involve both laboratory measurements and field studies under a wide variety of conditions. The duration would be two years and then an assessment of progress.

PROJECT: How Can Key Nutrients Be Removed from Various Sources Before They Reach the Bay?

Investigations are needed on how nutrients can be removed from agricultural and residential land runoff, sewage and combustion of fossil fuels. A combination of engineering and ecological research will be required to provide the knowledge base; such research will require enormous financial resources.

The objective is to provide a tested set of innovative alternatives for management of these nutrient sources.

The approach would include inexpensive engineering alterations of agricultural and residential hydrologic systems to systemize nutrient trapping and denitrification by downstream communities, research on land disposal, especially overland flow, and better methods for removing nitrogen and sulfur oxides from fuel combustion systems. We have no estimates of either cost or duration.

BIOASSAYS AND ECOLOGICAL EFFECTS TESTS

One of the least understood aspects of dealing with the problem of waste placement in the Chesapeake Bay region has to do with predicting the impacts of materials released to the environment. Management agencies must have the capability to assess the ecological consequences of waste discharges to the Chesapeake Bay system in order to responsibly regulate these releases.

A number of tests have been developed and used that begin to address this problem. Some of these include the following:

1. Acute bioassays
2. Mutagenicity tests
3. Chronic toxicity tests
4. Terratogenicity tests
5. Species agundance and diversity indices in the receiving environment
6. Pathological and histological examinations
7. Behavioral response studies
8. Bioaccumulation tests
9. Comprehensive ecological studies in the receiving environment
10. Microcosm studies

Different forms of these tests have been used both in the field and in the laboratory on a sporadic basis to try to accurately depict the environmental consequences of anthropogenic inputs of materials such as inorganic and organic chemicals, sediment, nutrients and chlorine to the Chesapeake Bay system. The problem has been interpreting these test data which at best only simulate what is happening in the real world. Some of the questions that continue to be raised include: What levels of some of these pollutants can the system tolerate without demonstrating a negative impact and how well do existing biological assessment methodologies approximate these results? What are some of the interactive and synergistic responses within the system to wasteland stresses? How can one filter out natural variations within the system brought about by climatic events over which man has no control? What species or suite of species should be selected for testing and can laboratory or microcosm study results be realistically related to the actual Chesapeake Bay environment? What assumptions must be made in this evaluation? Which of these tests are cost prohibitive relative to meaningful information derived.

Certainly management decisions can and have been made in the absence of absolutely definitive data. For example, regulations have set action levels for compounds such as Kepone within the environment; these levels have had enormous economic and social impact. Questions are continually being raised (and will be into the 1980s) concerning the validity of some of these levels based on the available data.

Indeed, much research is needed to develop the best procedures and methodologies for assessing the ecological effects of these materials entering the Chesapeake Bay system as a direct or indirect result of waste placement activities.

PROJECT: Development of Cost-Effective Laboratory Procedures for Bioassay and Ecological Effects Testing

There is urgent need for adequate information with which to determine lethal and sublethal effects on bay biota of anthropogenic materials introduced to the system. Some of the higher priority types of wastes needing attention in the 1980s include the following:

1. Chlorine and its derivatives
2. Chlorinated hydrocarbons from chlorinated waste streams
3. Specific chemical contaminants (organic and inorganic) known or suspected to be present in wastes entering the Bay
4. Fly-ash leachate
5. Hazardous waste disposal site leachate
6. Dredging activities
7. Dredge spoil disposal site releases
8. Synergistic and interactive combinations of waste material

We know that these and other kinds of materials will continue to enter the Chesapeake Bay system into the 1980s and beyond, and new assessment tools as well as those that are currently available must be evaluated to properly regulate the sources of these inputs. Criteria for decision making based on test results should be established which accurately represents the best scientific interpretation of the data.

Products

1. Specific laboratory testing schemes would be developed and evaluated for the different types of wastes entering the system.
2. Criteria would be established for interpreting data results for regulatory control decisions.

The strategies being considered might vary regionally within the Chesapeake Bay system (if appropriate), depending on the characteristics of the local receiving waters. These might be based on certain criteria such as a predominant use classification or a characteristic physical/chemical or biological make-up (This begins to touch on potential zoning or segmentation strategies that may evolve in the 1980s.)

PROJECT: Development of Cost-Effective On-Site Assessment Strategies on Which to Determine Lethal and Sub-Lethal Effects of Waste Discharges

Products

1. Specific field study assessment procedures for dealing with the different wastes potentially impacting the system.
2. Decision-making criteria would be developed for regulatory control strategies.

PROJECT: Design of Cost-Effective Testing Framework for Conducting Long-Scale Ecological Impact Studies Associated with Waste Placement Siting Decisions

Product

An effective predictive tool for evaluating the environmental consequences of waste disposal decisions.

The link must be adequately made between a limited (in time and place) number of test data results and the actual environmental impact.

CHAPTER 4
RECREATION

Committee: John M. Williams, Chairman,
Will Baker, Kenneth E. McElroy, Virgil Norton

The open waters of Chesapeake Bay, their tributary river systems and adjacent shore areas provide recreational resources for millions of people to participate in leisure time activities ranging from sportfishing to tourism. The 8,100 miles of Chesapeake Bay shoreline and nearly 4,400 square miles of water surface provide some of the finest recreational boating areas in the country, while generally favorable wind conditions and ample deep water have caused the Bay to be recognized for sailing throughout the world. Sport fishermen have highly regarded the Bay for its abundant yields and wide variety of fish and shellfish species, while hunters take advantage of its location along the Atlantic flyway with numerous waterfowl species moving into the area during fall.

Environmental quality is a key factor in determining the level of recreational use and the generally clean water conditions in most of Chesapeake Bay support heavy use by swimmers and waterskiers. A variety of opportunities are also available for residents and visitors to take advantage of Chesapeake Bay's aesthetic qualities through naturalist activities such as wildlife photography, hiking and bird watching.

Perhaps a less obvious but economically important recreational activity is general tourism. The picturesque harbor towns, fishing villages and redeveloped port areas such as Baltimore's Inner Harbor and the Norfolk--Newport News--Hampton improvements attract millions of visitors. Seeing men at work on Chesapeake Bay, whether in commercial fishing or in shipping, is itself a recreational experience.

MAGNITUDE OF THE USE

The numbers and sociological characteristics of participants involved in the different recreational categories vary widely depending upon the activity and cost of participation. Recreational boating to a large degree would involve a different population segment than hiking; and within recreational boating, sport fishing would represent one subcategory of this group, while sailing would represent another. Due to differences in recreational preferences, situations sometimes exist where recreational opportunities for a particular activity may not match the demands for that activity by the surrounding population. In 1975, 59,000,000 person-days were spent in recreation on the Bay (Corps of Engineers, Future Conditions Report, Appendix 8).

For some activities recreational opportunities are not sufficient to meet present needs. For recreational boating, general Bay surface area is more than adequate for the needs, while access to these waters through launching ramps and other facilities is not (Corps of Engineers Chesapeake Bay Future Conditions Report, Appendix 8). The same condition is true for swimming in many areas. The water is there, but access including support facilities (e.g., sea nettle nets) is not.

BRIEF HISTORY OF TRENDS

With demands at present population levels already exceeding the opportunities for some recreation, this condition will only become more acute as resident and non-resident use of Chesapeake Bay is projected to increase to 255,000,000 days by the year 2020 (Corps of Engineers Chesapeake Bay Future Conditions Report, Appendix 8). Associated with this growing need for recreational opportunities and increased use of existing facilities will be additional environmental impacts on the estuarine ecosystem and increased competition between user groups in some situations.

In many Chesapeake Bay tributaries, conflicts have arisen between recreational boating uses such as sailing and waterskiers. Fisheries management questions have long been raised over harvesting from the same fish stocks by sport and commercial users and how management decisions can be made in an equitable manner. Economic questions arise as port developers consider how recreational opportunities can be provided for when they are in competition with commercial interests for waterfront space. With the growing population projected for the Chesapeake Bay region, these issues will only become more and more pronounced.

VALUE OF RESEARCH

Because recreational activities involve sociological, economic and ecological questions, research in this area will necessitate an interdisciplinary approach. Research results on these questions will benefit management activities and assist planning agencies in maximizing recreational opportunities for a growing coastal population. Implementation of results will help minimize pollution impacts of boating activities, provide for more comprehensive fisheries management strategies, determine what recreation opportunities will best meet Bay population demands as well as their economic benefits, and reduce competition for space and facilities between user groups such as recreational boaters and waterskiers.

RESEARCH NEEDS

PROJECT: Chesapeake Bay Sportfishing Survey

Sportfishing participation and catches need to be surveyed at three-year intervals to provide adequate information for comprehensive fisheries management and facilities siting. This survey-work must address the economic as well as the biological impacts of sportfishing to determine the significance of sportfishing for the coastal economy as well as its importance to fisheries management. Information gained from this research will provide regulators with a more balanced consideration of commercial and sport interests in proposing fisheries regulations and will provide local planning agencies with user-group information for access points in their locales.

Objectives

The primary objective of this research is to determine the biological and economic impacts of sportfishing in Chesapeake Bay. Secondary objectives will be to determine patterns of site use by county of residency and other local sportfishing impacts-ramp use, etc.

Approach

The basic approach will rely on the survey methodology, with revisions used by Maryland and developed for NMFS in the 1979 and 1980 Chesapeake Bay Sportfishing Surveys. This approach consists of two paired survey efforts: One collects fisheries biological information and other trip-specific information from fishermen as they complete their trips at the access site; the other survey depends on telephone interviews designed to determine the number of fishing households and participation rates. Combining the two surveys yields total catch by species and other expanded totals.

Cost and Duration

The survey should be conducted every three years and cover an entire calendar year. Cost will total approximately $200,000 for Maryland and Virginia.

Related Studies

Maryland 1979 and 1980 Sportfishing Surveys; NMFS 1979 and 1980 Sportfishing Surveys.

PROJECT: Public Shoreline Access Location Survey and Implementation

This project is designed to identify those areas of potential use for future public access to Chesapeake Bay and determine a methodology for evaluating which sites should be acquired and/or developed from a cost/benefit perspective. With recreation needs growing at an increasing rate, a major limiting factor for public use of the Bay is having a place to get to it. In spite of Chesapeake Bay's immense shoreline area, recreational opportunities are limited because most of the shoreline is in private ownership. As more and more developments seek shore areas for their facilities, potential open space for public shore access will become a scarcer commodity. For this reason, potential shore access/recreation areas must be identified and evaluated as to their usefulness for public acquisition to provide areas to meet growing spatial needs of recreation.

Objectives

The objectives are to identify those shore areas of potential use for different Chesapeake Bay recreational activities and devise a methodology for determining which areas provide the optimum cost/benefits for development as recreation sites.

Approach

Identify sites using appropriate maps (i.e., tax maps, zoning) and aerial photography. Conduct on-site evaluations of sites with high potential to determine appropriate, geographical and socioeconomic information for later site selection. (This has been done already in Maryland under the BAPS program in Maryland-DNR.)

Develop an economic modeling approach to assist local and state governments in final site selection based upon acquisition costs and user preferences. Additional surveys of recreational preferences among local residents may be necessary.

Cost and Duration

Duration should be two years and estimated under $100,000.

Related Studies

Maryland Bay Access Park Study (BAPS); Maryland DNR-Tidewater Administration.

PROJECT: Waterskiing Patterns of Use in Relation to Other Waterbourne Activities

Chesapeake Bay areas useful for waterskiing have specific requirements relevant to basin area, water depth, obstructions and wave conditions. In many situations these conditions can only be found in more protected embayments. Consequently the location of these areas is also heavily used for small sailboats, sportfishing, swimming, commercial fishing and crabbing, and other competing uses. Due to the high speed and radius of operation of this activity, conflicts with other users have arisen and will increase. A research need exists to determine what areas are suitable for waterskiing on a county by county basis and what management practices will maximize participation in this recreational activity while minimizing competition with other water activities.

Approach

This research must involve several disciplines and would require a cooperative set of studies. Due to the site specific needs of this issue, some aspects of the research will only have local applications, while others will be more broad. The basic objectives are to determine whether waterskiing conflicts exist and how they can best be managed.

The following goals must be met.

1. Identify higher use waterskiing areas.
2. Determine temporal/spatial patterns use.
3. Survey different water users and residents on waterskiing impacts and other uses, etc.
4. Determine possible management techniques, water zoning, day/hour restrictions, etc.
5. Determine by survey acceptibility of management approaches to determine possible effectiveness.

Cost and Duration

This survey should be done on a county by county basis in cooperation with local governments and extend over one recreational year. In each region, costs can be minimized through using local government personnel; costs should be under $130,000.

PROJECT: Evaluation of the Potential Role of Tourism in the Future Economic and Biological Conditions of the Chesapeake Bay Area

The current trend estimates indicate that the population of about 9,000,000 in the Chesapeake area will increase to about 16,000,000 by the year 2000. This increasing number of people will place great demands on the various natural resources of the Bay area. Just the pressures from these resident populations will exceed the desirable use levels of particular resources in certain areas. Resources are considered to mean fish, wildlife, beaches, water, scenic views, shoreline and all other resources that can provide enjoyment and relaxation to users. This will result in overcrowding, deteriorating quality and possible elimination fo some important resources and uses.

The resident population growth, however, is not the only problem that must be faced by resource planners and decision makers. During the next decade, tourism from outside the area will also increase adding even greater pressures to the resource. Moreover, the Bay is circumscribed by major tourist areas--Philadelphia, Baltimore, Washington D.C., Annapolis, Richmond and Williamsburg--which should further tend to increase the number of tourists.

Although these tourists represent possible environmental impacts on the Bay resources, they also represent important economic resources. Many local communities rely on these tourists for their economic well-being.

The basic question then is how to balance the potential economic contribution of these nonresidents against the potential deterioration in quantity and/or quality of the Bay resource that may result from growing numbers of tourists. An important aspect of this question is how to allocate the use of the Bay resources among resident and nonresident users.

Objectives

1. To identify the growth in tourism: resident use ratio of various Bay resources under alternative fee, zoning and other use control approaches.
2. To estimate economic and biological impacts associated with various resource use rates by tourists and residents.

Approach

1. Estimate rate of growth (uncontrolled) in area Bay population.
2. Evaluate rate of growth (uncontrolled) in tourists using Bay resource.
3. Evaluate the legal and economic implication of differential fee charges for resident and non-resident users.
4. Determine the role of zoning and other controls (i.e., the number of hotel and motel rooms allowed, etc.) in limiting the rate of growth in tourism.
5. Relate alternative tourist and resident number to individual resource use demands and determine appropriate carrying capacity.
6. Identify economic impacts, by local areas, of alternative methods of controlling number of tourist and resident users.

PROJECT: Evaluation of Locational and Operational Impacts of Marinas and Boat Launching Facilities on Chesapeake Bay Tributaries

A number of environmental and sociological questions surround the siting and operation of marinas and other boating facilities around Chesapeake Bay and its tributaries. These questions include: Do enough facilities exist to meet boating demands? How many marinas can be located within a limited stretch of river? What are the impacts of boat sewage disposal, painting operations and land runoff on receiving waters? Does marina development change the social structure of small coastal communities? How close can these types of facilities be located near fish spawning areas and shellfish beds?

Considering only environmental impacts, marinas pose three general types of problems: construction impacts, aesthetic impacts and operation impacts. While much information exists on construction engineering and designs for limiting wetlands damage, less data are available concerning the impacts of boat discharges and other marina inputs into receiving waters. Information on these post-construction impacts of marinas would be particularly useful for determining how many marinas can be placed within a given tributary, whether distance restrictions are important for protecting fish and shellfish stocks, and how effective Federal Water Pollution Control Act, Section 312, has been in reducing waste discharges.

To fully evaluate boating and marina operation effects on water quality, research must include sampling in tributaries with different hydrologic regimes and marina concentrations. Flushing activity from tidal action and river discharge is very important in limiting the intensity of local impacts. For results to be applicable to other watersheds, this research must account for changes in flushing due to season and watershed area as well as basin morphology. This research will have greater than local significance since its results should be applicable to other estuaries with low tidal amplitudes such as Pamlico Sound in North Carolina. Much of the previous research on marinas in estuaries has been conducted in locations with greater tidal amplitudes than Chesapeake Bay such as Narragansett Bay in Rhode Island.

Objectives

1. To determine the seasonal inputs from marina operations into tributary waters and their impact on biota.
2. To relate the flushing aspects of hydrology to concentrations of coliform bacteria, heavy metals, and other introductions.
3. To determine the relationship of marina densities to water quality impacts.

Approach

For research results to be applicable to numerous tributaries, site selection will be very important. Variables to consider in selecting sites with marinas and control areas would include river discharge, tidal flow, fetch and bottom topography. Marinas using different types of pollution abatement mechanisms (with and without pump-out facilities) should be included.

Water chemistry measurements should sample heavy metals, hydrocarbons, dissolved oxygen, temperature, salinity, turdidity and other variables. Biological sampling should address impacts on the benthos and nekton of the area as well as coliform bacterial levels.

Sampling design for this study must consider the monthly as well as daily variability in boating activity. Sample size and frequency for each variable should be contained in a valid statistical design.

Cost and Duration

This sampling effort should cover two consecutive years intensively with supplemental sampling over a succeeding boating season. Costs have not been estimated.

Related Studies

Chmura, G.L. and N.W. Ross. 1978. The environmental impacts of marinas and their boats. Mar. Memo 45, Univ. R.I., 32 p.

Collins, C. and F. Sedgwick. 1979. Recreational boating in Rhode Island's coastal waters: A look forward. Mar. Tech. Rept. No. 75, Univ. R.I., 76 p.

Ervin, T.L., C.E. Abrahamson and J.E. Frank. 1980. Anne Arundel County Boating and Marina Study. A.A. Co. Off. Pl. and Zoning Rept., Annapolis, Md.

