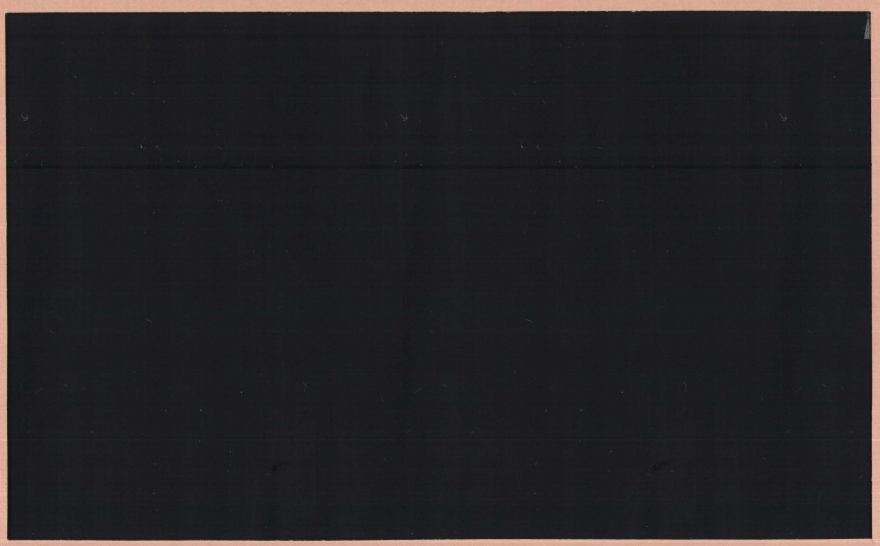
MARINE SCIENCES RESEARCH CENTER
STATE UNIVERSITY of NEW YORK
STONY BROOK, N.Y.

THE DELAWARE ESTUARY PROGRAM

Informal Report of A Workshop Held 18-19 May 1990

to Identify

New Information Needed by Managers to Ensure Uses and Values Desired for the Delaware Estuary in 2020



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New Information Needed by Managers to Ensure Uses and Values Desired for the Delaware Estuary in 2020

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Approved for Distribution

J.R. Schubel

J.R. Schubel, Director

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This report was prepared through the Coastal Ocean Action Strategies (COAST) Institute of the Marine Sciences Research Center.

PREFACE

"The voice is Jacob's voice, but the hands are the hands of Esau."

Genesis 27:22

The views expressed in this report are intended to be those of the participants in the 18-19 May 1990 workshop. Our task was to record their statements, to synthesize them, to look for connections and to weave the views of the participants into a story -- a story consistent with the views of the majority of the workshop participants. The participants came from diverse backgrounds, had diverse interests and represented diverse and, in some cases, conflicting constituencies. Where there was not agreement, we have tried to make that clear also.

This report is an informal report of the second of two workshops. The reports of the two workshops are intended primarily to be input to the final report. While we do not intend to print a revised version of this report, comments received by 10 August 1990 will be considered in preparing the final report -- an integrated report to be based on the proceedings of the two workshops and on other materials.

J.R. Schubel
W.M. Eichbaum
J. Lee

Stony Brook, NY
25 July 1990

INTRODUCTION

The second of two workshops sponsored by the Delaware Estuary Program's Scientific and Technical Advisory Committee was held on 18-19 May 1990 at the University of Delaware's conference center in Newark, Delaware. The workshop was conducted by J. R. Schubel and William M. Eichbaum.

The first workshop, held on 30-31 March 1990, was designed to identify the uses and values desired by citizens for the Delaware Estuary in the year 2020. A report of that workshop has been prepared (Schubel, et al. 1990). This workshop was designed primarily to identify what new scientific and technical information is required to ensure that the estuary in 2020 can support the uses and values identified by participants in the first workshop. This report summarizes the information needed by managers and identifies the general areas of research required -- as seen by the participants in the second workshop -- to develop that information.

The goals of the 18-19 May 1990 workshop and the earlier (March 30-31, 1990) workshop are described in more detail below. The following statement is a very slightly modified version of the statement prepared by Jonathan Sharp and was sent to all participants in both workshops.

Goals of STAC Workshops*

Two workshops have been scheduled for March 30-31 and May 18-19, 1990 by the Scientific and Technical Advisory Committee of the Delaware Estuary Program. This statement is written to clarify the expectations of these workshops.

PURPOSE

The two separate sessions were scheduled as a two-part process. For the first workshop, the invitation list included primarily individuals who could be considered users of the Delaware River and Bay. They were diverse, ranging from environmental artists and bird watchers to waterfront developers and industrial dischargers. The major question addressed by this assembled group involved the current and projected future uses of the estuary. The second workshop had scientists, engineers, resource managers, and regulators as its major invitation group. They were charged with the question of what further information is needed as a background for rational present and future management of the estuarine resources. Central to this question were the uses identified by the first workshop.

EXPECTED RESULTS

The Delaware Estuary Program is in the five-year phase of developing the Comprehensive Conservation and Management Plan. Several rather routine considerations (e.g. toxic substances, living resources, etc.) have been identified as areas for public concern. However, it was felt that a clearer delineation is needed from the users of the Delaware Estuary of the values of this aquatic system. Therefore, a group of users was assembled in the first workshop that was much broader in interests than the public who responded last year in the original planning sessions for the program. This clearer delineation of estuarine uses is needed to formulate information needs for management. The following are expected results.

From the first workshop, a list of uses with some priorities and delineation of key locations to support those uses; identification of present and potential conflicts; and a preliminary exploration of strategies to reduce conflicts to "acceptable" levels -- levels consistent with the desired uses.

From the second workshop, identification of information gaps for management that aid in research planning for the immediate fiscal year and the following three years of the first phase of the program.

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*This statement is a very slightly modified version of the statement prepared by Jonathan H. Sharp on March 16, 1990.

The agenda for the May 18-19, 1990 workshop is included as Appendix A to this report. The participants and their affiliations are listed in Appendix B.

Following the opening plenary session in which W. M. Eichbaum and J. R. Schubel presented the goals and objectives of the workshop and a statement of the anticipated products, the group broke into five concurrent working sessions, each built around one of the major issues (themes) identified in the first workshop. The five working groups, their topics, facilitators, rapporteurs and participants are summarized in Table 1. Participants selected the groups in which they were most interested; only slight adjustments were made to ensure that each working group had a critical mass.

Following the working group sessions, each facilitator presented a summary statement to the entire workshop for discussion. These summary statements are presented in Exhibits A-E. The full statements developed by the working groups are contained in the appendices.

