A PRELIMINARY RESEARCH MASTER PLAN FOR DELAWARE'S INLAND BAYS

APRIL 1986

DE WP

A Preliminary Research Master Plan for Delaware's Inland Bays

Submitted to

Mr. David S. Hugg, III
Department of Natural Resources
and Environmental Control
State of Delaware
Dover, Delaware 19903

Supported by

Office of Ocean and Coastal Resource Management
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Prepared by

Evelyn M. Maurmeyer
and
Wendy L. Carey
College of Marine Studies
University of Delaware
Lewes, Delaware 19958

April, 1986

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
& ENVIRONMENTAL CONTROL
89 KINGS HIGHWAY
P. O. BOX 1401
DOVER, DELAWARE 19901

OFFICE OF THE
SECRETARY

TELEPHONE: (302) 736 - 4403

M E M O R A N D U M

TO: Inland Bays Monitoring Committee DATE: 3 November 1986

FROM: David S. Hugg, III, DNREC

SUBJECT: Preliminary Inland Bays Research Master Plan

I am pleased to submit to you the "Preliminary Inland Bays Research Master Plan" report by the College of Marine Studies (CMS). The department is pleased with the quality of this report and is using it as a basis to develop the "Inland Bays Research Master Plan".

There are several recommendations contained on pages 58 and 59 of the CMS report. These include: (1) establishment of a management plan for the Inland Bays; (2) incorporation of scientific research to support the management plan; (3) development of an environmental profile for existing conditions of the Inland Bays, and recognition of the identified problems; (4) establishment of a scientific review board; and (5) prioritization of research projects to fit immediate management needs. The reader may wish to refer to pages 58 and 59 of the CMS report in reading this memorandum.

The department does not feel that a management plan for the Inland Bays can be established until some data gaps are filled. However, the department is developing an Inland Bays Research Agenda which will be completed in January 1987. The research agenda will be refined as research is completed and will be used as a basis for the development of an estuarine management plan.

The second recommendation calls for the incorporation of scientific research to support the management plan. The CMS report further states that emphasis should be placed on the evaluation of historic data, filling in of data gaps, and the assessment of existing data and models to determine their usability. The CMS report does an excellent job of cataloging existing reports on the Inland Bays and will be of value to the department in making management decisions. Other evaluations of historic data within the department include the STORET data management system which stores all NPDES point-source discharge information. The department is also planning to invest in a geographic information systems (GIS) which will be used to store and correlate several types of data. If a GIS is not purchased by the department, other efforts will need to be made to assess and use historic data.

The second half of the recommendation calls for the assessment of existing computer models to determine their utility as a management tool. The department has used water quality computer models completed by Jensen, Ritter, and others on the specific projects for which they were designed. These models, however,

are of limited use because they lack complete circulation information. The department has recognized the need for a circulation model of the bays, as did the CMS report, and is planning to have the University of Delaware develop such a model for the Inland Bays. Previously completed models may be reevaluated when this work is completed.

The third recommendation identifies the need for an environmental profile of the Inland Bays and recognition of the problems. The problems facing the bays were recognized by the Inland Bays Study Group and the Governor's Task Force on the Inland Bays. The department is also continuing with many research projects, as you have been briefed on in quarterly meetings, aimed at a more complete characterization of the bays.

The fourth recommendation recommends the establishment of a scientific review board to develop and evaluate research proposals. The department agrees with this recommendation and is pursuing it.

The final recommendation calls for the prioritization of research projects and identifies research needs. The prioritization of projects will be done in the research agenda mentioned above which also includes the research needs identified by this report.

Copies of the CMS report have been made available at the College of Marine Studies, Lewes Campus, and the Lewes, Rehoboth Beach, Bethany Beach, Frankford, and Millsboro Public Libraries. If you have any questions, please call Marjorie Crofts, the Inland Bays Program Coordinator, at (302) 736-5409.