Nixon, S.W., C.A. Oviatt and S.L. Northby. 1973. Ecology of small boat marinas. Mar. Tech. Rept. Series No. 5, Univ. R.I., 20 p.

Williams, J. and F. Skove. 1981. The effects of marine boating on turbidity in relation to submerged aquatic vegetation. U.S. Naval Academy. Report to Ches. Bay Prog., U.S.E.P.A., Contract R-806136-01-0. 43 p.

Williams, J.B., T.P. Smith, H.J. Speir and S. Early. 1983. 1980 Maryland salt-water sport fishing survey. Md. Tidewater Adm. Rept. TA-CRD-83-1.

Suggested Additional Studies

Analysis of costs, need and potential benefits of artivicial fishing reef creation in Chesapeake Bay.

Determine the adequacy of access to shoreline natural areas by urban dwelling.

CHAPTER 5
ELECTRICITY GENERATION

Committee: Lawrence Kohlenstein, Chairman,
Joseph A. Mihursky

INTRODUCTION

The nature of the environmental problems posed by electricity generation has changed substantially over the last decade. Early focus was upon the open once-through colling systems that required large volumes of water for excess heat dissipation. Pumped-entrainment, pumped-entrapment and discharge plume effects on resident biota dominated early research efforts. Temperature was considered the major variable and concern. It was gradually realized that in addition to temperature, other physical and chemical factors associated with once-through cooling had to be considered. Chlorine, heavy metals, radionuclides, pressure, shear forces and altered hydraulic patterns received increased research attention. As local effects were understood, greater attempts were made to relate the direct impact to effects on populations and communities. Greater appreciation was achieved of the importance of power plant site selection for open once-through systems because of potential impact on major spawning and nursery areas, major bottle-neck areas for migratory activities, etc. In addition, alternative engineering designs and operating procedures were considered in order to reduce effects, e.g., ΔT alternatives, mechanical cleaning of condenser systems instead of chlorine, intake depth locations, discharge configurations, semi-closed cooling towers. The high rate of increase in electricity demand in the sixties and early seventies suggested that there would be a continuing need for rapid increase in generation capacity and continuing development of new sites. Nuclear power was projected as contributing a growing percentage of regional electric generation capacity.

During the last decade, much has been learned from the impacts of power plants; regulatory control has intensified, cooling towers are used instead of once-through systems for new plants, improved intake designs have become available, the projected rate of increase in electrical demand has decreased from 10% per year to about 3% per year and it appears that coal will be the energy source for most new plants and will be used in retrofit of many existing oil-fired systems. In addition, some older plants with relatively poor environmental safeguards have been shut down or modified. These developments have reduced and changed the nature of the potential impact and are responsible for the evolution of a new set of research priorities.

It is clear that a number of research areas have overlapped with other user-impact concerns about the Bay system. A prime example deals with questions of chlorine, its interactions with metals, sediments and organics. Similar larger questions are concerned with chlorine use in sewage treatment plants. Approximately 90% of the chlorine used in the Bay region is from sewage treatment plant operation. Other examples include: the effect of dredging operations, the release of toxic materials from coal and coal waste storage, and the impact on fisheries. Further, power plant issues must be examined in a conceptual framework that ultimately strives for understanding of what factors regulate abundance of populations and communities. Such understanding is necessary to estimate the significance of direct power plant effects to biotic populations and communities and to place those impacts in perspective.

Similarly, work on power plant problems provides important insight to the effects of other users of the Bay's resources and on fundamental biological processes. Recent examples include findings on striped bass population dynamics derived in part from studies in the Potomac Estuary, and on factors regulating structures and abundance of the benthic community during warmer seasons in the mid-Chesapeake Bay region. The latter was a spin-off from a long term integrated study at the Calvert Cliffs nuclear power plant site. In addition, this latter study has produced some of the better time series data demonstrating season-to-season and year-to-year fluctuations in populations and communities in the mid-Chesapeake region.

In addition to having spin-off value to other issues or problem areas of the Bay region, research on environmental effects of electric generation continues to improve the entire process of optimizing the siting, design and operation of these large engineering facilities in a manner that permits needed electricity production and also permits the maintenance of a quality Bay environment.

In developing the discussion of research needs, care was taken to be selective. Only important topics are addressed; among these, several topics of highest priority are indicated.

PRINCIPAL RESEARCH NEEDS

PROJECT: Biological Impact of Coal Derived Substances

Increasing dependence upon coal as a fuel source for power generation is accompanied by the need for considerable handling and storage of coal and its solid combustion products. Inadvertent losses of coal dust, flyash scrubber materials and leachates from these materials may result in organic and trace metal contaminants reaching surface waters. Poly-nuclear aromatic hydrocarbons emitted from stacks may be precipitated and deposited in the Bay and tributaries. The significance of chronic exposure of organisms to low concentrations of these materials is not known. Consequently, among our highest priorities is research with the following objectives.

1. Determine the responses (i.e., growth, development, behavior and survival) of sensitive organisms such as early life stages of finfish and shellfish to prolonged exposure to trace metals or organic contamin-

ants derived from coal or coal combustion products. For example, there have been inferences that heavy metals or organics associated with coal-fired power plant operations could be responsible for impaired skeletal development in juvenile fish. However, no direct relationship has been demonstrated, nor have juveniles with less vertebral strength been shown to have diminished chances for survival. Studies are needed to determine whether chronic exposure to coal-derived organics or metals, either singly or in combination, results in an observable impairment that can be shown to diminish survival.

2. Establish the pathways by which coal-related materials move through food chains. Determine uptake rates and body loads in aquatic organisms. Evaluate mechanisms of bioconcentration or biomagnification.

PROJECT: Speciation, Behavior and Fate of Chemicals Released to the Bay System from Power Plant Operation

Power plant operations are known to produce a variety of chemical residuals from biofouling control attempts, cooling tower operations, leaching from coal storage areas, leaching from ash and scrubber sludge storage areas, and heavy metal loss from condenser systems.

For new facilities that have cooling towers, dechlorination can be used to substantially eliminate oxidizing components. However, organic compounds remain of concern. Research is needed to better understand the nature of non-oxidizing, non-volatile halo-organics.

For some existing facilities with once-through cooling, remaining questions about the chemistry of products of chlorination may be relevant. Similar questions are even more germane to chlorination of sewage treatment plant effluent. Research could be useful on the following: analytical methods for the determination of individual halogen species at low concentration; a means of evaluating the concentration of reactive sites on aquatic humic materials; better determinations of the kinetics of some fast reactions involving halogens; better understanding of the reaction of halamines with other compounds; and mass balance between chlorine added and oxidation products produced. The interactions of chlorine with heavy metals and the organic and fine components of estuarine sediments are poorly understood.

Preliminary understanding of sorbed heavy metals in the estuarine sediment to the oxidizing effect of chlorine indicates a substantial desorbing response of the bound metals. This process is enhanced apparently when benthic material is resuspended during high wind and storm conditions. This resuspended material may be pumped through power station cooling systems and be subjected to chlorine's oxidizing action. Since it is apparent that biological responses are greatly influenced by the species state of a given chemical, it is necessary to better understand this process.

PROJECT: Atmospheric Contribution of Polynuclear Aromatic Compounds to the Chesapeake Bay from Electricity Generation

Recent research on anthropogenic organic compounds in the Chesapeake Bay system produced data showing that the concentrations of polynuclear aromatic hydrocarbons (PNAs) in sediments were highest in the Northern Chesapeake Bay, specifically one maximum was noted near the mouth of the Patapsco River. Further work showed that within the Patapsco, concentrations were often orders of magnitude higher.

Some of these compounds are produced by the combustion of fossil and carbonaceous fuels such as coal, oil and wood. Therefore, atmospheric transport and subsequent rain-out of exhausts, stack gases and particulates are likely routes of entry into the Bay. It is unclear how much water transport from rivers contributes to the Bay's burden relative to the atmospheric route. This must be determined. And, since many compounds belonging to this group are known or suspected carcinogens, mutagens and teratogens, the determination should be performed as soon as possible.

In the production of electricity by the combustion of fossil fuels, PNAs are produced. The relative contribution of these via stack emissions to those from automobile emissions or other sources is unknown. However in the near-field areas around power plants, the contribution could be significant. Therefore, research is needed to assess the problem and provide data necessary for proper and effective control. Research in this area should focus on the following:

1. The contribution to the Chesapeake Bay system of PNAs from fossil fuel power plants with particular emphasis on the atmospheric component.
2. Toxicities of PNAs to selected Bay biota.
3. Concentrations of PNAs in the aquatic biota inhabiting areas adjacent to power plants.

These topics are considered of high priority.

PROJECT: Factors Affecting Reproductive Success of Anadromous Fish

Otherwise attractive power plant sites are often located where they could influence spawning or nursery grounds for anadromous fish. With the advent of cooling towers and more effective intake screening, it is possible to design a plant to have a quite modest direct impact on early life stages. However, when the fisheries are not healthy, even a small potential impact takes on greater significance and raises public opposition. The complexity of the licensing process and to some extent the significance of the direct impact to the fish population depend upon the viability of the fishery.

In recent years the major anadromous species of the Bay have had very poor reproduction. American shad have reached such alarmingly low levels that for the first time a ban has been imposed on their harvest in Maryland. Striped bass harvest recently reached low levels not seen since the early 1930s. Reproduction of two other Alosa species has also been poor. Factors controlling reproductive success are not known. It is not known whether the sustained period of weak year classes is a consequence of natural environmental variations or man's activities. It is important to determine the factors limiting reproduction. Candidates include: Factors influencing migratory behavior to the spawning grounds; inadequate food for early life stages; toxic influences of heavy metals, pesticides or other organics from farming, industry or sewage treatment plants; low stock sizes in part related to overfishing; and combinations of such causes. Questions have been raised again about the impact of the enlargement of the C&D Canal on spawning in the upper Bay. These are issues of primary importance to the recreational and commercial fisheries and which, less directly, affect the use of the Bay for power generation. These topics are considered of high priority.

PROJECT: Population and Community Level Biological Effects

Although local biological effects have been demonstrated at various power plant sites, a larger and considerably more important question has often not been resolved. That is, given a local effect, what does it mean to the entire population of a species? Secondly, given population responses, what does it mean to community balances within a subsystem or indeed the total Bay system?

Such questions are difficult; however, they must be answered in order to place a measured or predicted direct effect in perspective. For example, cropping of fish eggs and larvae by a power plant may or may not affect the size of the adult population depending on what processes are regulating the abundance of the stock and the stage in the lifecycle at which abundance is limited.

Another consideration involving population or community level response might be power plant water pumping mortality effects upon abundant soft-bodied planktonic organisms such as jellyfish and combjellies. Such species are considered dead ends in the food web within the Bay, in that few other species feed upon jellyfish or combjellies. These latter species do in turn feed extensively upon the plankton community and thus compete directly with larvae of most fish species and adults of important forage fish such as the Bay anchovey and menhaden. Thus, loss of these soft bodied forms play an as yet unevaluated role in predator-prey relationships within the pelagic community. Such alterations may influence energy and material flow to economically important species.

Research is needed in the following areas:

1. Stated generally, there is a need for an adequate understanding of the population dynamics of recreationally and commercially important species to relate a direct loss (e.g., of early life stages from entrainment or a toxic effluent or of juvenile or adults from impingement) to a long-term impact on the population. To do this, one should understand the factors that are regulating the abundance of the population. More specifically there is a need for further evaluation of the role in determining year class strength of: food for early life stages, predation in early life stages, spawning stock size, early life stage mortality from natural physical and chemical conditions, toxic materials

from industrial and agricultural activities. Determine population responses to chronic low level exposures of early life stages in multivariate experiments involving temperature salinity, heavy metals, toxic organics, etc.

2. Determine the long-term significance to the population of stock augmentation from hatcheries and anadromous fish.

3. Assess community level responses to population level changes.

PROJECT: Refinements in Power Plant Design

Technological improvements have had an important role in reducing the impacts of power generating stations. Further improvement is needed in several areas.

1. Although dechlorination of chlorinated cooling tower effluents can eliminate or substantially reduce oxidative compounds, halo-organics are not removed. In circumstances where these pose a potentiial problem, the development of alternatives to oxidative biocides is needed. For example, the feasibility and effectiveness of ultrasonics for the prevention of biofouling should be determined.

2. Advances have been made in intake design that reduce entrainment and impingement. Laboratory studies are needed to refine profile-wire intake screen design to optimize their effectiveness in reducing entrainment and impingement. Field studies are needed to demonstrate their reliability under biofouling conditions occurring in an intermediate salinity regime (5-20 ppt). Screen development, in concert with behavior studies, is still needed to address impingement problems (e.g., crabs and finfish) at some existing plants using once-through cooling.

3. New combustion technologies (e.g., fluidized bed combustion, and synthetic fuel derived from coal) will result in a new array of potentially toxic materials. Emissions to be expected from such systems must be characterized. Research is needed on the potential biological impact of these materials.

PROJECT: Technical Development in Controlling and Monitoring Waste Materials

The increase in coal use and the emphasis on removal of contaminants from stack effluents have aggravated the solid waste management problem associated with power plants. There is a need to refine and evaluate waste disposal technology: to develop innovative disposal configurations, to contain leachate or prevent its generation, and to assess the durability and reliability of containment liner and cover material. Improved techniques are needed for monitoring for containment failures.

At some sites, dredging could be necessary to provide barge access, to ensure a reliable supply of cooling water or to construct plant structures or pipe lines. In such instances, issues similar to those encountered on a large scale for dredging shipping channels become relevant. These include determining acceptable dredge spoil locations, control practices and monitoring procedures.

PROJECT: Alternatives to Increased Power Generation Capacity

One approach to reducing the impact from new plants is to minimize the amount of new power generating capacity needed. A variety of techniques could contribute to this end. Peak demand might be reduced by economic incentives like time-of-day pricing. Conservation could also be encouraged by economic incentives. Distributed storage systems for thermal energy could reduce consumption of electricity. Underground pumped storage systems could help meet peak load. Non-conventional energy sources like distributed solar systems, low-head hydro, landfill methane and geothermal could make contributions.

In some instances, implementation may be fostered by further research on economic viability or institutional barriers. In others, projects that demonstrate effectiveness and viability of the technique are needed.

PROJECT: Economic, Social and Regional Effects and Implications of Constructing and Operating Power Plants

Construction of fossil fuel and nuclear power plants requires substantial capital investment. Contemporary nuclear facilities, for example, may cost up to 2 billion dollars. Power plants often are sited in regimes of relatively low population; thus, such infusions of money, coupled with a greatly increased work force, can impact established socio-economic patterns. Further, the long term resultants of each impacts can influence population growth patterns, individual and societal ambitions, land use patterns and, consequently, can influence local water quality conditions. A relatively simple and singular focus on operating power plants in an environmentally acceptable manner ignores the feedback relationship to the Bay system. Fostering increased growth in human populations portends additional pressures and problems for waste disposal and nutrient loading problems for the Chesapeake Bay.

1. Undertake a socio-economic case study of the consequences of construction of a power plant facility in a rural area. An investigation should be completed including an extended post-operation evaluation that captures the long-term impact of a dramatic increase in tax base.
2. Undertake a regional socio-economic evaluation, coupled with growth and development potentials on the Western Shore of the Chesapeake, in order to determine potential future impacts on water quality and biological resources of the western estuary subsystem of the Bay resulting from additional power plant development.

PROJECT: Hydroelectric Development

Within the Bay system, the Conowingo Dam exists as the largest single hydroelectric facility. More than 50 years after its construction, concern and controversy still rage over its effects on water quality and resident and anadromous fish species. Debate continues on the effect that fish passage facilities would have if used on the Conowingo and other dams. Small scale hydroelectric facilities are presently being considered and developed within the Bay watershed in response to the high cost of conventional energy forms. Such trends are likely to increase in the future. The impacts of such small scale devices on habitat, resident and migratory biota are also poorly understood.

Research is needed in the following areas:

1. Determine how changes in water flow characteristics affect habitat utilization by resident and anadromous species. Issues include relationships between water velocity and habitat quality, life cycle completions and migratory responses.
2. Determine the relationship of engineering design and operational features to water quality parameters such as temperature, dissolved oxygen, nutrients, pH and turbidity.
3. Determine, where appropriate, the feasibility of fish passage devices as a design feature of hydroelectric devices.

CHAPTER 6
SHORELINE DEVELOPMENT

Karl Kuhlman, Chairman,
Waldon R. Kerns, W.E. Robinson

INTRODUCTION

Chesapeake Bay and its tributaries both large and small have had a significant impact on regional land use. Not unlike other areas on the Atlantic Seaboard where there are large estuarine bodies, historic land development has been keyed to waterborne commerce, the seafood industry and recreation. In addition, the military establishment has played an important role, especially in Hampton Roads, Virginia.

Existing development of total Bay shoreline lands has been broadly categorized in a number of land classes such as wetlands, residential areas, commercial and industrial areas, transportation routes, agriculture and military.

Overall length of the shoreline of the Bay study area to the tidal limits is 8,100 miles. Ownership is classified as Federal, public and private, the use of which may be further subdivided according to land use and/or dedication. Of principal political interest are the alrge urban areas of Baltimore-Washington, DC, Richmond-Petersburg, and all of greater Hampton Roads. Not surprisingly, most of the shoreline is in private ownership. Hence, most control over shoreline lands is exercised by appropriate city, county or planning district governments.

Land use and shoreline development in the future will be guided by the several states, counties and cities involved. There appears to be, however, a growing Federal interest. The uniformity of present and future controls has been and will continue to be, to some extent, controlled and/or guided by both Federal and state legislative enactments.