TABLE 1

Summary of Topics and Compositions of Initial Working Groups

Issue		Facilitator	Rapporteur	Participants
A.	**Port Issues and Dredging**	William Johnson	Doreen Monteleone	Robert Biggs Leroy Cattaneo Edward Christoffers Mindy Lemoine Jonathan H. Sharp Marion C. Stewart Steve Whitney
B.	**Fisheries and Aquaculture**	Mary D. Gastrich	Trudy Bell	Franklin C. Daiber Charles Epifanio Bruce A. Halgren Harold Haskin Bruce Hargreaves John Kraeuter
C.	**Water Quality and Use**	Barbara A. Finazzo	Joseph Ohla	Thomas M. Church Gerald L. Esposito Lloyd Falk Ward Hickman Terry Jacobucci Timothy Jacobson Virginia Lee Andrew Manus Scott Nixon George Parsons Charles Rehy
D.	**Human Carrying Capacity, Management and Development**	Marjorie Crofts	Jihyun Lee	Harold Bickings John M. Campanelli Gale Critchlow Thomas Drewes John E. McSparran David P. Pollison Karen Schaeuffer Robert Scro
E.	**Wetlands Management**	Marria O'Malley	Ajit Subramaniam	Richard C. Albert Frederick Grassle Richard A. Hassel Greene Jones Kenneth Reisinger David Stout

EXHIBITS A-E

Exhibits A through E are slightly edited versions of the summary statements presented at the end of the first day to the entire workshop by facilitators of the five working groups. They summarize the views of the participants of each working group as to what additional information is needed relative to the theme (issue) of the working group.

EXHIBIT A. PORT ISSUES AND DREDGING

Additional Information is Needed:

- To identify the ecological and economic impacts of dredging and the possible beneficial uses of dredged materials.
- To assess the risks associated with the increase in maritime traffic, such as spills of oil or other toxic substances and the impacts of ships' wakes on coastal areas.
- To determine the ecological and socio-economic impacts of port growth and the impacts of the development of secondary structures and industry in support of expanded port facilities.
- To develop strategies to prevent the accidental introduction of exotic species by shipping activity.
- To identify and balance the existing and projected conflicts caused by competition for land and water space between port development and other coastal uses.

EXHIBIT B. FISHERIES AND AQUACULTURE

The discussion of fisheries and aquaculture focused on three themes: (1) fishability and human health, (2) fishability and the health of fish stocks and (3) fishability and ecosystem health.

1. *To increase fishability with regard to human health*

Additional Information is Needed:

- o To assess levels of toxicants in fish; coordinated tri-state management practices need to be continued and expanded.
- o To determine if toxicants perceived to have an effect on human health really do.
- o To determine the locations and strengths of primary and secondary sources (such as resuspended sediments) of toxicants; the routes and rates of transport of toxicants; the patterns of accumulation and the availability and ultimate fates of toxicants and pathogens.
- o To manage changes in the delivery of freshwater to the system without producing unanticipated and undesirable effects.
- o To reduce the inputs of toxicants on a regional level.
- o To eliminate contaminated sediments from the river and bay bottom or to isolate them.
- o To develop and use modelling to predict impacts of toxicants on the ecosystem.
- o To develop aquaculture to enhance food quality.

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2. *To increase fishability with regard to health of stocks*

Additional Information is Needed:

- o To identify the status and trends of living resources through stable, intercalibrated monitoring programs.
- o To identify limiting factors (spatial and temporal changes in habitat and water quality), and the effects of diseases and stock removal (fishing, entrainment and impingement by power plants) on the health of stocks.
- o To prevent unintentional introduction of exotic species.
- o To restock the oyster population with MSX-resistant seed.
- o To develop bi-state (NJ/DE), and in some cases tri-state (NJ/DE/PA), fishery management plans consistent with coastwide management plans.
- o To investigate the feasibility and desireability of restoring the salinity distribution to its pattern in 1900.

3. *To increase fishability with regard to ecosystem health*

Additional Information is Needed:

- o To establish (a) the distribution, abundance, production, species diversity and composition of benthic and planktonic communities; and (b) the distribution in time and space of important physical and chemical environmental parameters.
- o To identify the effects of oil spills, dredging, and pollution on the ecosystem.
- o To use aquaculture to reintroduce species and to reestablish existing species to desired levels.

EXHIBIT C. WATER QUALITY AND USE

The discussion of water quality and uses focused on five themes: (1) water resources, (2) system-wide waste disposal, (3) status of health of the system, (4) environmental crisis management, and (5) applied economic research.

1. *Water Resources*

Additional Information is Needed:

- o To identify present and projected water budgets.
- o To assess the effects of changes of freshwater input on flushing rate, salinity distribution and patterns and rates of sedimentation.
- o To identify the impacts on the estuary (habitat) and its living resources of changes in the allocation of freshwater to meet the increase in future water needs.

2. *System-Wide Waste Disposal*

Additional Information is Needed:

- o To determine pollutant loadings including hydrocarbons and metals from the atmosphere from point and non-point sources (present and projected).

3. *Status of Health*

Additional Information is Needed:

- o To determine the levels of pathogens in the estuary.
- o To assess ecosystem health and diversity.
- o To determine the assimilative capacity of different segments of the system.

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4. *Environment Crisis Management*

Additional Information is Needed:

- o To establish the frequency and impacts of episodic combined sewer overflows (CSOs).
- o To develop effective management controls for spills of oil and other toxic substances -- prevention and clean-up.

5. *Applied Economic Research*

Additional Information is Needed:

- o To assess relative values of competing uses of Bay resources.

EXHIBIT D. HUMAN CARRYING CAPACITIES, MANAGEMENT AND DEVELOPMENT

Important components of a comprehensive management plan which were identified and which need to be completed are listed below.

Additional Information is needed:

- o To prepare a comprehensive documentation of all land uses throughout the system including developed areas, natural areas, water recharge areas, forests, flood plains, agricultural areas, wetlands, spawning and nursery areas, etc.
- o To assess the availability of water supply, now and in the future, and the projected demands.
- o To prepare a comprehensive plan to provide acceptable wastewater treatment. This will require development of appropriate standards for waste load allocation for the estuary and its tributaries and for groundwaters.

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- To prepare a comprehensive demographic analysis and a plan to ensure appropriate community services and energy sources for a changing population
- To prepare a comprehensive land use plan which ensures that population and population density are consistent with desired uses and values of land and nearby waters; open space must be an integral component of the plan.
- To develop a comprehensive and integrated Geographic Information System (GIS) for the entire system.
- To prepare a comprehensive storm water management plan specified in terms of quality and quantity of runoff; a plan fully integrated with a wetland management plan.
- To identify impared uses (impacts) associated with different land use practices (preservation/development).
- To develop comprehensive management programs based on each specific plan adopted to ensure that it is carried out.
- To prepare a plan to utilize Transfer of Development Rights in each state to maintain important characteristics of counties.
- To incorporate into plans provisions for monitoring and periodic updating of plans by the implementing agencies.

EXHIBIT E. WETLANDS

Additional Information is Needed:

- To effectively define and implement a "no net loss" policy.
- To develop diagnostic indices of the function, health and value of wetlands on a variety of spatial scales.
- To assess the relative importance of the different functions that wetlands serve in different segments of the system.
- To develop effective public education programs that clarify the roles of wetlands and their importance to the Delaware Bay system.
- To assess the effectiveness of present regulatory and enforcement programs that deal with wetlands and to ensure that there is an appropriate level of consistency among the requirements of the several states and the federal government.
- To inventory wetlands throughout the Delaware Bay system. The effort should start with existing information, be supplemented as appropriate and be updated periodically.
- To determine why some artificial wetlands succeed and others fail and to use that knowledge to develop a framework for wetland creation and mitigation specific to the Delaware system.
- To assess the roles that hydrologic processes play in the formation, functioning and evolution of wetlands.