DSH:MAC:bh

Acknowledgements

This project was funded through a grant from the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, under the provisions of Section 306 of the Coastal Zone Management Act of 1972, as amended. The authors wish to thank Mr. David S. Hugg, III, for general guidance and review of the project, and Dr. Carolyn A. Thoroughgood and Mr. Andrew T. Manus for suggestions throughout the course of the study. Special thanks go to Alice Hall, Librarian, and Dorothy Allen, Library Assistant, for their help in locating the references reviewed for this report. Tammy Bunting and Julie Tigue are gratefully acknowledged for typing the manuscript.

TABLE OF CONTENTS

INTRODUCTION

Recently, much attention has been focused on management strategies for Delaware's Inland Bays. In 1984, the Governor's Task Force on the Inland Bays identified a number of issues affecting Rehoboth, Indian River, and Little Assawoman Bays. Along with problem identification, recommendations were made to ensure the present and future economic, social, and environmental quality of the Inland Bays region.

The purpose of this report is to present an agenda for research on water quality and circulation in the Inland Bays to serve management needs. The ultimate goal of the Research Master Plan is to provide an understandable and inclusive base of scientific information that can be used by planners and managers to formulate Inland Bays policies. A preliminary step toward achieving this goal is a compilation and summary of available data on water quality and circulation in the Inland Bays system, and identification of gaps in existing knowledge. After the existing information has been organized with regard to types of data collected, types of analyses performed, and a general qualitative assessment of the data, data gaps may be recognized. This then permits identification and prioritization of future research needs which would complement rather than duplicate existing information. Moreover, this approach assures that both scientific information and proposed research projects will be incorporated into a comprehensive and organized master plan. The new initiatives established in this project will create a research agenda on Delaware's Inland Bays.

The effort to protect the environmental quality of Rehoboth Bay, Indian River Bay, and Little Assawoman Bay can benefit from research that is directed toward resource management. Management decisions for the Inland Bays should not be postponed until all possible research questions are answered. In certain cases, it may be possible to develop management strategies based on existing data. However, until all management priorities and approaches are defined, it is not possible to direct scientific research toward these specific needs. In some circumstances, new research and an extended data base are necessary to implement certain management strategies designed to ensure wise use of the Inland Bays.

In sum, the intended purpose of this project was to bring together managers and scientists in order to clearly identify management needs, to devise scientific methods to meet these needs, and to develop a comprehensive research agenda that managers and planners can use to address specific Inland Bays problems. However, at this time (February, 1986), management needs for the Inland Bays have not yet been clearly defined. An effort is currently being made by the State to articulate management goals for the Inland Bays. Thus, the outcome of this project was not a clear and comprehensive integration of State management needs and scientific research, but rather a recommendation for an approach towards development of a comprehensive Research Master Plan. Priority research topics are identified based on perceived rather than defined management needs. Individual research initiatives for the Inland Bays described in this report were

presented at the request of the Department of Natural Resources and Environmental Control (DNREC) management personnel at the September, 1985 workshop.

EXISTING SCIENTIFIC DATA BASE AND DATA GAPS

A necessary prerequisite for establishment of proper management strategies is a solid base of scientific data on which to base decisions. A common goal of all past, present, and future scientific activities in areas such as the Inland Bays is to answer questions about the status, trends, and relationships of environmental quality and estuarine resources. New scientific data collection is conducted to determine whether and to what extent environmental conditions are changing, and to assist in understanding the processes and effects of environmental degradation. Historical data collection is important as it involves identifying and compiling existing data already collected for purposes similar to the above. Inspection of historical data sets provides preliminary information about the status and trends of the environment and resources. Preliminary trends identified using historic data sets can be tested and correlated by more quantitative analyses in future research and monitoring programs.