TRENDS IN SHORELINE USE

Based on the Chesapeake Bay Future Conditions Report (Volume 4) it appears that with both the urban municipalities and the rural counties and communities of Maryland and Virginia, controlled growth will occur by expansion of already existing development. While population projections to 2020 for the Bay area have been reduced, it still appears that growth of the urban areas will be toward adjacent areas now lightly "urbanized"; the more rural or agricultural areas will likely remain that way. There is still a demand for recreation and second home development. Nevertheless, development pressure will have to seek shore and near shore lands now in other uses, predominantly forestry and agriculture.

Concerning the future of land use about the Bay, it is becoming more apparent that economic issues will continue to play a significant role. For instance, high interest rates have discouraged residential and other developments; curtailed Federal assistance to localities affect development; and we have seen the potential push toward the development of oil refineries needing water access. There also may be increased numbers of "planned communities"; in addition, the military may have requirements for "classified" land use.

VALUES OF RESEARCH

Traditionally, research has been in two directions: one, to assist land use planning in the form of terrestrial development of zoned use areas (such as American Institute of Landuse Architects (AILA) criteria); two, where proposed development occurs on or near water, assessing the impacts thereof through various permit systems. In the second area, most research has been directed toward prediction of the adverse environmental impacts of various developmental proposals, some on a case-by-case basis.

In discussing the topic of research, the subcommittee emphasizes two points. One is the importance of continuous availability of those who are knowledgable on various environmental concerns; the second is that case histories demonstrate that the current state of the art on environmental impacts is further advanced than the political systems involved in making decisions. We are only in the early stages of undertaking the interaction and interrelationship of various uses for short term analysis of shoreline development proposals. What comes to light was the inadequacy of knowledge of the socio-political system involved in making decisions, especially at the local level, on current and future land use planning for the Bay. There may be as many differences as there are political subdivisions even given the fact that there are the various regulatory statutes in effect.

It is therefore believed that research, especially on the socio-political level, is both current and most important. It is recognized also that shoreline development considerations cross the lines of virtually all the other topic research areas on the Needs for the 80s. The urgency is for use as soon as possible by the political decision makers under some form of inter-intrastate unity.

RESEARCH NEEDS

In reviewing the urgency analysis ratings of the questions brought out in the section on Shoreline Development, none of the problems were Urgent-Critical (CRC Publ. No. 100): All were in the Desirable-Urgent range. However, the subcommittee did not share their view and chose to delete or modify some of the topics and to add others. The proposed objectives follow.

PROJECT: In-Depth Analysis of the Socio-Political Processes in Land Use Planning for the Bay

Approach

Inventory the various processes of the appropriate Federal, state and local governments in land use planning. Summarize areas of disparity and uniformity. Suggest ways and means of achieving more uniform practices even if the legislative vehicles are not now available. Methodology must be developed to identify and evaluate alternative development courses of action. Ways must be developed to incorporate and use scientific data in economic analysis of alternative development courses. Research is needed to evaluate institutional arrangements which are efficient, effective and politically acceptable for use in allocation of limited resources between development alternatives and other uses of the Bay shoreline. Methodology for determining the full cost and benefits for various types and sizes of construction proposals must be developed--including impact on income and employment, detriments to the environment and minority groups. What factors are important for localities to make optional decision as they exist or how can they be provided? What institutional arrangements are most effective, efficient and politically viable to allow for management of shoreline development.

Probable Duration

Six months, intensive, plus a continuous lower level activity.

PROJECT: How the Scientific Disciplines Can Best Relate Their Findings to the Decisionmakers

Approach

Bring findings together in an understandable, usable form; be area specific if possible; use case studies if possible. Suggest pathways to the resolution of conflicts.

Probable Duration

One year.

Related Studies

Through the use of case studies and elements of probability, suggest the secondary impacts of major developments on resulting population distributions and the needed services required.

High Priority

Services must be provided with development. Develop methodology to provide estimates of need and efficiency of services required after development. What impact does available services have on development in an area?

Identify and evaluate relationships which exist between various types and sizes of developments and other uses of waters in the area. Refine techniques to measure nature of development activities for a local area and for the region.

ADDITIONAL IMPORTANT PROBLEMS (LISTING ONLY)

PROJECT: Study of Processes Related to Shoreline Erosion (High Priority)

Several processes are involved in future development of shorelines to effectively prevent erosion and introduction of contaminant materials such as pesticides-herbicides-fertilizers. For instance, a better understanding of hydraulic processes is required.

PROJECT: What Are the Appropriate Uses of Floodprone Lands? (High Priority)

What impact does current knowledge of shoreline erosion have on developmental decisions both public and private? Research is needed to establish a management framework for private landowners and localities to be used in establishing an erosion abatement program. Part of that relates to who gets the benefits of control and who should pay for the abatement program. Research is needed on the most cost-effective abatement structures. Research is needed to learn how to implement insurance programs in coastal areas.

PROJECT: Effects of Development (Medium Priority)

Identify and evaluate factors which impact on land resources when development such as marinas, recreation areas, access areas and shellfish areas affect existing developments and use of agricultural lands. What impact would water zoning have on existing developments?

PROJECT: Storm Surge Predictive Model

In recent years, the Tidewater areas of Virginia and Maryland have not seen the destructive force of a major hurricane. However, it is quite probable that one will hit this area in the future. The loss of life and property damage from these storms results more from the storm surge than from the strong winds. Storm surges of 20 feet or more are not uncommon and together with high winds, waves and the battering-ram effects of floating debris, the devastation can be considerable.

The development of computer models to predict the effective height of a hurricane-generated storm surge along a straight open coast, the so-called SPLASH model of Jelesnianski, has allowed accurate predictions to be made. However, it is only within the past 5 years that the work of Thacker in Miami has resulted in a technique for extending the model into the more geographically complex Bays, estuaries and barrier island lagoons. The lower Bay and Hampton Roads areas as well as the lower reaches of the James, York, Rappahannock and Potomac rivers and other areas would be highly suitable areas for the Thacker type of predictive storm surge modeling.

The primary inputs to the tight triangular grid model are angle and speed of storm approach, wind speed in the approach area bottom topography, Bay or estuary configuration and depth, and the topography (manmade and natural) of the land around the Bay or estuary. All parameters except those of the storm itself (angle of storm and wind speed) can be determined in advance and entered into the computer. As the storm approaches, the storm parameters are entered, and the model produces a graphic presentation of the expected storm surge heights at grid points around the Bay or estuary. This information can then be used to determine those areas where immediate evacuation is essential, and the information is included in the evacuation instructions broadcasts.

The development of these models for the several Bay areas where storm surges can be expected to be most destructive could save a large number of lives. This alone should be adequate justification for initiating this storm surge prediction research in the very near future. Most of the objectives above are being addressed by the Baltimore District, Corps of Engineers, in its development of a numerical storm surge model which will produce stage frequency curves for the entire Bay region.

PROJECT: Possible Coastal Inundation from Long-term Rise in Mean Sea Level

Recently, some researchers (Emery, Shephard, Hicks, Fairbridge) have extrapolated the recent accelerated rate of sea level rise to predict vast coastal inundations within the next several hundreds of years. This is believed by some to result from the so-called "greenhouse effect" which they say is due to the accumulation in the upper atmosphere of carbon oxides from the burning of fossil fuels. This layer in effect reflects enough of the back radiation from the earth to cause a warming trend that is causing the slow melting of the polar ice caps. This water added to the ocean is causing a steady rise in sea level.

Although it is doubtful that anything can be done to modify the system, some evaluations of the effects of possible inundation of all or most of the lower lying areas around Chesapeake Bay should be considered. A "what-if" study is recommended.

CHAPTER 7
MINING

Committee: Harris B. Stewart, Chairman,
Edward Callender

INTRODUCTION

In the Chesapeake Bay area, mining operations are almost exclusively limited to the land areas. There is a broad range of both metallic and non-metallic minerals in the Piedmont, whereas the Coastal Plain region has primarily non-metallic deposits consisting of sand and gravel, marl, and clays used for bricks, tiles, sewer pipes, ceramics, etc., depending on grade composition.

Within Chesapeake Bay itself, there is presently very little mining going on. Some sand and gravel for construction aggregate is dredged from streams leading onto the Bay, and for a short time, sand was dredged from the Maryland side of the Potomac River. Presently, some mining (dredging) of oyster shells is being done in the upper Bay. Some of these shells are being used to establish "seed" beds. However, other minerals and chemicals that may be in the Bay sediments have not been found in sufficient quantities to attract commercial interest.

It is well known that Chesapeake Bay contains extensive surficial sand deposits. These sands are prevalent in the Susquehanna Flats area, the Tangier Sound area and in a relatively narrow band along each side of the Bay.* The fact that recovery of these sands in the Bay is not now economically feasible is illustrated by the observation that sand and gravel for construction purposes in Portsmouth and Norfolk are mined near Richmond and barged down the James River to Hampton Roads. However, as the nearby sand pits become depleted, and sand and gravel must be obtained at increasingly greater distances from where they are needed in the Bay area, the increased costs of transportation could very possibly reach the point where nearby Bay deposits become economically attractive.

*See Ryan, J.A 1953. The Sediments of Chesapeake Bay, Md.-Dept. Geol., Mines and Water Resources Bull., 12, 120 pp.

RESEARCH NEEDS

Research related to mining operations in Chesapeake Bay must be considered as anticipatory research--research that should be initiated now in anticipation of future need, maybe in as little time as 10 to 15 years. If anticipated mining operations are to be carried out effectively and with a minimum of adverse effect on the Bay environment, this research should be completed prior to the initiation of actual mining operations. Two research projects are recommended.

PROJECT: Assessment of Chesapeake Bay Sand, Gravel and Oyster Shell Resources

Although the areal distribution of surfacial sediments in Chesapeake Bay is relatively well know, there has been no systematic, definitive survey to ascertain the three-dimensional extent of these sand and shell seposits, and thus no estimate of the total volume of available material. Comparable surveys of the near-shore area off the Atlantic Coast have been made by the Corps of Engineers and others to determine the distribution and abundance of sand for beach replenishment. Lower Chesapeake Bay sand deposits are presently under investigation by VIMS, and surfacial surveys have been conducted by Maryland and Virginia, but there are no comparable data on the quantities available for the rest of the Bay and its larger tributaries.

The objective of this project would be to make a quantitative evaluation of the sand resources in all of Chesapeake Bay in anticipation of their being required as construction aggregate, roadbed and landfill, and material for beach replenishment. The approach would be to utilize a vessel-mounted sub-bottom acoustic profiling system to identify possible sand bodies (and relict oyster bars) which would then be verified with deep coring or drilling equipment. Not only would those areas of surficial sand be investigated to determine their subsurface extent, but silt and clay bottoms might represent a relatively thin veneer over extensive sand bodies and should be investigated also. In short, the entire Bay system should be surveyed in this manner.

The project is envisioned as having a three-year duration. The first year would be the field phase utilizing approximately 240 days of ship time at an estimated cost of $1,000 per day for a total ship time cost of $240,000. Personnel would include one project principal investigator, four shipboard technicians who would also double as laboratory technicians during the second and third years, one experienced marine geophysicist to head the analysis phase, and one-half secretary comprise the personnel requirements for an estimated total three-year cost of $390,000. Equipment purchase is estimated at $300,000 for the sub-bottom acoustic system, vibracorer and an adequate navigation control system. Additional costs for travel, expendable supplies, communication and publication should be budgeted at approximately $25,000. Thus, the three-year project cost is estimated at $955,000 (less overhead costs).

PROJECT: Environmental Impacts of Mining in Chesapeake Bay

Studies on the environmental impacts of such mining activities would be similar to those developed for dredging to deepen channels in sand areas. The only mining activity presently taking place in the Bay is the dredging of oyster shells in the upper Bay north of Baltimore. This mining of relict oyster shell deposits is being carried out by a private contractor to the Maryland Department of Natural Resources. Shell dredging in Maryland waters started in 1965, and the average yearly production is approximately 600,000 cubic yards (16.5 bushels per cubic yard). One half of this material has been used for oyster bed planting in Maryland and one half for the dredging contractor who has sold it as a chicken feed supplement, road material, for use in septic tank systems, as oyster "cultch" on private oyster grounds and in Delaware and Virginia.

In Virginia waters of the central and lower Bay, however, the shell mining of the mid-1960s was terminated after four years. No surveys of the location and extent of Virginia shell deposits have been made. Such a survey is urgently required and should be included as part of the sand surveys recommended above. If it is found that the shell resource is of limited size, then serious consideration should be given to limiting shell dredging solely for the use of the oyster industry.

The objective of the environmental impact study would be to determine the nutrient and heavy metal release potential of these deposits during mining operations The approach would be two-fold. To determine the nutrient and heavy metal content that exists in exchangeable sites on the surface of sand grains and associated with "fines" that may be found with shell deposits.

Environmental monitoring surveys of mining sites should be conducted before, during and after mining operations. These surveys would include monitoring of hydrographic properties, turbidity, and sampling for dissolved and particulate nutrients, metals and other toxic substances.

It is anticipated that the project would last for several years. The first year wold entail sampling and analysis of mateials taken from potential mining sites. Subsequent years would be spent doing environmental monitoring of mining sites. Cost for the first year is estimated at $120,000 for a research team of two to three people. Budgets for subsequent years would approach $250,000 per year to conduct environmental monitoring surveys and chemical analyses.

Related studies would include environmental impacts of dredging and dredge spoil disposal; research into environmental monitoring of nutrients and toxic chemicals; and development of sampling and analytical techniques to determine the pollution potential of dredge spoil material.

CHAPTER 8
PRESERVATION

Committee: John M. Williams, Chairman,
J. Kevin Sullivan, W.P. Jensen

INTRODUCTION

The issue of preserving the natural integrity of sites within Chesapeake Bay involves two separate classes of areas. One type of area includes those geographically localized sites which should be preserved because of their importance as estuarine research reference areas, their historical or aesthetic value, or because they provide unique or rare ecological units. Another class of preservation areas would include those broad-scale ecological units such as marshes or tidal creeks whose environmental integrity is essential to the Bay's production as a whole.

In defining research needs for preservation, it was important to consider what projects were needed to further the end result of preserving an area in its natural state. For this reason, research into whether or not broad units such as marshes, oyster bars or finfish spawning areas should be preserved was determined not to be necessary since their importance and preservation is already an important part of Chesapeake Bay management. However, research is still needed in determining best management practices for some of these important areas, particularly anadromous fish streams.

With regard to reference research areas and areas of scenic or aesthetic value, analysis is needed for identifying their locations, determining how they can best be managed, and, in the case of reference areas, what types of research should be emphasized there. A system of estuarine research reference areas would be of particular value to Chesapeake Bay studies since they would provide long term protection for representative marsh-tidal creek systems to serve as reference areas with minimal human disturbances. Such a system of sites should be coordinated as part of the Chesapeake Bay Estuarine Sanctuary.

RESEARCH AND ANALYSIS

PROJECT: Identification of Estuarine Research Reference Areas and Development of Preservation Management Approaches

This study's main objective would be to identify estuarine sites around Chesapeake Bay to serve as reference areas for estuarine research and education. These sites should be representative of larger estuarine areas and be distributed throughout the length of Chesapeake Bay. Watershed management approaches should be developed for the lands adjacent to these sites to preserve their natural qualities. This research will help establish relatively natural undisturbed estuarine areas to serve as reference areas for studies of estuarine changes in other locations due to human activities.

Approach

Use aerial photography and site visits to identify sites and then evaluate their usefulness to research through a scientific review committee. Integrate these sites into a coordinated Chesapeake Bay Estuarine Sanctuary System. Review existing watershed management approaches to select most appropriate methods to preserve reference areas.

Cost

Minimal except for acquisition.

Related Studies

Maryland Chesapeake Bay Sanctuary Program. Maryland-DNR, Md. State Critical Areas Program.

PROJECT: Preservation of Chesapeake Bay Locations for Scenic, Historic and Cultural Purposes

Various sections of the Bay's waters and shoreline have traditionally been prized for their scenic, historic or cultural values. Not all such areas are natural or pristine and some are subject to multiple uses. Examples include Jamestown and New Point Comfort in Virginia and Calvert Cliffs and the Annapolis inner harbor in Maryland. Little attention has been given to identifying and cataloging these sites or to developing explicit management approaches to their preservation. Exceptions include the work of the Maryland Geological Survey in identifying pre-colonial settlements on the Bay's shoreline and the preservation activities of the Virginia and Maryland Historic Trusts.

Approach

It is recommended that research be initiated to develop criteria for identifying areas that might warrant preservation for scenic, historic or cultural purposes. In a related effort, a small project could be undertaken to survey preservation management techniques that have been used elsewhere in the U.S. and the extent to which they might be applicable in the Chesapeake.

PROJECT: Development of Appropriate Land-Use Management Techniques to Preserve Water Quality in Anadromous Fish Streams

Most of the important anadromous fish spawning streams in Chesapeake Bay have been identified. However, best land-use management practices in the adjacent watershed need to be determined and their importance to stream preservation incorporated into local decision-making processes. With recent declines in anadromous fish stocks, this effort will enhance conditions for better spawning success.

Objectives

Determine land-use strategies and compatible development technologies which will best preserve stream water quality. Educate and promote use of these practices by SCS, local government and citizen groups.

Approach

Available literature on watershed land-use practices and runoff control should be evaluated for its applicability to maintaining water quality for fish reproduction in Chesapeake Bay tributaries. Field comparison studies should be made in different rivers to determine the most effective watershed management methods as well as the relationship between land-use and discharge controls and spawning habitat quality. Approaches should then be developed to incorporate appropriate land-use practices in county development plans and educate property owners in watersheds.

Related Studies

Maryland DNR and Dept. of State Planning Aquatic Critical Areas Program. Isaak Walton League's Save Our Streams Program.