SOME PRIORITIES

SOME POSSIBLE UNIFYING THEMES FOR THE DELAWARE ESTUARY PROGRAM

Every national estuary program should have a unifying theme. The following themes were proposed as candidate themes for the Delaware Estuary Program.

- o The role of wetlands in a major estuarine system.
- o Rehabilitation of the urban river as a key to conserving and restoring the Delaware system: If the river is healthy, the Bay will be fine.
- o The effects on a major estuarine system and its living resources of chronic exposure to low levels of organic and metals toxicants.
- o Hopelessly polluted or an estuary with no major problems: The Delaware has alternatively been described as both. Would the real Delaware estuary please stand up.

GENERAL

On the second day of the workshop the participants met in plenary to sift through the long list of ideas developed on the first day (see Exhibits A-E), to select some priorities for the Delaware Estuary Program and to expand slightly on those priorities.

The workshop conveners believe that the first guiding principle in managing the Delaware system should be to take appropriate steps now to ensure that those parts of the system that are in good condition remain in good

condition. Prevention of environmental problems in the first instance is a far more effective strategy than remediation, and a far less costly one. Shifts in demography and associated patterns of development pressure will have to be considered in formulating management plans. This will require research to guide the development and application of "tools" to relate land use practices to water quality, habitat and living resources. Preventive environmental medicine, then, should be the first priority of management of the Delaware system.

The workshop conveners believe that the second guiding principle in managing the Delaware system should be to restore desired habitats, values and uses which society considers to be important and where knowledge exists to produce the desired results at predictable and acceptable costs. It is implicit that priorities must be assigned, that choices must be made.

Once steps have been taken to ensure that all healthy environments are properly protected and once those degraded habitats, uses and values that have been given a high priority for restoration have been rehabilitated and stabilized, then attention should be turned to chronic problems where solutions are uncertain and costs high.

GENERAL RECOMMENDATIONS

HYDROCARBONS

The Delaware system is the major point of entry for oil and other petroleum products for the east coast of the United States, accounting for about 70% of the total petroleum entering all east coast ports. While the safety record on the Delaware in transferring and transporting petroleum is an

excellent one, the potential for a large accidental release exists and countless small releases have occurred.

It is surprising that so little information exists on the levels of hydrocarbons, including chlorinated hydrocarbons, in the system, on the processes that control their transportation and accumulation, and on the effects of chronic exposure to these low levels of hydrocarbons.

MODELS

Some of the earliest, successful estuarine hydrodynamic models were developed for the Delaware. These were used in prescribing strategies to rehabilitate the environment and were successful.

All existing models should be inventoried and assessed for their potential for addressing unresolved management questions throughout the Delaware system. This assessment should be the basis for any future development of hydrodynamic and water quality models for the system.

The Delaware presents interesting opportunities for development of a new generation of a different kind of models to guide the management of the system and its living resources. This potential is enhanced by the recognition of the need for multiple, small, specialized models, rather than a single, large all-purpose model. Among the potential areas for model development are:

- Forecasting loadings of nutrients and contaminants including those from non-point sources, and associated with different land use patterns; and assessing the effects of different loadings on the Delaware and its living resources.

- o Guiding the levels and kinds of development throughout the drainage basin to achieve and sustain desired use patterns and values of the river and estuary. Models must be capable of handling point and non-point sources.
- o Managing the hydrology of the Delaware system; surface waters and groundwaters; the effects of different withdrawal rates on the system and its living resources; the effects of hydrology on wetlands.
- o Fate and effects of hydrocarbons, including polychlorinated hydrocarbons, their routes and rates of transport, their patterns and rates of accumulation, and their effects on living resources.
- o Incorporation of plankton dynamics into the simple hydrodynamic models of the Delaware.

HABITAT

The Delaware Bay is rich in diversity and quality of its natural habitats, particularly its wetlands. *The system's important habitats should be characterized, inventoried, mapped and their values and functions assessed. This will require not only the use of existing knowledge, tools and techniques, but the development and application of new knowledge and diagnostic tools.* These must come through research. They do not exist. Two activities now being sponsored by the National Research Council may be of value. These should be followed carefully.

New knowledge is needed to develop strategies to conserve existing habitats in the face of conflicting uses and increasing pressures from development. Research is also needed to evaluate and develop strategies to create new habitat. One focus of this research should be on the beneficial uses

of dredged materials to create wetlands in the tidal reaches of the river and to nourish saltmarshes so that they can keep pace with an acceleration in the rate of rise of sea level.

The Delaware is rich in wetlands. The wetlands have a long history of manipulation; and a considerably shorter history of thoughtful management.

One essential component of a comprehensive habitat management plan is a clear, unambiguous assessment of the needs of important species during different life cycle stages. Once this information is available the conservation and restoration of critical habitats will be facilitated. Zone I was identified as the region that should receive a priority for studies of habitat requirements by important species.

There is no historical record of submerged aquatic vegetation (SAV) in the Delaware estuary and analysis of cores failed to reveal its presence. There is an historical record of the presence fo SAV in the tidal reaches of the river; its coverage may be more extensive now than in the 1800s. *More information is needed on the history of SAV for the entire system.*

NUTRIENT LOADING AND EUTROPHICATION

Over the past several decades, there has been a very successful reduction of oxygen demand of the waters in the tidal river through a major program to upgrade sewage treatment plants and reduce industrial effluent impacts. Most of the sewage treatment plants discharge between Chester and Philadelphia, Pennsylvania where the vast majority of the point source loading occurs. This program was begun in the 1960s with massive federal support beginning in the

1970s in response to the Clean Water Act and was designed primarily to increase levels of dissolved oxygen. The dissolved oxygen content of the tidal river has increased significantly with annual average content more than doubling in the areas of greatest stress. Over this same period, the nutrient nitrogen content has decreased, but only slightly and the total phosphorus has dropped dramatically. In the past 10 years, the dissolved phosphate of the total phosphorus pool has increased. The large longer term decrease in total phosphorus and more recent increase in dissolved phosphate may both be the result of increased riverine water quality. This emphasizes the complexity of the biogeochemistry which results from management of these aquatic resources.

There is significant disagreement between managers and scientists as to the need, or even the desireability, of further reductions in nutrient levels. A number of scientists who have had long and distinguished careers studying nutrient dynamics of the Delaware system argue that a decrease in the levels of nutrients might not be beneficial, at least to the estuarine postion of the system and to the adjacent shelf waters. A large fraction of the nutrients that reach the estuary are transferred to the shelf with relatively little delay. These sewage-related nutrients may enhance biological productivity in the lower estuary and in open coastal waters.