Water quality and circulation in Delaware's Inland Bays have been studied by scientists for several decades, and the data are in the form of numerous published and unpublished reports, papers, theses, and dissertations. State agencies have conducted field measurements relevant to water quality, and have compiled an extensive data base. Various federal agencies (National Ocean Service, National Marine Fisheries Service, U. S. Navy) have also collected data on currents and water quality in the Inland Bays. The results of these investigations are scattered among federal and state agencies, and academic institutions. Approximately 120

references dealing with water quality and circulation in Rehoboth, Indian River, and Little Assawoman Bays have been identified and reviewed as background information for development of the Inland Bays Research Master Plan. A bibliographic listing of references and the annotated bibliography are included in the Appendix. The annotated bibliography is modeled after the NOAA NEDRES database. Each entry contains information on the geographic area of research, period of study, data collected, analyses conducted and methods used, a qualitative assessment, and information on location of the report or reference, which is especially helpful for hard-to-obtain or unpublished data. Three examples of the annotated bibliographic summaries are presented in Tables 1-3. These data summaries provide an overview of existing available information, and should be considered a preliminary step towards a basin-wide assessment of the data available on water quality and circulation in the Inland Bays. Many of the reports have potentially usable data bases which can be used to determine changing trends of water quality, and for calibration and fine-tuning of hydrodynamic models. However, a more thorough and critical evaluation is necessary to determine the quality of the historic data. Furthermore, compilation and summary of available scientific data permit recognition of gaps in existing knowledge. This allows identification of future research projects which would complement rather than duplicate existing information. An evaluation of past work with regard to present and future needs is essential in determining the exact nature and requirements for projected data needs for management purposes.

AUTHOR:	Biggs, R. B.
DATE:	1984
TITLE:	Ambient Dissolved Oxygen Concentrations in Delaware's Inland Bays
BIBLIOGRAPHICAL INFORMATION:	Final Report to Department of Natural Resources and Environmental Control, Dover, Delaware, 22p.
ABSTRACT:	Ambient dissolved oxygen concentrations were measured at dawn during August, 1983 in Rehoboth and Indian River Bays. Dissolved oxygen values were below the state's minimum water quality standard of 5 mg/L 59% of the time in Indian River Bay; 17% in Rehoboth Bay. Absolute values of apparent net daytime photosynthesis and nighttime respiration are very high. Indian River Bay is more stressed than Rehoboth Bay; annual nutrient load to Indian River Bay is twice that to Rehoboth Bay.
GEOGRAPHIC AREA:	Indian River Bay, Rehoboth Bay, Lewes-Rehoboth Canal
PERIOD OF STUDY:	August, 1983
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Dissolved oxygen; salinity; temperature; total nitrogen; total phosphorus; chlorophyll a; conductivity. Dissolved oxygen monitored at dawn at 19 stations; hourly over a 24 hour period at 5 stations. Dissolved oxygen measured 1 m above bottom, micro-Winkler technique.
QUALITATIVE ASSESSMENT:	Presentation of data on non-point sources and loading to Indian River and Rehoboth Bays; dissolved oxygen data presented as concentration and percent saturation; water column respiration estimated; gas transfer coefficient computed; calculations of apparent net daytime photosynthesis and night respiration presented. All stations in Rehoboth-Indian River Bays; no studies conducted in Little Assawoman Bay.
REPORT OR REFERENCE LOCATION:	Department of Natural Resources and Environmental Control, Dover, Delaware
DESCRIPTORS:	DISSOLVED OXYGEN; WATER QUALITY; EUTROPHICATION; NUTRIENT ENRICHMENT

Table 1. Example of annotated bibliographic entry in Inland Bays data base.