Suggested Additional Studies

PROJECT: Development of Methodologies to Best Preserve Aquifer Recharge Areas

PROJECT: Application of Blackwater Wildlife Refuge Marsh-Loss Restoration Methods to Other Wetlands in Chesapeake Bay

CHAPTER 9
FUNDAMENTAL RESEARCH

Committee: Robert E. Ulanowicz, Chairman,
Anson H. Hines, Harold Marshall, Frank O. Perkins

INTRODUCTION

Fundamental research is not addressed to a particular present application. This is not to say that the results of fundamental research are of little value to those concerned with managing the Chesapeake Bay. Although knowledge gained in basic science often finds application indirectly or after the passage of considerable time, the ultimate benefits are usually substantial. A fundamental grasp of the workings of a community or a particular process can obviate the need for an entire series of particular case studies.

The perspective taken in fundamental studies usually varies according to the scale of the phenomenon under consideration. Direct observation and measurement usually take place at the level of the organism or the population. To proceed down the hierarchical order to cellular or biochemical processes requires an analytic, reductionistic perspective. In contrast, one must synthesize or induce basic facts about communities or whole ecosystems. The projects outlined below reflect these dual perspectives. Elucidating the mechanisms of disease transmission is likely to be species-specific, whereas in gathering data to construct flow networks our ultimate objective is to test theories of development which may also be applicable outside the discipline of marine science and possibly outside the realm of ecology.

RESEARCH NEEDS

PROJECT: Identification of the Structure of the Chesapeake Bay Ecosystem

Much, if not most, of the biological research which has been conducted on Chesapeake Bay has been directed toward helping to elucidate how the Bay ecosystem is structured and how it functions. A large body of scattered and fragmentary knowledge about the system exists, but nowhere is this knowledge integrated into a single adequate picture of the Chesapeake ecosystem.

Ten years ago, large-scale models of the ecosystem were proposed to consolidate our knowledge and theories. The intervening years, however, have shown the ecosystems modeling approach to have a number of shortcomings. Among them are the lack of predicting ability, the inability to address functional and topological changes, and the failure to anticipate "emergent surprises." These failings have led to a retrenchment of attitudes on how best to consolidate particular findings into an overall perspective so as to leave open our options for further analysis of the entire system.

The Scientific Committee on Oceanic Research, Working Group No. 59 (Modeling in Biological Oceanography) has suggested an approach to the problem of how to best aggregate information in ecosystems (SCOR 1980). Since ecology by definition is a study of the interactions between populations and the environment, we should emphasize the quantitative nature of these interactions. In particular, they urge that we measure the rates of flow of energy and/or materials among the various components of the marine (here the estuarine) ecosystem. The final product is a graph network or matrix of the flows and their estimated magnitudes.

Such an array of information could be applied to a number of both practical and fundamental issues (Platt et al. 1981). Those charged with managing the ecosystem, or components thereof, would be able to see how any particular population relates to the remainder of the community. For example, what does that population depend upon, what depends upon it, what cycles does the population participate in, what are potential parallel or competing pathways? This quantitative network would advance immeasureably the manager's ability to make informed decisions.

Furthermore, a quantitative network of flows (a weighted digraph in mathematical terminology) would provide raw data for testing a number of current hypotheses about development and control in ecological communities. Patten's (Patten and Auble 1981) theory of the niche, Jorgensen's (Jorgensen and Mejer 1979) principle of maximal energy, Hannon's (1979) theory of maximal energy storage, Paltridge's (1979) postulate of maximal dissipation, Ulanowicz's hypothesis of maximal ascendency all could be better tested if more ecological network data were available. The description of the Chesapeake Bay network would certainly appear in publications dealing with questions at the forefront of ecological theory, thereby giving Chesapeake Bay research greatly increased visibility among the larger scientific community.

Objectives

To create a quantitative network of flows of energy, carbon, nitrogen and phosphorus among the major components of the Chesapeake Bay ecosystem.

Approach

Relatively little new field work would be required. Experience in describing subsystems of Chesapeake Bay shows that most fluxes can be estimated to within an order of magnitude by judicious questioning of experts on those populations involved in the given transfer. Hence, a first cut of the network could be made by two principal investigators with two or three assistants over about a two-year period.

Cost and Duration

$220,000 over two years.

Related Studies

Monitoring activities, fish and wildlife, information management.

References

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PROJECT: Life Cycles and Population Dynamics of Important Species of Chesapeake Bay

The life cycles of many estuarine species appear to be qualitatively different from species in other habitats in that: (1) there is an abundance of species which reproduce and have early life stages in locations substantially removed from the adult phase; (2) many species undergo migrations during critical phases of their life cycle; and (3) many species in estuaries are on the periphery of their habitat and can be considered as "invading" estuarine zones from marine or freshwater habitats. Many of the key species of Chesapeake Bay, and estuaries in general, fall into two major categories: (1) those which are dependent on estuarine habitats for completion of critical phases of their life cycles, e.g., anadromous, semi-anadromous and catadromous species; and (2) species for which the estuary is a suboptimal habitat, but which often provide dominant portions of its biota, e.g., many of the bivalves and polychaetes are predominantly marine in origin but contribute enormously to the abundance and productivity of the Bay and are key trophic links in the system.

At a first level, there remains a basic need to provide complete descriptions of the life cycles of many common species in the Bay. At a much more sophisticated level, there is a need to determine the environmental factors which both regulate the survivorship of particularly sensitive life stages, especially larvae and juveniles, and control the behavior of migratory stages. If anthropogenic influences are to be identified, it will be important to delineate the interrelationships of key life stages with environmental factors which contribute to "normal" population fluctuations.

Objectives

Identify species for which life cycles are inadequately described, especially species which are not exploited but which are ecologically significant, and provide complete life history studies of these species.

Approach

1. Straightforward literature survey and short-term (i.e., 1-2 yr) study of the life cycle for each species are required to "fill in the blanks."

2. Determine the subtle interactions of sensitive life stages with environmental factors for those species which are important both economically, e.g., finfish, crabs, oysters, clams, and ecologically, e.g., Chrysaora, Mnemiopsis, Neomysis, Crangon, Palaemonetes, Acartia, Eurytemora, Anchoa, Menidia, algal species. It will be important to determine these interactions as regulatory mechanisms in the population dynamics of the species.

   a. Correlation analysis of existing long-term catch statistics with meteorological and water quality parameters to identify key environmental factors operating at limiting life history stages. This approach has been used by Ulanowicz and appears to be particularly suited for such anadromous and semi-anadromous finfish species as white perch, rockfish and shad.

   b. Laboratory experimental studies of the factors and limiting life stages identified in (a) above: These studies will clarify the mechanisms of environmental control.

   c. Behavioral studies of larval stages of species (esp. blue crabs) which appear to utilize the stratified counterflow of estuaries for dispersal and retention of larvae within the Bay. These studies require better analysis of seasonal variations in circulation patterns and hydrography of the lower Bay and shelf. Field studies are needed to determine the location of each larval stage.

   d. For oyster and clam larvae, much more work is needed to determine the factors regulating larval survival in the field and to determine the details of substrate selection and settlement. A major objective in these studies should be to explain the causes of large annual fluctuations in recruitment success of the major species of bivalves in the Bay.

   e. Short-term studies are needed for non-exploited species which are of ecological importance to generate accurate survivorship and fecundity schedules for life tables of typical populations.

3. For the major anadromous, semi-anadromous and catadromous species, determine the spatial and temporal variations in the migratory tracks and the details of migratory behavior in terms of regulatory mechanisms (e.g., environmental cues).

Approach

a. Develop and apply appropriate telemetric techniques for tracking movement of key species both during migrations and during non-migratory activity.

b. Determine the numerical and geographic size of spawning stocks of key species. Application of established protein electrophoretic techniques will be useful for many species. We need to determine the amount of population exchange both between subsystems of the Bay and between the Bay and other regions of the coast.

Cost and Duration

Extremely difficult to predict. Both long-term (5-10 yr) and short-term (1-2 yr) studies are needed.

Related Studies

See Monitoring and Fisheries Sections

PROJECT: What are the Physico-Chemical and Biological Factors which Control Bay Populations of Non-Exploited but Ecologically Significant Species?

Since they have been demonstrated to be of great importance, the organisms which should be considered include:

Chrysaora quinquecirrha - Sea nettle

Mnemiopsis leidyi - Comb jelly

Neomysis americana - Opossum shrimp

Crangon septemspinosa - Sand shrimp

Palaemonetes vulgaris - Grass shrimp

Acartia spp. - Copepod

Eurytemora spp. - Copepod

Anchoa mitchilli - Anchovy

Trinectes maculatus - Hogchoker

Menidia spp. - Silverside

Zostera marina - Eel grass

Where detailed knowledge is lacking, the life cycles should be fully elucidated. Cultures should be established to permit experimental manipulation of species. The researcher would then be in a position to determine factors which affect populations.

Initially the study should concentrate on laboratory studies using a microcosm approach to elucidation of limiting factors. Knowledge gained from such efforts could then be applied to investigations of population dynamics in the estuary.

The information derived from such studies could be used to predict population sizes of the species which are important in providing food or habitats for, or in limiting, numbers of commercially significant organisms. The ultimate significance of the studies would thus be a provision of data which would permit assessment of conditions necessary for generating acceptable populations of commercially important species.

PROJECT: Research Directed to Completing Our Knowledge Gaps of the Economically Important Species in the Bay System

Although there exists considerable information on the biology and ecology of the biota in the Bay, there are also major gaps in our knowlede of many of these species. The purpose of this research will be to identify what these shortcomings are, then to conduct research in those areas identified as significant. Areas of concern would include behavioral pattern, stages of life cycles, trophic relationships and response patterns to altered environmental conditions.

Objectives

1. Complete the knowledge of the behavioral patterns of important Bay species throughout their life cycle.
2. Determine the nutritional environmental requirements of the various life history stages of important Bay species.
3. Identify the location or migratory pattern of the various larval and juvenile stages, seasonally, for economically important Bay species.

Approach

Assemble a team of experts on shellfish and fish of the Bay who will identify the major species of economic importance. Each of these species will be reviewed as to the significant areas of knowledge regarding their biology and ecology that are known. Research plans will be identified to obtain this revising information. Publish species monographs.

PROJECT: Exchange of Chemical Substances within an Estuarine System

Dissolved and particulate chemical substances exert a pronounced influence on estuarine biota and water quality. Point and non-point source inputs contribute significantly to estuarine eutrophication and toxification through nutrient uptake, primary and secondary production, ecological succession pathways and through pollutant-bioaccumulation pathways. Monitoring of pollutant input loads is a time-honored tradition in environmental "research" and should continue into the future. However, our knowledge of what happens to various pollutants once they enter an estuarine system is woefully inadequate. Are all nutrient elements immediately taken up by primary producers and do they go through a production (incorporation)-respiration-consumption-regeneration-deposition cycle, or do some elements go through a different biogeochemical cycle such as inorganic adsorption-sedimentation-diagenetic regeneration? Are potentially toxic metals tranferred directly fro the water to biota, or do some follow a pathway whereby they are converted from one "harmless" chemical form to another form (e.g., mercury, arsenic) which is toxic to higher level organisms? What are the chemical constituent transfer rates among various estuarine compartments (i.e., particulate-dissolved, dissolved biota, sediment-water, trophic levels), and how do they determine the (ecological) response of the system to chemical perturbations (pollution inputs)? Only when we understand better the pathway and rates of exchange of any chemical species among estuarine compartments, can we assess the environmental and ecological impact of waste inputs (planned and unplanned) on an estuarine system.

Objectives

1. To compartmentalize an estuarine system considering macrointerfaces (air-water, sediment-water, freshwater-saltwater), microinterfaces (dissolved-living and non-living particulate, inorganic-organic), and food web/trophic level interfaces.
2. To decide which environmentally important and ecologically sensitive chemical constituents can be used to understand the material and energy transfer through an estuarine system.
3. To develop methodologies for quantitatively measuring the "pool" sizes of estuarine compartments and the rates of chemical transfer among compartments.
4. To measure or estimate the exchanges of one or two chemical constituents among all the compartments within a tributary estuary of Chesapeake Bay.

Approach

1. Convene a conference (or workshop) of estuarine scientists for the purpose of developing a conceptual compartmental model of an estuarine system in general and the Chesapeake Bay in particular.
2. Commission a "task force" which would review the estuarine, environmental and ecological literature as related to nutrients-metals-organics in order to recommend what chemical constituents could be used for such a study and which of these were feasible from a sampling, analytical and ecological point of view.
3. Conduct fundamental studies on the forms and quantities of specific nutrients, metallic elements and organic chemicals; when freshwater

mixes with saltwater; when oxygenated water mixes with anoxic water; and when populations die and/or are consumed.

4. Gather frequent data on these constituents in several "model" estuarine systems which are being perturbed by natural forces (e.g., storms, shoreline erosion) and those associated with man's activities (e.g., point and non-point source inputs, dredging).

PROJECT: A Study of Second-Order Estuarine Flows

Longitude tidal and density flows in estuaries have been well-studied. The hydrodynamic theory for vertical and lateral flows has been documented in the literature, but in practice these second-order flows are much more difficult to measure with accuracy. Sometimes they are not observed directly, but rather calculated from the spatial and temporal patterns of longitudinal flows.

Although the second-order flows may be small in magnitude, they often control the transport processes in the lateral and vertical directions. Hence, their proper description can be key to predicting biologically important events such as water-column turnover or lateral dispersion of ichthyoplankton.

Objectives

1. To understand how lateral transport may vary spatially and temporally in a coastal plain estuary.
2. To describe the spatial and temporal variation of vertical transport in the main stem of Chesapeake Bay and the major tributaries.
3. To classify and explain the residual circulations forced by the interactions between the oscillatory tidal flow and bottom topography.

Approach

All three objectives can be addressed simultaneously by judicious choice of hydrographic monitoring sites throughout the Bay. To study these second-order flows will require denser spacing of current meter and salinity probes than most previous studies. Hence, the program is apt to be costly in terms of equipment, boat time, manpower and data reduction effort. In addition, continuous sampling and analysis for macronutrients will provide additional valuable data relating hydrodynamic processes to nutrient transport. Discrete plankton sampling should accompany this effort so that the overall relationship between vertical transport processes and plankton ecology can be discerned.

Cost and Duration

Two principal investigators, five research assistants over five years at about $700,000.

Related Studies

Waste placement, electricity generation, shoreline development, mining, information management.

PROJECT: The Response of Estuarine Ecosystems to Physical "Pulses"

Pritchard has defined estuary as "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage." It is this mixing of fresh water and salt water which makes estuaries unique, and it is the quantity of fresh water inflow that determines, in part, many important properties of estuarine systems (flushing time, position of salinity wedge, position of turbidity maximum). For Chesapeake Bay proper, the large quantities of late winter/early spring runoff from the Susquehanna River provide much needed nutrients to the Bay. Subsequent production or organic matter combined with declining fresh water inputs result in stratification of the water column and the formation of anoxic conditions in the bottom waters of the middle region of Chesapeake Bay. The chemical and biological responses to these perturbations are enormous. In the Potomac, a large sub-estuary to Chesapeake Bay, winter flooding causes erosion of nutrient-rich bottom sediment located near metropolitan District of Columbia sewage outfalls; the sediment is transported downriver to the null zone where during summer low-flow conditions benthic regeneration becomes an important source of nutrients to the water column. Obviously, the ecological impact of pulsed flow is very significant.

Objectives

1. To determine the physical, chemical and biological variations in Chesapeake Bay and its tributary estuaries before, during and after high freshwater inputs that occur during the late winter and early spring.
2. To determine the effect these changes have on the community structure and ecological succession of biota within Chesapeake Bay.

Approach

1. Review the historical data base provided by Chesapeake Bay research groups in order to determine whether suitable physical (temperature, salinity), chemical (nutrient species) and biological (primary productivity, species) data exist.
2. Pending the outcome of the first exercise, conduct data-acquisition cruises along longitudinal transects before, immediately after and several weeks to months after high winter/spring inflows of fresh water occur.
3. Analyze all data to determine the nature and extent of change in the structure of the estuarine ecosystem.

The duration of this research effort on Chesapeake Bay and its major tributaries would be a minimum of three years. The first year would involve examining the existing data base with respect to the research objectives. The next two years would be spent gathering and evaluating new data that can be applied to the problem.

Cost and Duration

Approximately $150,000 the first year for a principal investigator and two assistants plus computer time and travel. The next two years would involve considerably more funding, considering a minimum of two groups, ship time (30 days per year per group), laboratory analyses, etc.

Related Studies

Includes monitoring, ecological modeling and laboratory/field nutrient culture response studies.

PROJECT: The Transmission, Pathology and Life Cycles of Major Molluscan and Crustacean Disease Organisms

Avoidance or control of diseases such as Minchinia nelsoni (MSX), M. cortalii (SSO), Perkinsus marinus (Dermo), and Paramoeba perniciosa ("grey crab" disease) is more possible if the life cycles are development in the hosts is well known. In addition, if avoidance or control of the disease is not possible, such knowledge can permit harvesting of the host before expression of the disease becomes economically damaging.

Approach

Since most details of the disease organisms' structures are already known, methods for transmission of the diseases must be identified; then developmental sequences can be observed in the host. If other hosts are involved, they must be identified and their roles in the life cycles must be determined. The most and least favorable physico-chemical conditions for expression of the diseases must be determined in order to assess possible control mechanisms. If knowledge of the protist structure is not adequate for following its life cycle, then fluorescent-antibody techniques must be used.

If the disease organism is clearly related to other disease organisms where chemical control has been achieved, then such chemicals should be further explored, particularly under aquaculture conditions where limited water volumes are involved.

Cost and Duration

$300,000 and four years.

PROJECT: Publication of Standard Anatomical and Cytological Reference Sources for Significant Chesapeake Bay Organisms

Despite decades of effort on certain major organisms in the Chesapeake Bay, standard reference sources on their macroscopic and microscopic structure are not available. It is believed that such atlases would be invaluable, because many studies require a knowledge of structure. The blue crab, Callinectes sapidus, has been described; however, thorough works on the American oyster, the striped bass, menhaden, stinging nettle, hard clam, croaker and others would also be useful. In addition, many studies center around the microalgae. An atlas of those species for identification purposes would be valuable, particularly on the ultraplankton (F10 mm). Such atlases would facilitate studies of a wide diversity in ecology, physiology and biochemistry.