The Delaware Bay is a turbid estuary and the high levels of suspended sediment may be the limiting factor in primary productivity. Reductions in suspended load might lead to undesirably high levels of productivity (eutrophication).

More research clearly is needed to understand the roles and interactions of nutrients and suspended sediments in determining the level of primary productivity in the Delaware Estuary. In addition, the high suspended sediment loads appear to scavenge potentially toxic metals and organics from the water column. The importance of this process needs clarification.

The interactions between primary and secondary productivity, including fisheries, is an important and fruitful area for fundamental research.

The existing data indicate relatively high levels of primary productivity, levels which are not reflected in the fisheries data. Fisheries yields are lower than would be expected from the primary productivity. Are fisheries yields underestimated? Is primary productivity overestimated? Or do the conventional relationships between primary productivity and fisheries yields not hold for the Delaware? The answers are not clear. *More research is needed to better understand the fate of primary production, and the transfer from primary production to secondary production, including fisheries harvests.*

Although there are no low D.O. problems in the Delaware estuary and levels in the tidal reaches of the river have shown dramatic improvement over the past decade, D.O. levels in the lower river sometimes still fall below 4.0 ppm during the summer. Studies have shown that fish show signs of stress when levels of D.O. fall below 4 ppm. Stress may interfere with spawning success and may contribute to other problems associated with contaminants.

The Delaware River Basin Commission (DRBC) in cooperation with the U.S. Environmental Protection Agency and the states of Delaware, New Jersey

and Pennsylvania recently completed a feasibility study of bringing D.O. levels in the Delaware River between Camden (NJ) and Philadelphia (PA) to the standard of 4 ppm on a sustained basis. Point sources (treatment plants) dominate nutrient loadings in this stretch of the river, but urban runoff contributes significant amounts of nutrients. The conclusion was that compliance with the standard could be achieved. Their analysis indicated that nitrification of ammonium using breakpoint chlorination may be the best strategy to use at existing plants.

Point and non-point sources contribute to the low D.O. problem and the major contributors to the problem vary in different parts of the system. Non-point sources apparently are not the dominant factor on the main stem of the river because the problem occurs in the summer time during the period of low river flow.

The specific primary causes of the low D.O. problem in the river are not well understood. Research should be done before putting in place any expensive corrective measures that may have uncertain consequences. In addition, the full impact of recent improvements in sewage treatment plants should be documented to reflect the current status of the river.

Several scientists in the workshop questioned the proposed DRBC strategy. They pointed out that below Trenton in the region of Philadelphia, primary productivity is low, that there is an alkalinity sag in the river and questioned whether removal of nitrogen is the best strategy. Part of the system is phosphorous limited in the spring and summer.

Nutrients must also be examined in the tributaries in terms of their levels, their sources -- both point and non-point -- and their fates.

DATA AND INFORMATION: ANALYSIS/SYNTHESIS/INTERPRETATION

The existing data and information for the system should be synthesized, analyzed and interpreted:

- To chronicle the changes in the condition of the system and its living resources.
- To establish the current status of the system and its living resources.
- To document past and present research and monitoring efforts and to use this information to identify research and monitoring priorities.
- To prepare a comprehensive directory of past and present data, information, investigations and investigators.
- To identify which existing data sets are good and which are not.
- To develop appropriate strategies for combining historical data sets with more recent initiatives.
- To recommend a range of standardized methods of sampling, analysis and data reporting to be used for the Delaware Estuary Program and recommended for the future.

Among the specific topics that should be focused on in this synthesis effort are:

- What have been the patterns and rates of wetland loss and how have these losses impacted the system and its living resources? Attempts

should be made to separate losses from different causes: erosion, sea level rise and other causes.

- o What has been the history of freshwater input (and withdrawal) and how have variations in input impacted the system and its living resources?
- o What have been the cumulative impacts of impingement and entrainment of organisms by power plants?
- o What have been the changes in land use patterns throughout the drainage basin and what impacts have these changes -- including point and non-point sources -- had on the system and its living resources?
- o What have been the patterns of fisheries (stocks, landings, etc.) and what factors -- natural and anthropogenic -- have contributed to the fluctuations?

Historical data should be collected, evaluated for their quality, analyzed, synthesized and interpreted. (This process was begun during the first year of the study.) The rich data bases of utilities should not be overlooked in this effort. Potentially valuable data are being lost, or at least not utilized, and they should be exploited.

A regional data/information center should be established through a partnership among the several states with stakes in the Delaware system. The center should focus on transforming data into information. The time lag between data collection and analysis, synthesis and interpretation should be shortened. A centralized directory of data, information and specialists is an important first step. It is important to design this directory so that it can be easily accessed and maintained.

A comprehensive Geographic Information System should be created for the Delaware system.

New Jersey has a GIS for its portion of the Bay, but Delaware does not. A single comprehensive system is needed. It should be accessible to diverse audiences (users) and should be capable of developing a variety of informational products tailored to the specific needs of different user groups. The GIS should be "tied into" PCs either directly or through a diskette service. Remote sensing technology and data should be used where appropriate.

HYDROLOGY OF THE DELAWARE SYSTEM

The Delaware estuary may be unusual among drowned river valley estuaries in the percentage of water that it receives from groundwater. The groundwater input is poorly known; estimates range from 1 to 50% of the total freshwater input. *The uncertainty in the magnitude of this source must be reduced through a carefully designed measurement program.* The quality of the groundwater input may also be important in determining water quality and habitat in the estuary, depending upon the strength of the groundwater signal.

Models must be developed and exercised to predict the effects of a range of levels of consumptive uses of water from the Delaware River. The models must be capable of predicting the effects not only on the salinity distribution, but also on habitat and living resources.

FISHERIES

The development of fisheries management plans for important resident

species and for important anadromous and catadromous species should be given a priority.

Plans for resident species will require the cooperation and collaboration of Delaware, New Jersey and Pennsylvania. Plans for migratory species will require cooperation and collaboration with other states and federal fisheries management councils and should lead to the development of plans consistent with the coastal plans already in existence. Regional management plans should be developed for each of the important fish that utilize the Delaware system during a portion of their life cycle. These include: summer flounder, bluefish, weakfish, striped bass, shad, blue crab, short-nosed sturgeon and eel. Integrated, bay-wide management plans need to be developed for important resident species that spend their entire lifecycles within the Delaware system. These include: catfish, white perch, oysters and large mouth bass.

Integrated, regional management plans also need to be developed for important birds and mammals including: ospreys, falcons, piping plover, Perigren falcon, bald eagle, turtles and a number of other important species.

Fish in more urbanized stretches of the system exhibit a variety of diseases. The causes of the diseases are believed to be contamination, but evidence for cause and effect relationships is lacking.

Several other factors were identified by workshop participants as being important to fisheries:

The Delaware River Cooperative Fishery Management Plan should not be

overlooked and should be utilized in developing any new fishing plans.

Habitat and water quality are important, but the effects of fishing pressure on stocks should not be underestimated.

Better estimates are needed of fisheries yields (landings).