AUTHOR:	Dennis, W. A., and R. A. Dalrymple
DATE:	1978
TITLE:	A Coastal Engineering Analysis of Roosevelt Inlet, Lewes, Delaware
BIBLIOGRAPHICAL INFORMATION:	Ocean Engineering Tech. Rept. No. 18/DEL-SG-4-78, Delaware Sea Grant College Program, College of Marine Studies, University of Delaware, Newark, Delaware, 195 p.
ABSTRACT:	This report presents a one-dimensional model of the hydraulics of Roosevelt Inlet, encompassing all bays and waterways (including Rehoboth and Indian River Bays) from Indian River Inlet to Roosevelt Inlet. The model predicts net southerly flow through the system from Roosevelt Inlet to Indian River Inlet, and shows good agreement with field data. Southerly flow attributed to (1) shape of the discharge curve; (2) friction in the Lewes-Rehoboth Canal; and (3) mass transport associated with progressive waves.
GEOGRAPHIC AREA:	Indian River Inlet to Roosevelt Inlet/Broadkill River, including Rehoboth Bay and Indian River Bay
PERIOD OF STUDY:	1977-1978
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Field data: tides, currents, discharge. Predictive model based on equations of motion and continuity (freshwater inflow and wind neglected, but may be easily added).
QUALITATIVE ASSESSMENT:	The predictive model provides output on tides, currents, discharge, location of tidal division line, and mean pumping of water through the system. However, mass is not conserved within the system (outflow exceeds input by 1.8%, due to computer accuracy in performing integration routine over a tidal cycle).
REPORT OR REFERENCE LOCATION:	Available from Delaware Sea Grant College Program, DEL-SG-4-78, College of Marine Studies, University of Delaware, Newark, Delaware.
DESCRIPTORS:	HYDRAULIC MODELING; WATER CIRCULATION

Table 2. Example of annotated bibliographic entry for Inland Bays data base.

AUTHOR:	Jensen, L. D.
DATE:	1974
TITLE:	Environmental Responses to Thermal Discharges from the Indian River Station, Indian River, Delaware
BIBLIOGRAPHICAL INFORMATION:	Prepared for Electric Power Research Institute, Cooling Water Discharge Research Project and Delmarva Power & Light Company, EPRI Pub. #74-049-00-3, 205 p.
ABSTRACT:	This report presents a compilation and interpretation of water quality and biological data collected from the Indian River estuary to evaluate the influence of the Indian River Power Plant of DP&L. The studies involve a detailed examination of water quality, nutrients, and temperature in the Indian River estuary.
GEOGRAPHIC AREA:	Indian River estuary
PERIOD OF STUDY:	1966-1971
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Water quality, temperature, salinity, dissolved oxygen, alkalinity, pH, nutrients, phosphorus, nitrate, ammonia. Data presented in form of tables, graphs, and discussion section. Detailed description of all methods in each chapter of book.
QUALITATIVE ASSESSMENT:	Twenty stations sampled routinely; regular summer weekly synoptic surveys for temperature, salinity; bimonthly field trips. Detailed study of the upper parts of the Indian River estuary, with data and discussions on phytoplankton and primary productivity; benthic invertebrates; fish populations; zooplankton entrainment; meteorological data.
REPORT OR REFERENCE LOCATION:	Morris Library, TD 427.H4 J46
DESCRIPTORS:	INDIAN RIVER ESTUARY; WATER QUALITY

Table 3. Example of annotated bibliographic entry for Inland Bays data base.

A detailed evaluation and discussion of the scientific research conducted in the Inland Bays area is beyond the scope of work for this project, but general research trends and data gaps can be summarized and identified based on the compilation of existing data. In this way information needs and suggested direction for future work may be identified. The scientific literature reviewed for this project was limited to studies dealing with water quality and circulation in the Inland Bays. Research conducted on estuarine biology in the Inland Bays was reviewed only as it pertained to water quality data. Thus, much of the extensive work on the biology of the bays is not included in the bibliography or literature review.

There are both temporal and spatial data gaps in regard to present knowledge of water quality and circulation in the Inland Bays. A very obvious missing link in the geographic extent of the research that has been conducted in the Inland Bays is Little Assawoman Bay. When compared to the extent of investigations covering Rehoboth and Indian River Bays, little or no research has been done in Little Assawoman Bay. If Little Assawoman Bay is to be considered an integral part of the entire Inland Bay system, more information is needed regarding its characteristics.