PROJECT: Develop Selective Breeding Procedures and Genetic Manipulation Techniques to Improve the Status and/or Harvest of Economically Important Bay Species

Approach

Research directed to improve the stock of shellfish for faster growth, resistance to disease and other desired qualities.

Cost and Duration

Estimated at $150,000 for 3 years.

PROJECT: The Dominant Species or Groups of Microalgae

Since microalgae, both planktonic and benthic, have been demonstrated to be the most important primary producers in most estuaries, it is desirable to know which species are most important and what factors control their numbers. If significant factors which could be controlled were identified, then decisions could be made which would be favorable for encouraging the best population balances. Such population balances would be of significance to controlling metazoan populations in the Chesapeake Bay; for example, greater or lesser numbers of coelenterates, finfish or shellfish.

Approach

Where not already known, dominant species of diatoms, cyanobacteria, phytoflagellates and dinoflagellates must be identified; laboratory studies must then be initiated, using cultures to obtain estimates of their relative contributions to the total primary production as a verification of their suspected importance based on numbers estimates. Using cultures, physicochemical factors which control their numbers must then be determined. Verification of such conclusions should then be obtained from field observations of their population dynamics.

Cost and Duration

Considering the scope of this effort, it is not possible to estimate costs and duration. Ten years would easily transpire before completion of much of the work.

This could be regarded as an "open-ended" project; however, limits of $1,000,000 and 10 years could be set before terminating the project if success were not to be obtained.

PROJECT: Identify the Trophic Relationships that Exist with the Ultra-Phytoplankton Component of Bay Waters

The ultra-phytoplankton represents a widely distributed and highly abundant component of the plankton community; however, very little is known of the trophic relationships of this group to the local ecosystem.

Approach

Conduct laboratory and field investigations regarding the contributions of ultra-phytoplankton, in comparison to other phytoplankton species, as a food source to zooplankton and those plankton feeders among the economically-important Bay species.

Cost and Duration

Estimated at $70,000 for two years.

PROJECT: The Relative Role of Allochthonous Contributions to the Chesapeake Bay

Typical of Class B estuaries, the Chesapeake is a gradient system. For example, salinity increases from the landward to the seaward end. A similar situation exists with light penetration. Conversely, turbidity and suspended material decrease as one progresses from the maximum zone to the oceanic end. Also, the distributions of many biota have abundance values that increase or decrease in a gradient manner within the Chesapeake. A number of additional specific examples could be identified.

A fundamental feature of our natural areas (estuaries included) is that carbon energy supplied by the photosynthetic process to a large measure determines the ultimate animal production of these regions. Within the Chesapeake, it is clear that there are two major sources of carbon energy that are ultimately made available to various animal species. One source is from in situ photosynthetic activity carried out by phytoplankton, attached algae and submerged vascular plants. A second supply is provided by marsh and land-based vegetation that is carried into the Bay by various forces. The relative contribution of these two sources to the carbon energy budget is unknown. Their role to the food webs of the Bay is incompletely understood. It is clear that man's activity on land will continue to influence marsh and other terrestrial vegetation patterns and abundances. Similarly, substantial changes in waterflow patterns undoubtedly will occur or be proposed in the various watersheds within the Chesapeake Bay region. It is important, therefore, to quantify the relative contributions of these two sources to the Bay's carbon energy supplies. Further, food web utilization of these materials would be clarified.

Objectives

1. To quantitatively measure the contribution of in situ carbon energy production in the Bay and the contribution of land and marsh-based contributions in the form of allochthonous material.
2. To evaluate qualitatively and quantitatively the food web responses to these two carbon energy sources.
3. To determine the role of weather patterns and various hydrologic and hydraulic patterns on the quantity and timing of deposition of allochthonous material to the Bay system.
4. To evaluate the relative value of allochthonous sources to animal production in the Bay through analysis of the timing and magnitude of availability from these two sources.

PROJECT: Entropy Production as an Indicator of Biological Activity

Radiation is received at the earth's surface with energy concentrated in the visible region of the electromagnetic spectrum. The energy is utilized by many physical and biological processes and released back to the universe in a much lower quality (higher entropy) as longer wavelength infrared radiation. Remote sensing techniques are available to monitor the incoming and re-radiated spectra for a given patch of Bay surface. Using these spectra, it is an easy matter to calculate the rate of entropy production for the surface.

In any map of entropy production the regions of high production should prove indicative of highly irreversible, far-from-equilibrium processes. In turn, high entropy production appears to be a necessary (although not sufficient) condition for high biological activity. The maps of entropy production could be examined a-posteriori to assess how well they identified productive areas.

Objectives

To identify those regions of Chesapeake Bay where greatest entropy production is occurring and evaluate the significance of entropy production as an indicator of biological activity.

Approach

Visible and infrared spectra taken from either fixed or movable platforms over diurnal and seasonal periods would be used to create a seasonally-averaged map of entropy production. Regions of high and low dissipation would be examined later in the project to assess the cause of contrasting dissipation rates and to determine whether the causal phenomena are biological in nature.

Cost and Duration

Two principal investigators, two assistants, three years. About $450,000 is estimated unless remote sensing can be piggybacked onto existing NASA operations.

Related Studies

Fisheries and wildlife, waste placement, electricity generation, shoreline development, mining, monitoring.

PROJECT: Maximum Dissipation as a Determinant of Estuarine Hydrographic Flow and Geomorphology

Recently C.W. Paltridge (1975) has been able to predict the long-term climatological consequences of environmental changes (e.g., change in the solar constant, albedo of the earth). He accomplished these predictions by casting the energy budget of the atmosphere as a balance of various meteorological processes. Each process was mathematically described, but the parameters of each descriptive function were not specified a priori. Instead they were chosen so as to optimize the rate of energy dissipation (to long wave-length radiation). The hindcasting achieved by this method was amazingly accurate, lending persuasion to his prognostication.

Similar methodology could be applied to the hydrodynamics and sediment dynamics of Chesapeake Bay. Probable morphological changes as a consequence of bottom and shoreline engineering alterations would result.

Objectives

To predict future morphology and hydrodynamic regimes resulting from dredging, mining and shoreline alterations by employing the principle of maximum dissipation.

Approach

See G.W. Paltridge (1975) and above section on project description.

Cost and Duration

Two principal investigators for three years at an estimated $240,000.

Related Studies

Transportation, shoreline development, mining.

References

G.W. Paltridge. 1975. Global dynamics and climate--a system of minimum entropy exchange. Qrt. J.R. Met. Soc. 101:475-484.

PROJECT: Biological Control of Estuarine Pests

Efforts should be made to find or "create" viruses, bacteria or protists which are lethal or inhibitory to Chesapeake Bay pests such as the stinging nettle, Chrysaora quinquecirrha, and the oyster drill, Urosalpinx cinerea. If successful, the significance of the efforts are obvious. Recreational use of the Bay would increase and oysters could be grown in more regions of the Bay.

Approach

A survey to find viral and/or microbial pathogens would be initiated. Once identified, such agents would be established in culture and used as a source for experimental studies. Under laboratory conditions attempts would be made to produce a more virulent strain of the pathogen by alteration of the genome using chemical and irradiation techniques. If a suitable strain were identified, then extensive testing would be initiated to determine host specificity. If an acceptably high level of specificity could be found, then macrocosm studies would be initiated, followed ultimately by field testing. The effort is a high-risk venture but if one or suitable agents are found, then the benefits could be highly significant.

CHAPTER 10
MONITORING

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RESEARCH NEEDS TO SUPPORT MONITORING IN CHESAPEAKE BAY

INTRODUCTION

Monitoring is a term used to describe a wide range of activities. For environmental purposes and in the most general sense, the term can be defined as the systematic collection of measurements of observations of any environmental variable for the purpose of determining a change in the state of condition of the system of concern. In systems like Chesapeake Bay and its tidal tributaries many different types of measurements and observations have been made for many years by numerous people and organizations. These measurements have been taken with variable spatial and temporal scales and methods so that it is often difficult to compare the results.

The Chesapeake Bay System is a national resource recognized for its high productivity. This is reflected in fishery yields, recreation and its use as a water-course providing large volumes of water for industry and transportation. In recent years, a number of signs have given reason for concern about the state of "health" of the Bay. Projected population growth over the next 20 to 40 years has added to the concern of citizens, managers, scientists and policy-makers. Effective and appropriate monitoring of the Bay ecosystem is probably one of the most important tasks that can be undertaken, if we are to detect and predict environmental change that will affect the Bay's capacity to continue to provide essential goods and services that makes it a national resource.

The purpose of this paper is to suggest a framework for research in support of monitoring activities and to indicate how time-series data can be used to suggest hypotheses regarding the nature of environmental change. Within this framework it should be possible to learn more about how to take the "pulse" of the tidal Bay system and track other vital signs. Though it is interesting to associate the medical analogy with ecosystem level change, we have no fundamental basis for its application. Its heuristic value suggests that ecological processes should be considered in a monitoring plan and research in support of monitoring since environmental problems result from changes in these basic processes. For example, human health depends on many physiological and biochemical functions, i.e., liver and kidney activity to purify the blood and an effective circulatory system to transport nutrients and waste materials to name a few. Ecological processes involve estuarine circulation to transport materials (bottom sediments, especially marsh and Bay grass sediments) which modify the availability of natural and anthropogenic chemicals and organic decomposition, thus helping balance production of organic matter.

The integrity of physiological functions at the organism level is obvious and consequences of disfunction may result in death. However, ecological dysfunction has important consequences in terms of human use of the Bay. In this context ecological "death" may be over-drawing the analogy; however, the point should be clear--factors affecting ecological processes should be the basis of pulse-taking for the Chesapeake Bay and tidal tributaries.

The development of a research needs plan is subject to the following constraints:

1. The multiple usage, size and complexity of the Bay and its tidal tributaries makes it difficult to design a simple monitoring plan.

   This statement is a caveat intended to temper expectations. Fiscal, political and technical considerations provide a real challenge to the development of an understandable and practical monitoring plan. We hope this report will help clarify important elements and relationships inherent in a monitoring plan.

2. A statement of environmental quality objectives and their implementation will help direct research in support of monitoring.

   Though the goal of Bay management emphasizes the continued biological productivity of the Bay and tidal tributaries, it is recognized that some areas are more stressed biologically than others. Further research is indicated to define more clearly near-field and far-field effects of pollutants and the sensitivity of adjacent areas to "hot-spot" areas. Monitoring will help determine whether management controls are effective in reaching stated objectives.

3. It is essential to acknowledge that the utility of monitoring is ultimately limited by the state of knowledge concerning the ecological relationships that define the fundamental nature of the Chesapeake estuary.

   This statement is offered without the need for amplification.

Assessment of the present environmental quality of the Bay requires an understanding of its past condition. The lack of an organized description of present and past monitoring activities within the tidal estuarine waters of the Bay and tributaries makes it difficult to characterize the objectives, quality of the data and trends for the expected wide range of activities on a Baywide basis. This task should have a very high priority.

As part of its mandate, the Chesapeake Bay Program of the U.S. Environmental Protection Agency is currently assessing trends in living resources, primarily fisheries, and environmental variables including freshwater flow to the estuary, insolation, rainfall directly on the tidal waters, sediment loading and various water chemistry variables, e.g., nutrients and toxic chemicals. This effort draws on research and monitoring studies and will contribute to the documentation of ongoing monitoring. Before changes are made in existing monitoring programs or new ones are added, it is necessary to evaluate the effectiveness and costs of ongoing efforts. Modifications to the suggestions contained herein should be considered following the conclusions and recommendations of the U.S. EPA Chesapeake Bay Program.

Types of Monitoring

This section will briefly describe the types of monitoring, in part to provide a definition of terms. It is important to recognize that monitoring involves several objectives--traditional ones have included:

1. Data to evaluate compliance to regulations.
2. Regulatory development.
3. Development of trends to assess unusual environmental conditions such as season to season and year to year fluctuations in abundance of living resources and water quality variables, especially the ability to distinguish natural from anthropogenically mediated change.
4. Provision of a framework of data for designing programs of management or research.

The literature contains many references to monitoring and each approach has distinctive benefits; however, research in support of monitoring is most easily described when the wide variety of approaches to monitoring can be classified into a few general types.

A convenient framework in which to evaluate monitoring is given in Figure 1. The diagram shows the flow of a possible pollutant from its source to a target where an effect may occur. Sources may involve point-sources, e.g., effluents, or nonpoint sources such as agricultural and street runoff. The transport pathways are often complex in the estuary where estuarine circulation and tidal action make prediction difficult and expensive. Various processes can change the temporal availability of a pollutant, e.g., burial in sediments or seasonal lags imposed by incorporation into detritus. A wide range of effects are possible depending on the populations at risk and their toxicological sensitivity.

The framework is useful if the objective is to provide one or more controls on the source of a pollutant. Valuable insights can be provided to the resource manager even though effects might be poorly known. Knowledge of the environmental transport and fate of a material can be gained through exposure monitoring which, by itself, does not include effects information. However, if populations at risk are known, then an exposure assessment can be made based

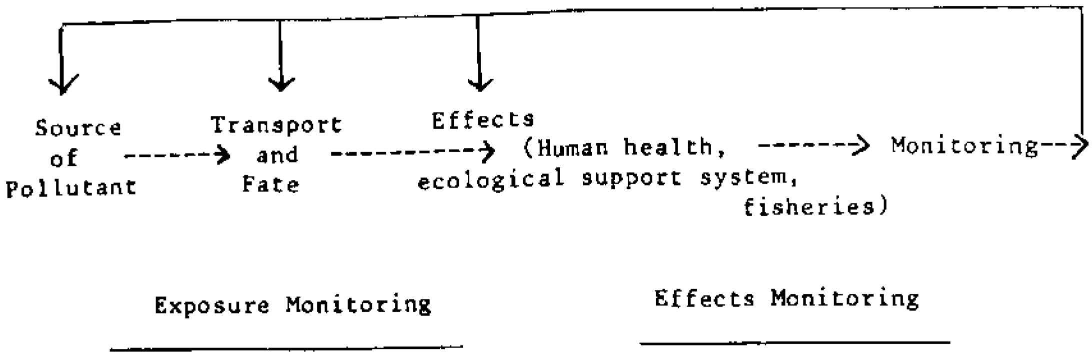

Figure 1

upon the relative hazard of a chemical or material. A stronger case can be made if effects are known based on previous laboratory/field data. In these situations monitoring data can be a powerful tool for the resource and water quality manager. Often the effects are described in terms of correlations and direct cause is somewhat speculative. An hypothetical example is the case where an increased supply of a toxic chemical to the Bay is coincident with decreased abundance of fish. The actual decrease in the fish abundance may be the direct result of low levels of dissolved oxygen or increased predation.

It is generally recognized that the source of many pollutants originates within the drainage basin but upstream of tidal influence. Thus, it is reasonable to expand monitoring activities to a larger geographical coverage than just the estuary. This framework is basic to a comprehensive monitoring strategy that makes the necessary linkages between the source of a pollutant and its effects in the Bay and tidal tributaries. Similarly, it may be appropriate to consider atmospheric precipitation which may, in fact, have a source distant from the Bay drainage basin.

The monitoring scheme discussed above can have people as an end point in the assessment of effects and chemical residuals. However, this report is largely focused on ecological relationships and places limited emphasis on direct human health effects.

For clarification of terminology, monitoring can be categorized into abiotic and biotic variables (Figure 2). The scheme is presented in a binary fashion for ease of understanding but in practice most monitoring would involve a mix of the various media and levels depending upon the objectives of the monitoring plan. Abiotic components help to organize data that are most helpful in estimating transport and fate aspects of a pollutant. Meteorological data can help explain the transport of a pollutant or the transport of organisms in the water column which may be brought into contact with the path of a pollutant. Biotic monitoring can be divided into laboratory or field (ecological) observations. These distinctions probably represent the extremes along a continuum. For example, microcosms grade from controlled laboratory systems

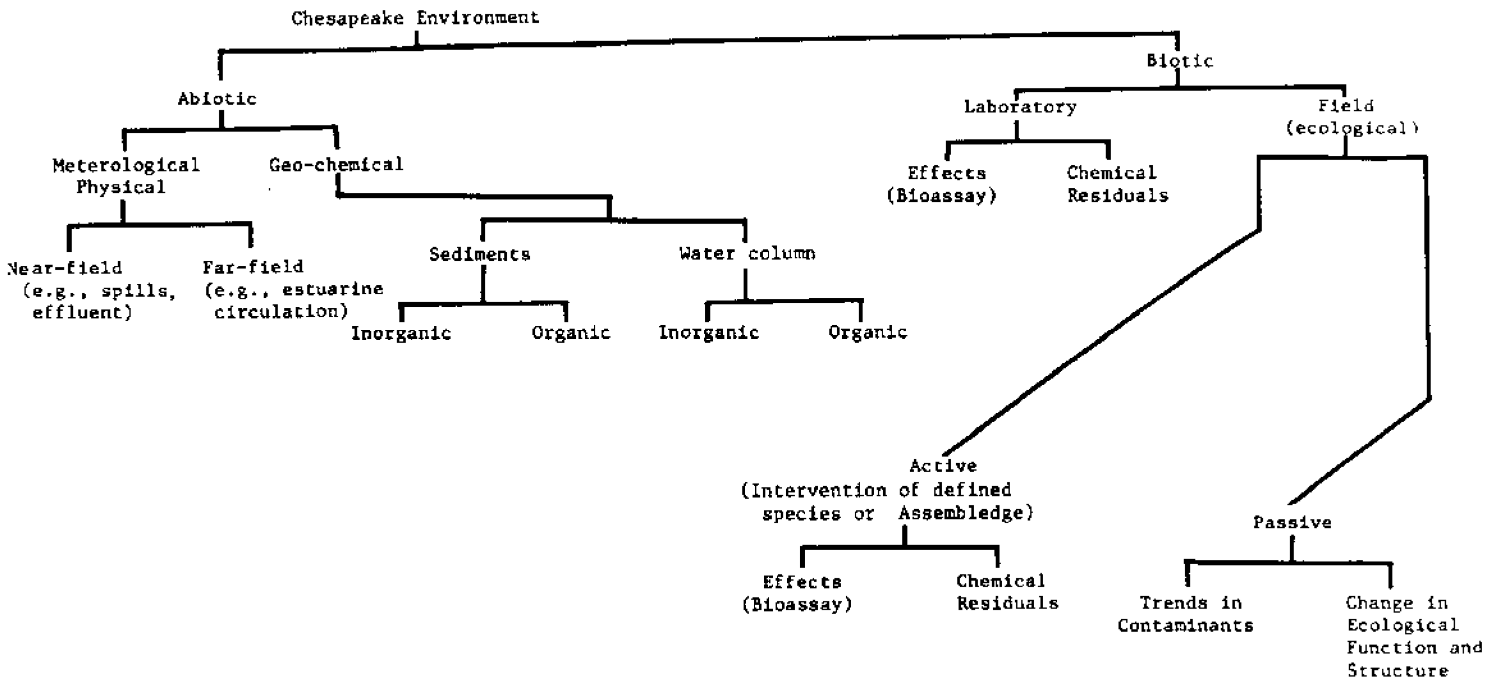

Figure 2. A binary scheme for organizing environmental variables useful in monitoring the Chesapeake ecosystem.

to field ponds where less control is often available. In an ecological or field context, we can distinguish between active and passive monitoring. Active monitoring is similar to the "canary in the cage," for example, fish may be caged and exposed to pollutants in an industrial waste stream or in the natural environment. Passive monitoring focuses on observing changes in the ecological structure. It is not a deliberate exposure of an organism to a particular situation. Passive monitoring can involve the field assessment of effects following a toxic spill or it can involve time series data on fish harvests or a number of other field observations. These two approaches are most effective when they are combined (See Luepke 1979).