Participants in the first workshop stated a goal of increasing fishery landings by five-fold by the year 2020. *This will require research and the development of effective management strategies.* It also may require the use of aquaculture to supplement natural stocks, to develop disease resistant strains and to directly supplement seafood in the marketplace.

BIRDS AND WILDLIFE

The Delaware Bay is unusual, if not unique, among the nation's estuaries in its importance to migrating waterfowl, to shorebirds and to a variety of other birds. It also provides important habitat to a number of species of mammals and reptiles. *The importance of these uses should be assessed; the habitats that support them should be identified and conserved.*

FISHABLE/SWIMABLE

Participants in the first workshop identified as a goal for 2020 to have the entire Delaware Estuary and river fishable and swimable. Participants in the second workshop indicated the need to define with specificity and clarity what the terms "fishable" and "swimable" mean.

Are there legal definitions of fishable and swimable? Are these

definitions what the public wants and expects? Coliform standards now determine swimable. To what extent do aesthetic qualities -- for example, the presence of obnoxious, but innocuous floatables -- enter into the public's determination of "swimable"? Should there be standards for toxicants (e.g. metals) in certifying bathing areas? At present there are not; but it was reported that they are under development.

Fishable should mean that all areas of the system are of a quality to support natural stocks of commercially and recreationally important fish and of other species that are ecologically important. Fishable also should mean that fish that are harvested throughout the system are safe for consumption without limits or advisories on the number, or amount, that can be eaten safely.

Where do PCBs enter the system? How do they affect the health of the fishery and the edibility of fish?

Reference

Schubel, J.R., William M. Eichbaum and Susan E. Schubel, 1990. The Delaware Estuary Program. Informal report of a workshop held 30-31 March 1990 to identify uses and values for the Delaware Estuary in 2020. Marine Sciences Research Center Working Paper 43, Reference 90-8.

APPENDIX A

DELAWARE ESTUARY PROGRAM

Workshop II

18-19 May 1990

University of Delaware
Conference Center

Objectives:

(1) To identify the new information needed to manage the estuary and its drainage basin now and in the future to ensure a good match between the values and uses society wants for the Delaware Estuary and the values and uses that characterize it.

(2) To identify the areas of research needed to produce the information required for effective management.

(3) To indicate any changes in management strategies -- policies and practices -- that will be required to ensure that the estuary in 2020 meets society's expectations.

18 May 1990

Day 1

0800-0900	**Registration**	
0900-1100	**Session A -- Plenary**	
	o Welcome and introductions.	J. Sharp, et al.
	o A summary of the purposes of Workshop I and an Overview of what we intend to achieve during this workshop and how we will go about it.	J.R. Schubel
	o A comparison of the present Estuary with the Estuary desired for the year 2020...as revealed by the first workshop.	W.M. Eichbaum and participant in first workshop
	o Summary and charges to Working Groups.	J.R. Schubel

1100-1200 **Session B -- Working Groups**
(Built around themes...uses and values -- identified by Workshop I -- and targeted at the objectives for Workshop II).

A. Port issues & dredging

B. Fisheries and aquaculture

C. Water quality & use

D. Human carrying capacities, management, & development

E. Wetlands management

1200-1330 **Lunch and address by a Regional Leader**

1330-1530 **Session C - Working Groups Continue**

1530-1600 **Break**

1600-1700 **Session C -- Plenary**

o Working groups report on their findings. W.M. Eichbaum

o Discussion

1830-2030 **Dinner and after dinner address by Regional Leader**

By the end of the first day we should have:

(1) Identified the NEW information needed to manage the uses of the estuary and its drainage basin to ensure that the estuary has the values and can support the uses that society thinks are important -- now and in the year 2020;

(2) Identified the NEW areas of research needed to supply the information needed for management.

19 May 1990

Day 2

0830-0930	**Session A -- Plenary**	
	o A brief recap and clarification of objectives.	J.R. Schubel
	o Reconstitution of Working Groups and clarification of their charges Working Groups will be formed around management "tools" (e.g. science/ research land use planning; zoning of estuary; economic incentives and disincentives; effluent controls etc.) to achieve program objectives and goals.	W.M. Eichbaum
0930-1100	**Session B -- Working Groups**	
1100-1200	**Session C -- Plenary**	
	o Working Groups Report on their Conclusion and Recommendations	
	o Discussion	
1200-1330	**Lunch and address by Regional Leader**	
1330-1500	**Session C -- Plenary**	
	o Reaching consensus on a summary statement.	W.M. Eichbaum J.R. Schubel
1500	o Adjourn	

APPENDIX B

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APPENDICES C - G

Comprehensive Accounts of Ideas, Recommendations and Conclusions Expressed By Participants of Each Working Group on Day 1.

APPENDIX C

WORKING GROUP A: PORT ISSUES AND DREDGING

This group identified areas of research needed and management strategies according to following subtopics:

- Dredging
- Impact of an increase in maritime traffic
- Impact of an increase in ports - ancillary structure
- Development of secondary industry
- Potential for introduction of exotic species
- Competition for land and water space

(1) Dredging

The modification of habitat caused by dredging was addressed as an important problem to investigate. It was indicated that information about habitat characterization (present and projected) and habitat requirements of the organisms are necessary for future management planning.

To assess the feasibility of the use of dredged materials in a beneficial way (to enhance or create habitat), it should be determined if they are toxic, where the right place is for using them, and how cost-effective it is to use dredged

materials vs. disposing them.

Another concern associated with dredging was the contribution of dredging on the suspended sediment load in Delaware estuary. It was asked if the movement of salt water up the estuary due to dredging will cause the increase of flocculation at salt water/fresh water interface, and if the reduction of the suspended sediment load is desirable.

The need to assess the ecological and economic costs in maintaining or deepening the channel to 45 feet (currently 40 feet deep mean low water) was also addressed.

(2) Impact of an increase in Maritime Traffic

It is necessary to identify the present and future maritime traffic levels, to know what materials are being shipped into the estuary, and to assess the risks associated with traffic increase, such as oil or toxic spills.

The low level chronic spills into the estuary could be also a significant problem.

The ships themselves could affect the coastal environment. The effects of short-term turbidity due to the passage of ships on the aquatic organisms and the wake induced impacts on the coastal environment should be identified.

(3) Impact of an increase in Ports-Ancillary structure

The group suggested that it is necessary to look at the potential reuse of industrial lands that were abandoned and to identify existing sites large enough to be used for port development.

The environmental and socio-economic impacts of port growth (increase in size of existing ports and addition of new ports) and development of secondary structures should be assessed.

(4) Development of secondary industry

It should be identified what secondary industries would grow up associated with the port growth and their impacts.

(5) Potential for introduction of exotic species

It was felt that some management controls need to be instituted to prevent introduction of exotic species on cargo, in ballast of ships, or attached to ships.

(6) Competition for land and water space

The conflicts between port needs and water dependent and non-water dependent uses are predicted. It is necessary to assess the projected increase of other coastal uses such as recreation and to identify the increase of conflicts associated with the competition for coastal space.