CONCEPTUAL FRAMEWORK FOR RESEARCH TO SUPPORT MONITORING OF CHESAPEAKE BAY

Background Perspective

We now understand that many chemical variables in water are involved in the requirements for growth and survival of aquatic organisms. In recent years, the role of physical variables has been emphasized as limiting biotic populations or, at least, setting a boundary in an ecosystem within which biotic elements interact. Traditionally, temperature and salinity have been known to exert important effects at the physiological level. More recently, the role of climate and its interaction with the circulation of marine and estuarine waters is now acknowledged to play an important role in the distribution and abundance of many populations both directly and through processes such as "upwelling" and mixing of waters of different characteristics.

These considerations suggest that our ability to understand the relationships among environmental variables, including water quality and the biological components of a water body, will necessarily involve processes and rates in a dynamic sense as compared to point-in-time (ambient) measurements. This is a fundamental premise which underpins all monitoring schemes.

The Chesapeake Bay and tidal waters, as all aquatic systems, can respond to material additions in diverse ways. The Bay system can be thought of as one or a series of compartments; such a model helps one to conceptualize the ways the system might respond to material additions or external pressures. Figure 3 is a simple representation that emphasizes that materials can flux or exchange across compartment boundaries, for example, sediments, air-water interface, upstream and the ocean or the most seaward extent of a defined compartment. The "box model" approach has some advantages, especially in the accounting or bookkeeping efforts associated with mass balancing a material of interest (D'Elia 1981). For example, if nutrients are of interest, one could determine, as D'Elia points out, the amount of nutrient in the box after a given time interval as a function of the amount of nutrient or standing stock in the compartment at the beginning of the interval minus the amount lost over the interval plus the amount gained over the interval. Thus, one could think of the mainstem of the Bay or a tidal tributary as a series of linked boxes whereby the maximum amount of nutrient available for biological reactions, e.g., plant growth, can be tracked or mass balanced as described above. This approach is essential to the development of more complex models and has been employed by modelers to the Chesapeake system. However, at

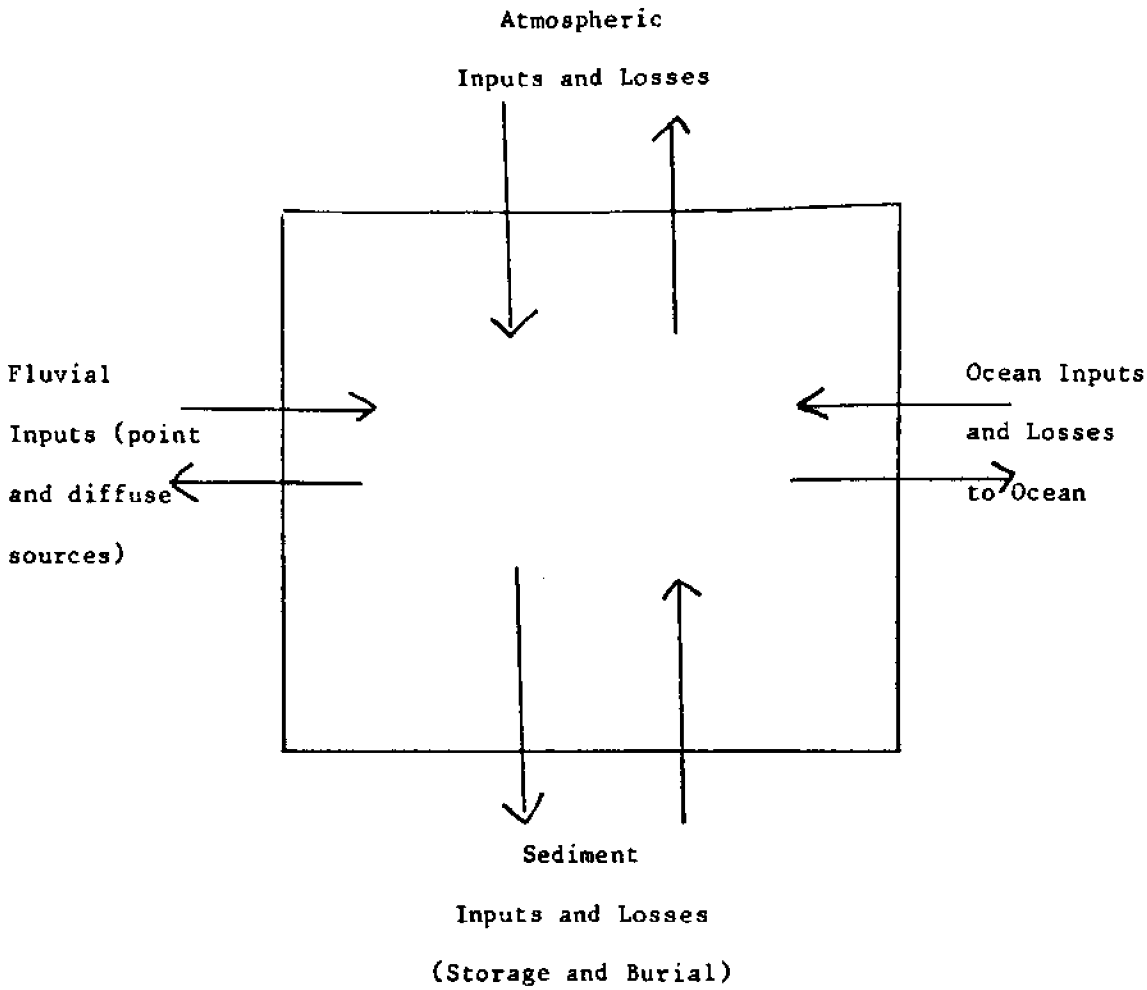

Figure 3. Simple box-model of materials balance in an estuary. (Where two-layered estuarine circulation exists the landward boundary of the box-model can transport material upstream.)

the "black-box" level of analysis many important things are unknown. For example, the internal response of plants to nutrients may be minimal if light is limiting photosynthesis. Also, one does not know if grazers will be able to crop the plants so little plant biomass actually accumulates. If one wishes to know more about the internal dynamics or processes within a compartment, then measurements must be made within the compartment on processes of interest, for example, nutrient cycling in the water column or the effects of a toxic chemical. The reason for describing this framework is to emphasize that monitoring ambient levels of a variable is only one aspect to consider and we may learn relatively little about the biological responses with such limited information.

From another perspective, resource managers will ask practical questions regarding internal dynamics. For example, what are the consequences in terms of fishery biomass yields and which species will be abundant as a result of changes in nutrient supply? These are difficult questions and it is impossible to answer them precisely at this time. How researchers approach such questions is important. Long-term monitoring data should contribute to the fundamental understanding of the nature of breakpoints and thresholds in ecosystems with a multiplicity of "stable states" (May 1977). In fact, monitoring data may help determine if the above concept is valid in terms of energy flow and nutrient cycling that presumably leads to characteristic assemblages of fish stocks and supporting food web species. In the past, there may have been a tendency to assume that point-in-time measurements came primarily under the purview of monitoring, while rate measurements were carried out mainly by researchers. This approach may have lead to unrealistic expectations since both kinds of measurements are essential to the best interpretation of change in the level of an environmental variable (Taft 1981). Another possible difficulty has been the use of the so-called "steady-state" assumption as a basis for the rationalization and continued emphasis of ambient environmental measurements at the expense of rate measurements.

Geophysical Setting

An important consideration in effective interfacing of research information with monitoring data is the compartmentalization of the Bay and tidal tributaries based upon physical, chemical and biological factors. The Chesapeake Bay Program/EPA has proposed an approach based on the assumption that the Bay system is too diverse and complex to effectively manage it as a single unit. Monitoring strategies that are based on functional similarities of the Bay, e.g., tidal freshwater, zones of maximum turbidity and two-layered estuarine circulation, should assist in testing this fundamental hypothesis regarding segments of ecological similarity. This is basically an analog approach, e.g., the Patuxent might indicate the future state of the Rappahannock estuary if the latter were to receive similar types and amounts of pollutants. The "segmentation" approach should permit important ecological insights to be derived through comparative ecology of the segments (Ulanowicz and Nielson, 1974). Data provided through research and monitoring efforts will help test the validity of this concept. At this point, the traditional views of research versus monitoring are merged into an hypothesis testing framework.

Build on What Has Been Learned

The present intent is not to equate monitoring with research, in sensu stricto, but to suggest that the traditional approach has limited utility and that new tools and ways to take the "pulse" of the estuary are available and can be used to great advantage. The historical ambient measurements do have value as has been shown by the long-term temperature and salinity data taken by the Chesapeake Biological Laboratory and other long-term environmental and fishery statistics taken by other Bay institutions and agencies.

At this writing, we do not have the benefit of the synthesis of research conducted by the EPA Chesapeake Bay Program on toxic chemicals, nutrient enrichment and decline of the Bay grasses. The mathematical estuarine circulation model and water quality model and other information should give new insights to a broad-based water quality monitoring plan and future research in support of monitoring.

Some Important Criteria for Evaluating the Relevance of Research in Support of Monitoring

1. Does the research contribute to a better understanding of cause and effect relationships so that monitoring will lead to more effective control measures?

   Implicit in this question is the distinction between monitoring variables that relate primarily to ambient conditions versus changes in ecological processes that lead to a given ambient condition. An example is the possibility of increased nutrient loading and increased grazing which may result in the failure of algal blooms to develop with consequent loss of dissolved oxygen.

2. Does the research contribute to more cost-effective ways to monitor significant environmental change?

   We are interested in change that results from natural and anthropogenic influence; the distinction is essential from a management perspective.

3. Does the research lead to more anticipatory type monitoring, i.e., sensitive early warning indicators of environmental problems.

   We should look for changes in ambient conditions, for example, species shifts, water quality factors and changes in dynamic processes, such as nutrient cycling.

4. Does the research further understanding of the assimilative capacity of the system?

5. Does the research contribute to increased predictive power?

   It should be noted that understanding of cause and effect and prediction may vary among problem areas.

Assessment, Monitoring and Research

This section will attempt to integrate the three above important activities related to monitoring of the Chesapeake Bay system. Though discussion is focused on tidal waters, it is believed that the framework developed heretofore is holistic and contains elements that are drainage basin-wide. Thus, the approach has application to freshwaters as well.

Assessment

Assessment is key to any overall monitoring strategy and plan. Since environmental monitoring involves the collection of an enormously large volume of data, it is essential that regular assessments be made to determine if trends are present and evaluation to see if "the plan" is working. Short-term "flag raising" should be a continuous process but five or ten year comprehensive assessments are needed on a Bay-wide basis.

An interesting component of periodic assessments could be a description by segment of major changes in the biological features. The approach might be to convene experts and have them report on unusual or dramatic increases or losses of various species. Though likely subjective or, at best, semi-quantitative, this approach might provide a condensed synoptic view of changes in the biological characteristics which may provide key insights into factors that affect ecological succession. Such insights will likely have relevance to resource management.

To perform periodic assessments it is necessary that an overall data management system be employed. This system has the potential to become exceedingly expensive; thus, its design should be modular so that the basic integrity of the monitoring system will remain intact under changing fiscal conditions. A basic component of the assessment should involve changing land uses, review of the NPDES permits and other management and regulatory data. The evaluation should be done in a predictive framework with feedback to any chemical "finger-printing" approaches that may be underway. Such systematic assessments should shorten the time between the introduction of a material and the determination of environmental consequences. Therefore, the monitoring plan should contain elements that focus on changes in the known and potential sources of pollutants to the Bay. This approach emphasizes prediction versus hindcasting. The design of the desired monitoring system could benefit from research on information networks and aerial surveillance techniques.

Monitoring and Research

The goal of research in support of monitoring should be to increase the information content (understanding and prediction) of data developed through monitoring activities. Criteria discussed above should be emphasized as a basis for judging the value of research in support of monitoring. A secondary consideration should be the development of techniques that will permit the separation of a monitored variable (signal) from the usual high "noise" associated with environmental data. This aspect will be developed in this section as a general need. In summary, some general comments and guidance will be discussed regarding the application of segmentation as a monitoring framework.

The following section will expand on the framework discussed in the section, Types of Monitoring, Figure 1 and application of the box-model approach.

Sources

Within any segmentation scheme, the tidal waters of the Chesapeake Bay system can be viewed as an interface between these waters, land and atmosphere. Those hazardous materials that enter the estuary mainly via fluvial sources should be candidates in a monitoring scheme. Classes of materials can be conveniently grouped into nutrients, toxic chemicals, including trace metals and organics, and sediments.

Emphasis should be in developing a fall-line or head-of-tide sampling regime to flag materials that would present additional loads to the Bay which would have unacceptable consequences. The idea of unacceptable consequences is related to management criteria which are usually framed in terms of uses of the estuary and its resources. Research is needed as an ongoing enterprise to help link the source material to undesired effects or predicted exposure even if precise effects are poorly defined. It should be noted that sources for a particular segment include all boundaries, with upstream or lateral segments, the ocean or a more seaward segment, the Bay bottom, and the atmosphere.

The source material assessment activity should include a series of bioassays to help evaluate the relative toxicity of anthropogenic substances. These bioassays should be tested on a variety of organisms and biological communities including microcosms and mesocosms. The latter is necessary because single species bioassays often are poor predictors of the field behavior and effects of industrial chemicals. Emphasis should be placed on sub-acute effects and possible shifts in the food web. The greater ecological insights gained on source material effects will lead to a more rational basis for prevention of pollution.

Transport and Fate

As indicated above, the transport and fate aspect is coupled to the source identity. The present circulation model under development at the Chesapeake Bay Program needs additional research to add a sediment transport component. The significance of toxic chemicals and associated fine sediments argues strongly for this task to become a high priority. Calibration and verification might include an approach described in Appendix I.

Because of logistical and cost problems, the Chesapeake Bay-wide monitoring of materials from a transport/fate consideration will be difficult to achieve on a spatially and temporally dense sampling plan. Data taken to calibrate and verify transport models or update them seems to be a better strategy than attempting to directly assess the transport and fate components. Site specific problems may fall outside of this argument but tributary or Bay-wide efforts should use the predictive capacity inherent in mathematical modeling with a balanced use of ground truth.

Important questions will continue to require refinement, for example, to what extent do materials get locked up in river-reservoir sediment and organic matter which precludes materials from reaching tidal waters, and under what hydrographic conditions do selected materials pass through tributaries to the main-stem of the Bay and vice versa?

Effects

This topic is poorly developed in an ecological context except for nutrients, and here the capability is largely in terms of predicting changes in the concentrations of dissolved oxygen, i.e., little is known about food web effects of nutrients. Research on basic effects of nutrients at the level of food-web relationships is needed before a rational effects model can form the core of a nutrient monitoring plan. In this context, toxic chemicals can be modeled mostly in a qualitative way using conceptual effects models. Basic work is needed, especially chemical tags or markers to trace the flow of materials in the food webs and the ability to sort out meaningful signals in a typically "noisy" environment (Appendix II).

As a basic strategy, the present effects models being developed by the EPA-CBP should be used to predict the effects; and specific research studies should use the long-term monitoring data to test and improve the predictions. This approach has immediate utility for nutrients but since toxic chemical effects are much less clearly defined, the approach will be more qualitative. Application of mathematical models may help resolve critical management decisions in the future. For example, a significant increase in nitrate loading to the upper Chesapeake Bay may have minor effects on the main-stem; however, it has been speculated that this source may be transported down Bay to the Patuxent where an already stressed system may be further degraded. In this framework, mathematical models (presently largely limited to dissolved oxygen) should be recognized as essential tools in any monitoring plan.

An extension of the approaches described in Appendices I, II and III can be combined for research in support of monitoring of the Bay system bottom. The rationale for this approach is given in Appendix III. The suggestion is made that Foraminifera might prove useful as an indicator of environmental stress. Other groups of organisms and assembleges should be examined from the indicator viewpoint. The example in Appendix III is offered as a specific approach to the more general need for a better understanding of benthic community processes and ecological relationships. Such knowledge should improve our ability to develop more useful benthic bioassays and relate the source, transport and fate of materials to key environmental risks.

Additional activities in support of monitoring are discussed in Appendix IV.

AN APPROACH TO A MONITORING NETWORK

The previous sections proposed a framework in which research could more effectively support environmental monitoring of the Chesapeake ecosystem. The term ecosystem is emphasized to remind the reader that the land and waters have many interdependencies. Application of the box-model approach identified key boundaries where materials are exchanged among environmental compartments, for example, sediments, water and air. The box-model framework helps to organize the extensive data and relationships essential to understanding environmental processes. These processes must be modeled in a computer mathematical system; otherwise the complexity will overwhelm us. It is through long-term data acquisition that important hypotheses can be accepted or rejected. This view of monitoring as an important element in a larger hypothesis testing framework is often ignored.

If ecosystems were highly repeatable in their outputs, then mathematical modeling would be largely unnecessary since the system, for us the tidal estuary, would behave in a prescribed way. Though many features follow a generally predictable pattern, for example, life cycles, circulation and rate of primary productivity, once a stress is placed on the estuarine system or an important species, then the outcome is usually not amenable to simple analysis. In general, we are able to model and predict with more precision the flows of materials than changes in ecological structure, such as nutrient cycling versus the abundance of forage fish. The measurement of selected variables as a core set over time should help provide continuity necessary to understanding alternate outcomes in a dynamic environment. Thus, the real "trick" is to have a balance in variable selection and rate measurements that helps characterize the change in ecological processes whose interaction may lead to undesirable consequences for the public; examples of such consequences are unattractive algal blooms, anoxic waters and loss of fisheries. It is with this perspective that important elements of a monitoring network are discussed. The relationship of this section to Appendices I, II and III should become clear--it is a question of monitoring system behavior.

Elements

At this stage the elements will be highlighted; equally difficult is the determination of the monitoring design--largely a problem of spatial and temporal scale appropriate to a specific question. The approach deals first with physical-chemical variables, then logistical considerations and finally with biological aspects and specimen banking. The latter permits retrospective analysis of chemical residuals.

PROJECT: Develop a Core Set of Variables Measured as Part of Bay and Tidal Tributary Studies

Since costs of research and monitoring will continue to be a serious consideration, it would be desirable to have a Bay-wide mechanism to screen all field research so that a core of measurements are made routinely as part of all field studies. This is based on the assumption that for many field studies a major cost is associated with boat time. There are difficult administration questions associated with this proposal that will be discussed elsewhere.

Core measurements should initially include:

Dissolved oxygen

Temperature

Salinity

Chlorophyll a

Optical light attenuation

The above information should be reported on a standard form including latitude, longitude, hour, day, month, year, geographical marker as check on location and a comment section, for example, sea state, ice, unusual biological observations. Methods and sampling protocols need to be standardized. Administrative procedures will have to be worked out for acquisition of these data and their placement in a computer monitoring file. In addition, questions of quality assurance and control must be addressed.

PROJECT: Develop Physical Time-Series Information on the Tidal Estuaries at Fixed Points

Major consideration should be given to measurements of temperature, salinity, tidal characteristics, wind speed and direction, barometric pressure and "turbidity." Environmental chemistry should be considered as funding and technology permits. Most of the bridges discussed below are near EPA segment boundaries. Data should be taken within a mathematical modeling framework.

Permanent Platforms

The available bridges around the Bay should provide useful sites to develop automated monitoring systems for the above variables. Cory (1974) and Cory and Nauman (1970) have demonstrated the value and reliability of this approach in the Patuxent. It would be desirable to include dissolved oxygen in this set of variables These and others should be considered:

Susquehanna River

Chesapeake Bay Bridge

Chesapeake Bay Bridge Tunnel

Tappahannock, Rappahannock

Hampton Roads (James R.)

Mouth of Rappahannock

Mouth of York

Wilson Bridge, Potomac

Morgantown, Potomac

Benedict, Patuxent

Solomons, Patuxent

Key Bridge, Baltimore Harbor

Cambridge, Choptank

Vienna, Nanticoke

Chestertown, Chester

A cost and feasibility study should be a high priority task.

Moorings

As discussed above for permanent platforms, it would be desirable to include long-term moorings which provide similar information. In the case of the Potomac there is no bridge available at its mouth. Also, moorings might include information on current speed and direction which would be less subject to inteference from bridge support structures.

PROJECT: Develop Remote Sensing Capabilities for Monitoring

These conferences have discussed many ways by which aerial surveillance might contribute to coastal monitoring (NASA 1972; NASA 1977; Campbell and Thomas 1951). The value of synopticity for verification of hypotheses and development of new insights ranks high on the scale of worthwhile approaches. The ability to describe algal pigment groups, light attenuation, surface current patterns and other estuarine features gives this approach a special appeal.

Further feasibility studies over the entire tidal reaches are indicated. A combination of sea-truth and remote sensing is necessary for the latter to be useful.

PROJECT: Fall-Line Monitoring

This is probably a non-controversial activity as a general need; however, debate results when the specific sampling and analytical protocols are proposed. The fall line is an important boundary to tidal waters, especially the Susquehanna and the larger western shore rivers which contribute most of the freshwater supply to the estuary. Variables of general interest include flow rate, nutrients, trace metals, organic pollutants and sediments. Some samples cannot be preserved and thus do not permit automation at this time. In the interest of economy, most effort should focus on taking flow-weighted samples. Thus, few samples are probably needed much of the year. Bridges and dams will be useful.

PROJECT: Atmospheric Dry-Fall and Wet-Fall Monitoring

There is limited data on this subject. Its potential importance should be considered as a key topic in a workshop design to make recommendations. Some insights will be gained from initial studies supported by the EPA/CBP.

PROJECT: Biological Monitoring

This subject is extremely complex and it will be difficult to achieve universal acceptance. Biological monitoring offers the best information on the environmental quality of the estuary. Without biological monitoring we could never hope to connect sources of pollution with significant effects.

Many variations exist with biological monitoring as shown in Figure 2. The subject is too broad for a thorough coverage in this report. Examples of important activities are discussed below.

1. The Mussel Watch Approach

   This "active" monitoring program has been underway for several years (in Luepke 1979, see Lowman, 392-396) around the coasts. Some modification of this approach has merit for the Chesapeake--the temporal and spatial coverage could be changed to meet specific needs. One or more test organisms other than those used in "mussel watch" could be used.

2. Juvenile Fishery Survey and Shellfish Survey

   The states of Maryland and Virginia have maintained such surveys for a number of years. They are recognized as valuable monitoring efforts. Changes or "improvements" in these programs should be made only if the change is calibrated to the historical data base. Information has been collected on finfish juveniles and oyster spatfall. It should be noted that many biological forms are not amenable to fixed-station monitoring, e.g., anadromous fish eggs and larvae.

3. Adult Fish Harvest

   There is a serious weakness in our ability to translate harvest statistics or catch records to reliable estimates of fish stocks (Cronin 1982). This is an extremely difficult management area but all parties would seem to be better served if improvements could be made. For example, trend analyses could be better interpreted in terms of fishing pressure, natural variation and water quality.

   Note: Chemical residuals in selected organisms should be considered as part of a "mussel watch" related program or periodic analysis of wild species.

4. Plankton Surveys

   Data in this area could be made more useful to resource management agencies if more attention were spent on standardizing methods and reporting data. The Maryland Department of Natural Resources operates a core program that should provide a valuable long-term benchmark; possibly more effort on nanoplankton should be considered by all investigators.

5. Other

   As previously noted, periodic reporting by experts on biological observations that are considered rare or unusual should be given serious attention.

PROJECT: Environmental Specimen Banking

This topic was given comprehensive coverage in a recent symposium (Luepke 1979) and in a workshop that served as a practical guide to the whole environmental banking operation, "International Workshop on Environmental Specimen Banking and Monitoring as Related to Banking" in Saarbrücken, West Germany (May 10-15, 1982). An important objective of this approach is to establish environmental specimen banks which are essential in analyzing trends in exposure to previously unrecognized pollutants or pollutants for which analytical techniques may, at present, be inadequate.

PROJECT: Application of Emerging Technologies

The possibility that microbial genetic engineering may produce bacteria which can degrade specific classes of chemicals should open the door for rapid monitoring of specific pollutants. This exciting possibility warrants a special workshop to explore the potentials of this technology.

DISCUSSION AND CONCLUSIONS

Need to Recognize the Role and Responsibilities of Management Agencies and Research Institutions

Management agencies have traditionally supported monitoring activities and applied research through extramural programs. In the Chesapeake Bay region, several research organizations have historically carried out monitoring and research; the present trend is for research establishments to emphasize research and give less attention to the more traditional survey and monitoring efforts. However, sharp distinctions seldom can be defined. In these relationships, an important issue for research establishments is how can they maintain high quality science and continue to provide timely data and advice to meet the needs of management agencies. We feel that a continued sensitivity to this issue is necessary. By the nature of responsibilities, academic deans must emphasize quality science, often measured, in part, through publication in peer reviewed journals. Resource managers and decision-makers must emphasize quality decisions based on the best available information.

Need for Long-Term Research and Monitoring Coordination and Funding

To many, this topic is accepted as a given. The question is how to insure that this need will be addressed appropriately in the Federal and states budget processes. Though given little attention in the past, local governments may offer some financial assistance. A key to useful monitoring data is consistency and stability over much greater periods than often occurs in the typically four year election cycle. This problem will continue to be an important concern for resource and research managers, especially during difficult economic times.

Need to Focus Monitoring Activities Within an Hypothesis Framework

It was argued that hypothesis testing could be achieved with long-term monitoring data. The benefit of this approach is that it makes the selection of variables explicit in terms of ecological interactions. Ecological understanding suggests that ecosystems may have more than one "stable state"; hence, the way a particular hypothesis is framed is probably more important than the actual testing which may be more mechanical in nature.

A natural corollary to hypothesis testing is to link one or more hypotheses into a systems network whereby complex interactions can be made tractable in the form of mathematical models. The box-model approach was suggested as a first step in determining what variables should be measured. Application of this approach to Bay system analogues, or segments, was considered a basic element in a monitoring plan, This approach emphasizes the importance of ecological comparisons between "similar" segments.

Ongoing Activities in Need of Evaluation

The following activities are not inclusive but represent a spectrum of ongoing monitoring efforts that might benefit from statistical optimization techniques, e.g., spatial and temporal coverage.

Juvenile finfish surveys

Blue crab larval and juvenile surveys

Oyster spatfall surveys; natural bottoms and collectors

Plankton surveys

Water quality surveys

Adult fishery landings as a measure of fish stocks

Recognition of the Processes that Link Sources of Materials, Transport and Fate and Effects

This area requires an understanding of land-use, terrestrial soil-water chemical interactions, fluvial transport and estuarine circulation. Physical forces need to be given greater emphasis, for example, freshwater flows, timing, magnitude and duration of rainfall as a modifier of soil wash-off of chemical pollutants and wind and barometric pressure as major factors influencing estuarine circulation. It is important to keep in perspective that estuarine circulation and near-shore neritic processes may explain much concerning the distribution and abundance of estuarine and marine spawners. This knowledge is essential to a meaningful interpretation of "assimilative capacity." Such information will assist in the assessment of natural variability versus human induced effects. The value of this perspective should be apparent in the analysis of trends in living resources and anthropogenically mediated changes in chemical introductions to the Bay system.

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CHAPTER 11
EDUCATION AND PUBLIC PARTICIPATION

Committee: Frances Flanigan, Chairman,
Will Baker, John Gottschalk, Cranston Morgan

EDUCATION

The goal of public education relating to the Chesapeake Bay for grades 1-12 should be to instill in students an appreciation for the value of the Bay. The students should gain an understanding not only of the tremendous biological productivity of the Bay but of its vast multi-use potential. Furthermore, students should understand that such a multi-use potential will be realized only if coordinated and integrated management practices are incorporated.

If the goal is reached, a larger portion of the public will take an active interest in the Chesapeake Bay (and the natural world as a whole) so that they will seek out available information from the media, the literature, public forums, etc., on their own. A more educated public will have a greater ability to make the informed public policy decisions which are needed to properly manage the natural resources of this country.

The education program should incorporate background class room studies reinforced by applied field sampling, experimentation and observation to provide students with an understanding of:

1. The basic chemical, physical and geological functions of the Bay.
2. The biota of the Bay.
3. The Bay's effects on man.
4. The effects of man on the Bay.

An assessment of the scope of existing education programs has been suggested as a research project. Since a tremendous amount of information exists, a cataloging project is more appropriate than a research one. There is a real need for an evaluation of the effectiveness of the various educational programs. Techniques developed by educators to evaluate other kinds of programs may be applicable here, and in fact some of this work may be done. To develop a research project on the effectiveness of education programs, the Chesapeake Research Consortium will have to consult specialists in this field.

An important element of the broad education topic is the question of adult education. How does one equip an adult to participate effectively in decision making. Who, if anyone, has the responsibility to do this? What is the role of public interest and special interest groups in education? What kinds of information are needed and how is this information transmitted most effectively?

These questions and issues are relevant in this discussion of education, and are also quite basic to public participation. As is apparent by the list that follows, many organizations, institutions and agencies are involved in educational programs.

ORGANIZATIONS INVOLVED WITH CHESAPEAKE BAY RELATED EDUCATION

Virginia

1. Roanoke Resource Center, a part of the Roanoke School System
2. Peninsula Nature and Science Center
3. Portsmouth Museum
4. Old Dominion University--program involved with the Dismal Swamp
5. Virginia State University--Sea Grant project to develop marine studies projects for 4-H clubs which already have limited marine education programs at their camps.
6. The Virginia Beach School System, the York Co., Gloucester Co., and Poquosson School Systems all have marine programs.
7. The Hampton Institute
8. Virginia Wildlife Federation has had summer camp programs
9. Virginia Sea Grant Program
10. The Wallops Island Program
11. The Chesapeake Bay Foundation
12. The Richmond Math/Science Center

Maryland

1. Smithsonian Institution--grades K-12, family groups, senior citizens, etc.
2. National Aquarium in Baltimore
3. Maryland Academy of Sciences in Baltimore
4. The University of Maryland, undergraduate and graduate
5. The Anne Arundel Community College
6. St. Mary's College of Maryland

7. The Chesapeake Bay Foundation
8. The Chesapeake Bay Maritime museums
9. Maryland Sea Grant College Program
10. University of Maryland Center for Environmental and Estuarine Studies
11. Chesapeake Biological Laboratory at Solomons--tours for biology classes above junior high level
12. Army Corps Hydraulic Model at Matapeake

Note: Some of the above have developed curricula. The National Aquarium and CBF have extensive packages available. EPA has prepared a 40 page book on dynamics of Chesapeake Bay for the layman. The Maryland DNR has resource material.

PUBLIC PARTICIPATION

Involvement of the public in the development of scientific programs and in the application of science to questions of resource use is a difficult but necessary consideration in a report such as this A primary use of research findings is in the public decision making process; and the public, in the end, is both the financial supporter of science and recipient of the benefits from scientific research. However, the political process governs the adoption of research findings, and without citizen understanding and support, developed through public participation, neither the scientific efforts themselves nor the results are likely to be accepted or implemented.

Since the 1960s, requirements for citizen participation in federally sponsored programs have proliferated. These programs include some which are highly technical in nature. One result is a developing body of literature on how to involve the public in technical programs, as well as some excellent case study examples illustrating the accomplishment of this very difficult task.

In the Bay region we can document a number of efforts during the past decade to conduct public participation programs. The 208 programs developed as part of the 1972 Water Pollution Control Act Amendments, the 303e basin programs which came under the same act, and the intensive coastal zone management programs are notable examples of water quality planning and resource management programs with strong public elements. The EPA Chesapeake Bay Program funded the largest public involvement program in the agency's history. State resource and planning agencies have advisory committees, the Governor of Maryland has a Science Advisory Council, counties have oyster committees. The extension and advisory services of the universities provide technical information to large numbers of people. These are but examples to illustrate a phenomenon of the 70s--the recognition that government has an obligation to provide not only information about technical programs and subjects, but opportunities for public comment and involvement in instances where the programs result in public decisions or are funded by tax dollars.

The effectiveness of these expanded activities is difficult to assess. Public awareness of Chesapeake Bay as a complex and sometimes threatened ecological system has certainly increased. But there remains with most concerned citizens a lack of certainty with regard to the health of the Bay and what kinds of management and regulatory actions are needed to protect it. There is a public perception, which seems to be fairly widely held, that "The Bay has been studied to death" and that the rationale behind research proposals is to keep scientists in business. There exists also a deep-seated conviction that government programs to study and manage resources are slow, cumbersome, expensive and duplicative. Government and, unfortunately, the scientific community do little to dispel these notions.

In the meantime, a number of very basic issues concerning citizen participation in scientific and technological decision making go largely undiscussed and unresolved. They are:

1. What should be the role of the public in developing policy to the Bay?
2. What is the relationship between scientific research and the development of public policy concerning management and use of Chesapeake Bay resources.
3. Who should participate? How does one define what is representative and whose advice and comment should be solicited in technical matters?
4. Who should determine when the information base is adequate to make management policy decisions?
5. Should the public be involved in identifying research needs and/or prioritizing needs once they are identified?
6. How can technical information be effectively translated to address public policy questions?
7. How can the needs of user groups for information related to Chesapeake Bay resources best be met?
8. How can the public perception that the Bay has been "studied to death" be corrected?
9. What Chesapeake Bay use ethic could be used as a framework for developing research needs?