APPENDIX D

WORKING GROUP B: FISHERIES AND AQUACULTURE

The topic of this group was expanded to include all living resources in the Delaware Estuary not just finfish or shellfish. Discussion was focused on how to achieve the goal of "fishable" waters. The "fishability" of water was defined in terms of human health, stock health, and ecosystem health.

To enhance and maintain balanced and diverse fish stocks, we need to define current and future problems in the estuary.
Management and research needs should include both the Delaware estuary and a range-wide ecological approach. First, key species must be identified and examined. Their population size must be assessed to develop species abundance indices. "Bottle necks" or limiting factors of each key species must be identified. Management should then be either at a total system perspective level or just at a Delaware regional level. It then can be determined if maintaining habitat and water quality will manage species or if management should include enhancing stocks or possibly total replacement of stocks.

There are existing problems in monitoring the Delaware Estuary's living marine resources. There is a need to interconnect protocols for data collection. All three states which border the Delaware Estury (NJ/PA/DE) must use consistent protocols to make the data comparable. Such protocols include what to monitor (abundance or human health effects), what life stage to monitor and what methodology to use. Current techniques for data collection need to be improved. Better, cost-effective methods are needed to collect missing

information on ichthyoplankton and juvenile fish. Short-term data on key species is needed to start the program, but long-term studies are necessary to understand year-to-year variability. Beyond just monitoring, we need a seperate research program to investigate what is observed. The data must be made useful.

The research and information needed to identify the present status of the system were defined in four categories including human health threats, abundance/yield decrease or variation, diversity, and disruption of ecosystem.

We need to identify :

(1) Human Health Threats

- o What are threats on human health.
- o Sources, transports, distribution, and fate of contaminants.
- o The effect of oil deposition in wetlands.
- o Parasite threats.
- o The effect of resuspension of bottom sediments on the distribution of contaminants.

(2) Abundance/Yield - decreasing or variable ?

- o Which species or communities are low in abundance.
- o The source of problems (need for geographic survey).
- o Whether the decreasing or variable abundance and yield are caused by totally man-made, secondary man-made, or natural effect.
- o What is the cause of the problem associated with the coupling of primary production and fishery production.

(3) Diversity - decreasing ?

- o Where in bay the diversity of benthic communities are decreasing considering the stability of the Delaware Bay Bottom.
- o Causes of changing diversity.
- o If increasing diversity is important to the Delaware Estuary.

(4) Disruption of Ecosystem

- o The effects of spatial and temporal changes in habitats on major species such as oysters.
- o The impacts of impingement and entrainment by power plants and the impacts of chlorination from sewage treatment.
- o The magnitude of major disruptions of the estuarine ecosystem.

To conclude the discussion the group combined the goal of "fishable" water with the current status and problems identified. They furthered their discussion based on three major topics which include three subtopics such as status/trends, causes/reasons, and management strategies.

(1) Fishability with regard to human health

(a) Status/Trends

- o There is no information available on the trends of toxicants in major species in the Delaware river such as catfish, white perch, striped bass, and bluefish, etc.
- o More information is needed on the "pulse effects" of toxicants inputs (during rainstorms) and the effects on juvenile fish and plankton (transient effects).

(b) Causes/Reasons

We need to determine:

- o The specific effects of toxicants on human health.
- o Sources, availability, and fate of toxicants and pathogens (initial and secondary sources).
- o The levels of toxicants in fish: What does a natural background versus a raised level really mean?

(c) Management Strategies

- o Need a regional effort to change the state of freshwater.
- o Continue the assessment and monitoring of the range and extent of contamination in tri-state coordinated fashion.
- o Eliminate contaminated sediments from the river bottom.
- o Remove inputs of contaminants.
- o Use modelling to predict impacts.
- o Develop aquaculture.

(2) Fishability with regard to stock health

(a) Status/Trends

- o There is no adequate program present to assess the status of fisheries.
- o Need long-term commercial harvest trends, mid-term recreational harvest trends, and mid-term trawl surveys.
- o Need data on physical parameters.

(b) Causes/Reasons

We need to assess:

- o Limiting factors, spatial and temporal changes in habitats, pulse effects.
- o Diseases and their impacts: If disease is a limiting factor in oysters -

should a disease resistant oyster be introduced?

- o The effects of toxicants, especially on fisheries: We need to be able to analyze toxicants in specific tissues instead of just in the bulk flesh of fish. This also is a tool to identify the sources of toxicants. Sub-lethal effects of toxicants need investigation.
- o The impacts of stock removal by fishing, impingement and entrainment.
- o The impacts of chlorination.

(c) Management Strategies

- o Need stable, funded, intercalibrated monitoring programs for fish and wildlife including key food chain organisms.
- o Prevent unintentional introduction of exotic species.
- o Overwhelm natural population of oysters with MSX-resistant stocks or seed shifting to lower end of growing grounds.
- o Need bistate or tristate fishing regulation management consistent with coastwide management plan.
- o Have different management strategies on the resident species and migrating species.
- o Improve the management of fresh water input in terms of quantity and quality and reduce pulses.
- o Investigate moving salinity line to 1900 level.
- o Develop new technology for samplings.

(3) Fishability with regard to ecosystem health

(a) Status/Trends

- o Little information is available on the abundance, production, species diversity and composition on benthic and plankton communities.

o Need a mechanism for studying the status and trends of ecosystem health.

(b) Causes/Reasons

We need to assess:

- o Ecosystem health.
- o Physical parameters.
- o The effects of oil spills and dredging on the ecosystem.
- o The past and present pollution trends.

(c) Management Strategies

- o Consider dredging options.
- o Develop predictive modelling to assess the human impacts on the ecosystem.
- o Use aquaculture to reintroduce species.

APPENDIX E

WORKING GROUP E: WATER QUALITY AND USE

Several components of problems were identified based on the discussion on land use controls and water quality.

(1) Land Use

Land use in the vicinity of the Delaware Estuary was a concern. Currently there is a limited access to the estuary. Some land uses especially along the Delaware river inhibit public access to the water. In the upper estuary, swimming is often limited due to high bacteria levels but year round disinfection of effluents may improve the water quality. The property line for recreational uses (boating, etc.) need to be delineated. If the guidelines of the Coastal Zone Management Act (CZMA) are extended more areas along the estuary could be assessed. San Francisco has an analogous situation and allows for increased public access. Areas for both public and private uses of the estuary must be designated.

There are existing conflicts between different localities to put a land-use plan into action. For example, some areas are surface water deficient and their residents may need to access the estuary through another locality.

Some research needs regarding a projected population increase along the estuary are: What will be

- o The increase in water use?
- o The demand on the resources?

- o The associated water quality problems? - If the population is decentralized, septic tanks will be constructed over larger areas and there will be changes in the inputs of toxics and bacteria. What are the implications of degenerating sewer systems?

(2) Water Quality Standards

The public perceives the Delaware Estuary as being dirty water - not clean enough for recreation. Actually, the group felt that the risk analysis presently adopted is too stringent , and therefore prevents recreational use of streams.