Structuring these questions into a research proposal is beyond the capability of the authors, but expertise exists to develop such a proposal and to conduct the study. In addition to providing guidance on how to further understanding of the need for research and build support for continued scientific work, such a study could provide useful insight to address questions of cooperation and coordination which are discussed briefly below.

The public perception of duplication of effort and lack of coordination among both scientific and management programs presents a serious obstacle to obtaining maximum benefit from these programs. This perception is perhaps the most vivid testimony to the limited success current programs have had in communicating with the public. Compelling evidence that in the last decade cooperation and coordination have increased is abundant: The creation of the Chesapeake Research Consortium, the initiation of the Bay-wide Chesapeake Bay Program, and the appearance of the administrative Bi-State Working Committee and the legislative Chesapeake Bay Commission. The Chesapeake Research Coordination Act, passed but not funded, demonstrated federal recognition of this need. We think that the acknowledgement of this public perception and the development of techniques to deal with it are critical to the ultimate goal of involving the public in a meaningful way in science-based policy decisions on the Bay.

In the last decade an important role has been played by private organizations such as the Chesapeake Bay Foundation and the Citizens Program for the Chesapeake Bay. These groups have provided valuable links among the public and the scientific and governmental institutions. They provide the layman access to a sometimes overwhelming system, and they provide an education function that can be quite responsive to specific needs. In addition, they help to bring a Bay-wide perspective to public discussions of Bay issues. An analysis of the effectiveness of organizations like these, as communicators and as facilitators of the decision making process, would provide an interesting counterpoint to a similar analysis of governmental organs, and could be incorporated in the evaluation proposal we are suggesting later in this chapter.

In terms of needs for the 80s, special note should be made of the work conducted by the Citizens Program for EPA. The Citizens Program for Chesapeake Bay has been the recipient of substantial funding from EPA to conduct a public participation/education program in conjunction with the Bay Program. We have included here a draft of a proposal to evaluate that program.

A critical question for the 80s and one that could lend itself to a research effort involves the role of science in conflict resolution. The Bay area is replete with examples of conflicts that have resulted in delays, wasted effort and money, public antipathy toward some agencies and user groups, and doubt about the validity and application of the data base. Application of the developing principles concerning mediation and conflict resolution, perhaps in the form of a case study of one of the classic Bay conflicts, would undoubtedly provide useful insights into the complex relationships among research, public policy and the decision-making process.

PUBLIC PARTICIPATION IN SCIENTIFIC RESEARCH PROGRAMS

PROJECT: Evaluation of the Usefulness of Public Participation in the EPA Chesapeake Bay Program

From its inception the EPA Chesapeake Bay Program has had a distinct and major public participation component. Initially, the program consisted of educating the general public as to the issues and objectives being addressed by the study (EPA Program); and soliciting recommendations for subjects to be studied. The program produced a list of 10 high priority concerns related to the water quality of the Chesapeake Bay, of which three were selected for immediate study: toxic material, submerged aquatic vegetation and eutrophication.

In its later phases, public participation has been designed to assist in the evolution of the public and official responsibility for making decisions essential to water quality management.

While the value of the recent historical public participation has been acknowledged, to some extent for its political significance, there remains the dual question of how well it has involved the public in the policy decision making process, and how the program could have been structured to be more effective. Answers to both questions are of vital importance in terms of redesigning and managing future public participation efforts both in the Chesapeake Bay region and across the nation with the expansion of the concept of formal involvement of the public in policy decisions and program evaluation and implementation.

Objectives

To assess the effectiveness of the EPA Chesapeake Bay Public Participation Program in terms of:

1. The degree to which it was able to reach the public.
2. The extent to which public views influenced EPA Chesapeake Bay study elements including both subject matter and timing.
3. The value of public involvement in establishing responsibility for determining water quality goals for the Chesapeake Bay.

Approach

With the advice of an experienced consultant, a follow-up interview research effort would be organized in two phases. The first would be a series of perhaps 75 personal interviews, the respondents being selected from a list of major interest groups in industry/business, state/local officials, and representatives of citizens organizations. The questions would deal with the value the respondents placed in the Public Participation Program efforts. The second phase would be a mail or telephone questionnaire addressed to a random sample of Bay region residents to determine public awareness of EPA, the Chesapeake Bay Program, Chesapeake Bay use issues, and degree of concern for the future of the Chesapeake Bay.

Cost and Duration

This project could be accomplished within one year, and, depending on its ultimate scale, at an estimated cost of $50,000.

Related Studies

None known on the entire Chesapeake Bay. A related study in attitudes toward the Chesapeake Bay is being carried out at VIMS under Sea Grant funding. The first phase of detailed planning would include a review of related projects.

CHAPTER 12
INFORMATION MANAGEMENT

Committee: J. Kevin Sullivan, Chairman,
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INTRODUCTION

For purposes of this report, information management is defined as the production, compilation and dissemination of information relevant to the management and public understanding of Chesapeake Bay. Excluded from this definition is any explicit consideration of problems associated with data management for scientific purposes. The focus of concern then is information to be used by management agencies at all levels of government and by the general public.

Since 1970, there has been a substantial increase in the availability of information about Chesapeake Bay. To a large extent, this appears to be attributable to greater emphasis on public participation in major Bay programs and considerably more use of technical and scientific information by Bay management agencies.

Public information programs were almost non-existent in 1970. The 1970 report of the CRC on research needs for Chesapeake Bay does address information management, but only in the context of handling scientific data. No public use functions are mentioned. since then there have been substantial improvements. In 1972, the Marine Environment Resources and Research Management System (MERRMS) system was established at VIMS which provided the first large-scale management oriented information base on the Bay. The Maryland Coastal Zone Management Program, begun in 1974, has made consistent efforts to provide general and issue-specific information. Similarly, the Sea Grant Programs of both states have been effective in public information activities particularly with the media and in information transfer programs with Bay user groups. The EPA's Chesapeake Bay Program, while primarily a research effort, has had a major focus on public participation and public information. Most of the Bay's major research institutions now have public information offices including the Horn Point and Chesapeake Biological laboratories of the University of Maryland, the Chesapeake Bay Center for Environmental Studies, and as indicated above the MERRMS system at VIMS. VPI, the University of Maryland and the College of William and Mary have advisory (extension) services supported in part by the Sea Grant Program. In addition to these formal programs, there exist considerable informal interactions between the Bay's scientific community and management agencies. At VIMS, the management mandates of that organization assure that research information is responsive to management agency needs. Although a similar arrangement does not exist in Maryland, there is a high level of interaction among research administrators, most scientists and the agencies.

CURRENT ISSUES

Although there is now substantially more effort on publication information activities than in 1970, there are several issues which should be addressed.

PROJECT: Integration of Bay Information Sources

Of particular concern is the diffuse nature of Bay information soruces. For the public, it is still extremely difficult to obtain useful and timely information. Similarly, there has not been a great deal of coordination among the agencies in generating Bay information and some duplication of efforts has occurred in the past. This issue has been recognized recently by the Citizens Program for the Chesapeake Bay, Inc., which has organized a year-long study to determine the feasibility of establishing a Chesapeake Bay information center or network. The study was completed in January, 1983. Although it is primarily oriented towards the coordination of information sources, it will also address several related problems including the interpretation of complex technical information for public use and understanding, and the conduct of case studies to determine the extent to which the lack of information was a limiting factor in important Bay management decisions. The study has already produced several products. One is a compilation of existing information sources and services around the Bay which has now been published by CPCB. The other is a survey of approximately 20 existing information centers in the United States which should serve as an excellent source of data about these kinds of operations.

PROJECT: Chesapeake Research Exchange

Another project which has some bearing on Chesapeake Bay information is the development by the CRC of a Chesapeake Bay Research Exchange (CREX). While oriented mainly towards use by the scientific community, such an exchange would provide information about completed and on-going Bay research which could be of public and agency use. CREX focuses on active investigaters and in on-going and recently completed research efforts and will provide information on immediate products of these efforts (progress reports, grant and contract completion reports, special reports). Those scientific products that are not readily traceable to a specific research project are available through the Chesapeake Bay Bibliography Project initiated at VIMS in the early 1970s which is being coordinated with CRC's CREX project.

PROJECT: Information Specialists for the Bay

Aside from the diffuseness of information soruces, a frequently cited public need is for the avaiability of information transfer specialists. The function of such persons would be to serve as an intermediaries between the practicing scientist and those posing management-related questions. Whether such an activity would significantly improve either the acquisition of management information or the communication process between the two groups is an open question. A small study could be carried out to address this issue with very limited resources. Some unpublished work along these lines has been done by Robert Coward at Princeton.

PROJECT: Improved Perception of Research on the Bay

Another issue relates to the generally negative public perception of research on the Bay. This perception is usually stated as concern over the relative lack of "answers" to Bay issues in comparison with the total research effort. To some extent this situation has improved in recent years probably as a result of public involvement in the research planning process, particularly the EPA's Bay program, and better communications between the public and the research community.

RECOMMENDATIONS

In summary, the most important current problem in information management is the diffuse nature of existing information soruces. To a large extent, this problem is being addressed in the Chesapeake Bay Information Center project. It is recommended that further investigations or research on the topic be deferred until this study is completed and evaluated. Establishment of the Chesapeake Research Exchange, expected in 1983, with its ties to the Chesapeake Bay Bibliography project, should be continued as these projects will provide one of the primary information sources for any information network or center that might be developed during the decade of the 80s. It is also recommended that some research be undertaken on information transfer techniques, particularly their availability and effectiveness in conveying research results and the limitations of research to the public.

APPENDIX I

PROJECT: The Bay Segment Viewed as a Box Model—A Bay Monitoring Range

Problem

Traditionally, marine environmental sampling or measurement programs have been limited to single component samples in time and space (e.g., a multi-station cruise), continuous measurements in time at a single station (e.g., tide gauge), or continuous measurements in time over a line in space (e.g., echo sounding underway). But for a truly meaningful program to monitor environmental vairables, a system is needed that simultaneously and continuously measures a broad spectrum of environmental variables over a three-dimensional segment of the Chesapeake estuary, i.e., an area the size of a tidal freshwater segment or larger scale, to help calibrate and further verify a mathematical computer-based circulation model. The horizontal dimensions of the monitored area can be as great as the funding for in situ instrumentation will allow but may be constrained by the need to avoid navigation channels.

Approach

The basic concept is to instrument an area within Chesapeake Bay with as much in situ instrumentation as possible. The data would be hard-lined or telemetered to the beach and to an automated data collection and storage facility with access to a computer facility for analyses of trends, cross correlations, etc. Instrumentation would be bottom-mounted, suspended from subsurface floats at various depths in the water column, buoy mounted, and on towers extending from the bottom up through the water surface to a height of 20 m above the sea surface. Parameters that can be measured with off-the-shelf instrumentation include but are not limited to the following:

Current speed and direction

Wave height and period

Water temperature

Air speed, direction, temperature, humidity and incoming radiation

Salinity

Dissolved oxygen

Nutrients

Turbidity

pH

Various dissolved and adsorbed constituents, e.g., nutrients, trace metals, toxic organics and biologically active organic complexes

Sea level (astronomic tides, wind setup, etc.)

Other environmental variables such as variations in the total composition of the biological community and sedimentary bedforms can be monitored by bottom mounted remote TV cameras or by divers operating from a habitat in the range. Other instrumentation could be added as required for special projects.

Ecology is the study of the relationship between organisms and their environment. We know a good deal about many of the organisms that inhabit the Bay, but we know very little of the day-to-day environmental variations to which these organisms are subjected or what effects the short term or longer term variations in environmental conditions have on the total biota. A few of the many questions that such a monitoring range might answer include:

What is the relationship between surface waves and water column turbidity?

How long does it take for a change in wind speed or direction to affect a change in the surface current regime and the currents at depth?

How are sediment bedforms generated, modified or destroyed by bottom currents?

How is biofouling activity affected by changes in temperature, salinity or concentrations of dissolved oxygen?

What environmental characteristics or combinations of such characteristics have observable effects on the makeup of the resident biological population?

What are the effects of severe storms on Bay water quality, bedforms and organisms?

What are the various fluxes through the boundaries of the range?

Numerous other questions will occur to Bay researchers which could be answered only by an instrumental range of this general type. It would be an ideal facility, for example, for the field testing of new equipment or instrumentation for marine use where environmental impact on line equipment (or of the device on the environment) could be monitored. Most importantly, the availability of this Bay range would provide scientists with the means to significantly increase our understanding of the Bay system, its processes and basic marine interrelationships, that could then be applied to our overall understanding of the marine environment.

Although the concept is intriguing and the potential from such a Bay range is exciting to contemplate, the cost within the present funding situation probably precludes anything other than a preliminary engineering feasibility study of the concept. Certainly such a study would be required as the first step on a program to secure the large original expenditure to establish the range as well as the funding for the expensive operation and maintenance of the range. While no cost estimate is made at this time, the cost would probably be less than some of the "big science" projects which the Federal Government has funded in waters much less important to the United States than those of the Chesapeake Bay.

APPENDIX II

PROJECT: Description of Ecosystem Function in Terms of Signal Processing

Project Description and Significance

In this project the Chesapeake Bay ecosystem is regarded as a black-box into which signals are fed and from which certain output signals can be measured. The input signals can be described, as in electrical engineering, as a power spectrum--the amount of power delivered to the system in any given frequency range (sunspot cycles, annual variations, lunar differences, diurnal and tidal variations, wave energies, etc.). The output signals can be cast over the same frequency domain. The "function" of the black-box (ecosystem in our case) may be described in terms of cross-correlation or coherence spectra between the input and output signals. Stress in the ecosystem is usually manifested as a breakdown in the coherence spectra between input and output. Hence, the consequences of toxic additions apparent at the level of the entire ecosystem may be quantified if the proper signal data are available. Microcosm response is being quantified in this manner by EPA, Athens (J. Hill personal communication).

Objectives

1. To describe quantitatively ecosystem-level stress in terms of the breakdown in the capability of the ecosystem to integrate its inputs into coherent system-level outputs.
2. To describe the signal processing of the physical realm in much the same terms as Objective 1, for example, describe the coherence spectra between local tidal currents and wind and barometric pressure at the mouth of the Bay.

Approach

The feasibility of these projects is intimately related to the availability of high quality time series data available from the monitoring program. It is important that we monitor not only the physical input variables, but also representative system outputs such as dissolved oxygen, pH, eH.

APPENDIX III

PROJECT: Bottom Quality Monitoring

Because much of the total marine resource of Chesapeake Bay is a bottom-dwelling resource (bottom fish, oysters, clams and crabs), it is important that there be some method whereby the basic environmental quality of the Bay bottom can be determined. The benthic Foraminifera may provide a good indicator of Bay bottom environmental quality. As an example, this project proposal focuses on Foraminifera; however, other equally reasonable proposals could be made.

The Proposal

The proposed study is a quantitative analysis of benthic foraminiferal (common bottom dwelling rhizopods) populations from an area in the lower Chesapeake Bay.

No comprehensive and detailed studies have been done on benthic foraminiferal population distribution patterns in the Chesapeake Bay. Moreover, no attempts have been made either to characterize distinctive habitats of this important bottom dwelling fauna or to relate particular distributions to the oceanography of the area and to the quality and productivity of the bottom environment of the Bay.

Objectives

1. Establish the relative abundance with which various species are distributed.
2. Compare relative abundance of living and dead populations.
3. Estimate the standing crop or number of living Foraminifera per unit area.
4. Estimate the number of living Foraminifera seasonally.
5. Estimate the number of dead Foraminifera per unit area so that a living to total ratio can be calculated as an indicator of relative rates of sedimentation.
6. Relate the foraminiferal distribution and abundance patterns to measure sedimentological and chemical parameters as an indicator of bottom quality.

APPENDIX IV

PROJECT: Additional Activities in Support of Monitoring

As indicated in the Background Perspective, the limitation of ambient measurements is appreciated. In the context of research outlined in Appendices I and II, it would be especially helpful to examine the coupling of dynamic measurements versus ambient ones. The cost of dynamic measurements generally is very high. Basic questions arise concerning the coupling of dynamic and ambient measurements, especially the spatial and temporal scales necessary to couple these measurements. A possible direct benefit of such studies might be the correlation of changes in ambient measurements with dynamic ones, the former possibly being a useful indicator of changes in processes that contribute to environmental problems.

Inherent in many aspects of environmental measurement is the need to separate the consequences of natural variability and anthropogenic effects. Research proposed in Appendices I, II and III should have this concern stated as a high priority.

In the Introduction, it was emphasized that monitoring data have been taken over varying spatial and temporal scales, which confounds trend analysis. It would be of fundamental interest to try to reproduce old surveys and techniques for comparison. A key to this effort would be an assessment of approximately similar antecedant environmental conditions as far as practical. Insights gained from this approach might help build confidence in the traditional trend analyses. As a minimum, much uncertainty may be reduced in these and future trend analyses.

The approach described in Figure 1 emphasizes the coupling of sources of materials introduced into the estuary to effects. There is a high probability that some effects cannot be readily tied to a particular source material. In this context, it would be desirable to classify effects so that a biota assessment might be used to predict the nature of the source material. The approach may have limitations but the use of active monitoring or use of target species might provide valuable insights into the nature of pollutant effects, especially for high risk materials. Such tests should be conducted in the framework proposed in Appendices I, II and III.

A basic concern in trend analyses is the problem of a threshold response. Many biological responses are non-linear. In the context of the foregoing discussion, it would be useful to examine ecological processes and biological responses to see which responses are predictable without elaborate time-lags.

Great emphasis has been placed on segmentation and the box-model framework. The Bay and tidal tributaries should be considered in the larger context of the box-model so that ocean/Bay flux monitoring is keyed to fall-line monitoring of major fluvial freshwater sources. Since much less is known about the Bay mouth as a boundary in mathematical modeling, it would seem wise to place initially more intensive efforts at the Bay mouth.

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