The Delaware is always light limited even with secondary treatment of waste water. This is due to natural particles and suspended sediments. Impoundments remove natural particles while dredging may cause resuspension. Secondary treatment in zone I and above the Pennsylvania/Delaware border has improved the overall water quality since 1972. The group felt, however, that chlorination of effluents was necessary year round. Point sources of pollutants such as CSOs also should be disinfected during high flow periods. Viruses from sewage have been a problem for shellfish (Shellfish feeding experiments are being conducted at Raleigh Durham, NC).

It is necessary to develop a set of water quality standards. These standards should be variable by sections of the bay and its uses (industrial, recreational, etc.). We should use the least costly ways to proceed. Permit schemes were recommended for government jurisdictions to buy and sell permits to maintain waterquality standards. A problem with drawing standards

is that the data are lacking to decide " where to draw the line" (for example, the effects of copper on human health), and also it was noted that interstate agreements on toxic substance regulations are difficult to obtain because of different state standards. There are other complications involved in developing water quality standards. One of them is that human may be able to tolerate more toxic than fish (for example, human can handle 10 times as much as copper as fich). If the threshold levels of fish are lower than human, we must use them as standards for water quality, in turn alleviates concerns about human consumption of contaminated fish. Another complication is that water qaulity standards are now based on discharges into wetlands, which has no cross-connection with the water quality 100 ft downstream.

"Pollution rights" could be issued to different entities. Pollution rights sales could be a problem, but there are ways to adjust sales using cost/benefit analysis. Technology coefficients can be worked out.

(3) Toxic Materials

We need a clear picture of the sources, the processes, the mechanisms, the fate(sinks), and the effects (on the productivity) of toxic materials in the Delaware Estuary.

The group questioned, if upstream of the Estuary is a pollution source, if pollution is from industrial areas, or if the local sewage is the source of metal accumulation - Is the Delaware a Sewage Pipe without walls?

Whole effluent toxicity analysis may be a good idea. Using bioassays, we could determine if toxicity from sewage treatment plant is manifested in the

river. To understand the processes of toxic materials and make predictions, more information is needed on light, sediments, nutrients, etc.

Although we have some information available on metal loadings, there is little or no information on oil hydrocarbons, and even previous data on the Delaware are not helpful. Before we go out and collect data, it is necessary to decide which specific compounds and processes we want to look at.

More research on organics is needed. The sources (roadway runoff, atmospheric, etc.) and the processes that cause pulses on wetlands need to be identified. Studies on sediment accretion rates should help us understand the dynamics. However, the bay is not accreting PAHs. Then, is dredging a problem? Is the source of PAHs the marshes or channels?

The following information must be collected:

- o Is there any evidence of high metals and PAHs in shellfish in the bay?
- o Are there differences in the upper, mid, and lower bay? (Zinc is higher in oysters on the east coast of the bay).

So far, studies indicate no fish-eating problems but Delaware has no testing policy for fish. The urban sections of the Estuary have PCB advisories.

We have good records on atmospheric deposition. The high zinc burdens in the estuary is postulated to come from the atmosphere.

(4) Freshwater Inputs and Uses

The major questions which need to be answered are:

- What are the consequences of changing freshwater inputs to the Delaware estuary?
- What should be the minimum flow requirements?
- Are the current inflow data sufficient for the year 2020?

Freshwater flows from rivers in the upper estuary but may change in the future because of damming. This could cause eutrophication problems. Different tributaries have different uses for freshwater. Permits for these uses involve " red tape" and can be difficult to obtain. Sometimes permits prevent uses because they require too much time to get water diversion requests (NPDS permit). Tributaries of the Delaware estuary from the Delaware River to Merrill Creek, NJ supply freshwater for the industry and residential uses. Hydropower (hydro-electric power or for cooling purposes?) does not drain freshwater from the system. Seven power companies have developed on Merrill Creek with few augmentations during high demand periods.

Ground water is another source of freshwater input to the Delaware Estuary. Problems with this source of water, for example heavy metals, are not known.

It is important to determine the water balance for the estuary. What is the freshwater input and storage capacity? Radon tracers should be used to answer this question. If flushing rates are to be maintained, how much freshwater needs to enter the system? The freshwater sources should be gauged to determine water balance.

The saltwater intrusion into potable water due to inbalance of freshwater

supply could cause serious problems such as potential increase of MSX in oysters.

(5) Sea Level Rise

It was asked if dredged materials can be put behind dikes in wetlands to deal with the rise in sea level. The US Army Corps of Engineers has large amounts of material to answer the issue of " dredge and reinforce dikes".

Sand replenishment is also a way of handling sea level rise. Specific management strategies should be developed open ocean versus bayside.

(6) Wetlands

The wetlands of the Delaware Estuary need to be quantified. We must clarify our view of wetlands function, particularly how it concerns water quality. We need to know how much toxic materials are stored in the wetlands that could significantly impact the ecosystem if a large meteorological events such as hurricanes occurred. The annual loss of wetlands needs to be determined. This may be done by annual photography checks. Historical data could be useful.

(7) Restoration

It is not yet clear why there is no submerged aquatic vegetation in the Delaware Bay. To develop management plan for restoration, we first need to know what the causes are - if the loss of vegetation is due to turbidity level or if it is water quality related.

(8) Monitoring

No regular comprehensive monitoring program exists for the Estuary. A

regional program for monitoring is needed but the design is not easy. Coliform monitoring was pointed out as not being as good as the data for nutrients and dissolved oxygen concentrations. Continual sampling is needed to know if conditions are getting better or worse and ultimately for predictive purposes. For example, we have 10-year records for Lewes, Delaware, and these are just enough to begin to say something.

There are funding problems in establishing long-term monitoring program. NADP has shut down. Monitoring programs should include several sites which can remain in the program if funding is lost. This conference should provide initiatives to develop long-term monitoring program.

Thus, funding must first support long-term monitoring, and then support research directed to resource manager's needs for site-specific assessment.

APPENDIX F

WORKING GROUP D: HUMAN CARRYING CAPACITIES, MANAGEMENT AND DEVELOPMENT

Three states neighboring the Delaware Estuary have different land-use plans, and their local governments affect the estuarine system with different regulations and management strategies. This situation has created conflicts and difficulties in managing the Delaware Estuary with a total ecosystem perspective. The recognition of these problems addressed the necessity of a regional land-use plan which could provide some guidelines and recommendations on local governing agencies.

Although the participants of this working group agreed on the strong need to develop a regional plan to achieve consistency among different governing units, they cautioned, however, that the feasibility of a mandate regional plan is still low since it would impose constraints on local governments, and suggested that it should be necessary first to dictate clearly what the benefits of a regional plan would be.

Zoning is a useful tool in the land-use planning, which determines what can or cannot be introduced in a certain area.
This involves the considerations of man-made or natural constraints, limitations on natural resources, increase in population, etc. The population of the Delaware Estuary region appears to be increasing and redistributing. Since the demography is one of the most important factors in developing any land-use plan, the discussion was focused on determining carrying capacity, in other

words, whether we can accomodate an increasing population and at the same time ensure the values and uses of the Estuary identified by the first workshop group. To determine limitations on carrying capacity, it is necessary to identify critical areas such as natural areas, well-heads, water recharge areas, wetlands, etc. Community services such as water availability, transportation, power source, hospitals, waste treatment, docking and port facilities, natural gas, fossil fuel and roadways also must be identified. The assessment of the present and future population distribution requires the understanding of the factors governing human behaviour such as economic incentives or tolerable density. The group questioned what units will be used to determine the carrying capacity. Estuarine and tidal units should be focused and county units can be used.

The following problems were associated with developing a land-use plan:

- o Ambiguous role of different levels of governments (federal, state and local government).
- o Lack of knowledge in local planning government.
- o Need for educational programs.
- o Conflicts between short-term benefits and long-term goals.
- o What are the long-term benefits/costs?
- o It is not enough just to protect one type of land use.
- o Conflicts or problems in coordinating different levels of governments.
- o Who is going to administer a regional plan? Do we have any existing governing unit to handle regional problems? Do we need to create a new governmental unit? Predict no changes in controlling government.

To solve those problems the following research needs and management strategies were suggested:

- o "Hope is no longer a viable alternative." Affirmation planning is required which looks to the future objectives rather than merely responding to past problems.

- o A planning program based on regulatory requirements must be supported by appropriate action at local, state, and federal levels of government.

  The federal role in assuring consistency among the states is important.

  The role of local government is to implement the plan.

  The state (and federal government) can provide incentives such as publicity, money, and legislative mandate.

- o In order to provide a base for reconciling short term and long term goals, a clear statement of the economic, ecological and social values of the estuary needs to be developed along with a strategy to achieve these values.

  While it is difficult to place dollar amounts on the quality of life and value of natural resources, these must be recognized.

  The economic interests which motivate individual and business behavior need to be understood and incorporated as well.

- o An education program to quality and train people in planning boards and other local units of government as well as community members, including the young, is essential to the operation of a land planning system.

Education should be general as well as provide specific information about proposed projects and the alternatives.

APPENDIX G

WORKING GROUP E: WETLANDS

The federal "no net loss" policy is a good one, but needs clarification and the development of strategies to ensure that it can be achieved. The participants in the second workshop reaffirmed the statement of the first workshop that the goal should be "no net loss of wetland function." They cautioned, however, that present knowledge is not adequate to characterize with confidence the value and function of different wetlands. If "no net loss of wetland function" is to be the goal, additional research is needed to develop diagnostic tools capable of assessing the value and function of wetlands and those tools must be applied throughout the Delaware system. The Delaware's wetlands should be mapped, inventoried and assessed. Special attention should be directed at the Delaware's freshwater wetlands. The National Wetland Inventory is a good starting point, but is not adequate: Wetlands under two acres do not show up, it does not include freshwater wetlands, and the Inventory is not updated frequently enough. The inventories should be available in public places such as libraries and should be accessible not only physically but technically as well to the large public. The public should be encouraged to comment on the inventories and to point out areas that are in error.

In determining the value and function of wetlands, this must be done on several spatial scales, from local through regional to national. Some values and functions, for example, water retention, must be given priority on a local scale. Also, in assessing the value and functions of wetlands, the relationship between wetlands and contagious areas -- both terrestial and aquatic -- must be

considered.

Research will be needed to develop indices of value and function of wetlands that can be used for management. These must have a good scientific basis.

Participants of the second workshop recommended that, where possible and appropriate, new wetlands should be created and that research should be done to identify the factors that determine success of efforts at wetland mitigation, restoration and creation. The results of this research should be considered in evaluating any proposals that would affect Delaware wetlands. A chronicling of what has happened to the Delaware's wetlands would be useful.

Efforts to map and classify wetlands should be expanded to include complete characterization and evaluation of important habitats throughout the Delaware system. These efforts should start with and build upon the NWI, the state initiatives (e.g. the Delaware program) and other federal initiatives (e.g. the U.S. EPA's identification of wetlands in Delaware). This effort should lead to a ranking of the importance of wetlands throughout the system.

A synthesis of what is known and what if not known about the Delaware's system's wetlands should be carried out early in the Delaware Estuary study and should become the basis for new research initiatives.

Some wetlands serve conflicting uses. The present lack of ability to assign values unambiguously to different uses makes it difficult to justify decisions permitting some uses and restricting others.

Uses of wetlands are competitive and some may not be compatible. The uses need to be clarified and priorities assigned. The unique and unusual values and functions of wetlands need to identified and made clear to the public. A demography change and as the racial and cultural composition of the population living within the drainage basin changes, the values and uses of the environment, including estuaries, that society considers to be important may drift. The uses and values identified by participants in the first workshop for the estuary of 2020 may not be those of the 2020 population. Clear and persuasive arguments for conserving wetlands would be helpful. It is impossible to compare the dollar value of wetlands or habitat and as areas for potential development. The impacts of wetlands need to be established.

Education

Special educational programs should be designed at all levels, K-12, college, and public education to clarify the values and functions of wetlands, what has happened to them in the past, and the importance of conserving them for the future. Data and Information should be shared among agencies and should be transformed into forms appropriate to all levels.

The regulatory programs of the federal government and the several states that affect wetlands of the Delaware system must provide an acceptable level of comparability and consistency. This apparently is not the case. Workshop participants felt that New Jersey and Pennsylvania regulations were more stringent than the federal regulations and that they probably provided an appropriate level of protection, but that Delaware's did not.

Present staffing patterns and levels may not be sufficient to carry out the desired programs.

Functions of Wetlands

Wetlands serve a number of important functions. This lists the functions considered by workshop participants to be most important:

- o Wetlands act as buffers between upland areas and the aquatic environment for water, sediment, nutrients and a variety of contaminants.

- o Wetlands act as recharge areas.

- o Wetlands are important in storm water management.

- o Wetlands stabilize shorelines.

- o Wetlands are important in maintaining biodiversity.

- o Wetlands provide important habitat.

- o Wetlands are important to sustaining fisheries.

- o Wetlands are aesthetically and recreationally important.

- o Wetlands act to purify.

Tools needed to Manage Wetlands

A variety of new research and management tools are needed to effectively manage wetlands. A number of these were described earlier. They relate to assessing the value and function of wetlands and the ability to mitigate/create methods. Other tools are models. Those identified by the workshop participants are listed below:

- o Hydrologic models
- o Sediment transport models
- o Nutrient flux models
- o Habitat suitability models

Each of the models would be useful to managers charged with responsibility for management of wetlands. Hydrologic models would, for example, be helpful in establishing the zone of influence of groundwater on wetlands, the relationships between surface and groundwaters, and effects of rising sea level. Sediment transport models could be useful in developing strategies to enhance sedimentation on wetlands so they can keep pace with an acceleration in sea level. Nutrient flux models would be helpful in determining the buffering effects of wetlands on nutrient inputs to the estuary and might be useful in dredging strategies to use wetlands in municipal wastewater treatment.