Data on salinity, temperature, and dissolved oxygen in the bays have been collected in conjunction with many biological and chemical studies in Indian River and Rehoboth Bays. These data are available from studies conducted from the early 1960's to the present. Similarly, historical water quality data have been

collected by DNREC throughout the Inland Bays region. In 1969, Daiber reported that, based on biological indicators such as algal species and benthic invertebrate fauna, the general health of the bays was good. Dissolved oxygen levels were found to be generally high, but variable, with warning signs that indicated the possibility of seriously low O_2 levels in the bays, especially in the summer. Biological studies indicated that both Indian River and Rehoboth Bays had been and still were very productive. However, Daiber (1969) did point out that there were indications that some of the Inland Bay tributary creeks had been seriously degraded. In 1976, Jensen reported that chemical water quality data in Indian River and Rehoboth Bays indicated that all tested parameters were within acceptable limits. Data collected by DNREC in the 1960's and early 1970's served as an indication that serious pollution was infringing in some parts of the Inland Bays (ultimately resulting in shellfish closures).

Therefore, although the water quality data collected to date are sufficient to indicate general environmental quality in the Inland Bays, available information is far from complete. Data acquired to date have value as trend-indicators. These data are useful in providing base-line information for future examination of the bays in terms of their ecological health and possible degradation by pollution, increased development, and general effects of time.

It is assumed that management and policy decisions for the Inland Bays will require water quality data in that this informa-

tion provides an indication of the extent to which the bay waters can support aquatic life and meet standards for various human uses. The water quality of the bays depends on the capability of the body of water to assimilate various stresses and pollutant inputs. When the Inland Bay's assimilative capacity is stressed or exceeded, the water quality deteriorates. Ultimately, aquatic life and human use of the bays is affected. Although existing water quality data are useful to management at the present time, certain steps should be taken and specific data gaps should be filled before water quality data are utilized as effective management tools.

Jensen made the observation in 1976 that no systematic attempt had been made to quantify and interrelate the various components of the Inland Bays ecosystem. This statement is still valid in 1986. A comprehensive characterization of the Inland Bays environment will yield an effective management tool for resource managers. Such a characterization can be initiated by 1) characterizing the present water quality in the Inland Bays system, and 2) identifying long-term water quality trends in the existing historic data base. Existing data (also referred to as historical data) can eventually be incorporated into models to evaluate both the short- and long-term effects of various developmental and regulatory policies in the Inland Bays.

In essence, the following data gaps should be addressed and considered by Inland Bay resource managers. Because the management goals for the Inland Bays have not yet been described

by the State managers, these gaps have been identified based on perceived management needs.

1. Identification of general historic trends in water quality in the Inland Bays. Historical data should be examined, evaluated, and synthesized. Temporal and spatial gaps in specific water quality data should be identified. There are geographic areas within the bays where data are few. Distribution of data sets is patchy during the approximately 30 year historic data period. Existing data (with a few exceptions) are concentrated in short time periods (e.g. many samples taken in summer months, few in winter months), or they may not cover enough years to establish firm trends. Some analytical and sampling procedures may not be cross-calibrated. Also, it may be difficult (or impossible) to apply statistical analyses to historic data for trend identification.

2. Characterization of existing water quality in the Inland Bays. At the present time, both scientists and managers have only a limited ability to characterize water quality in the Inland Bays. Information is lacking with regard to the amount and composition of nutrients and primary productivity in the bays. This is also related to the characterization and understanding of the non-point source inputs into the bays. Preliminary work has been initiated on non-point source pollution in the bays, but a synthesized and integrated understanding of the productivity and nutrient levels in the bays has not been achieved. This basic

information is useful as a foundation to build management policies and numerical models.

3. Description and quantification of circulation patterns (system transport mechanisms) and residence time of Inland Bay waters. Although general information is known with regard to circulation in Indian River and Rehoboth Bays (i.e., bays are shallow, waters are well mixed due to tidal action and winds; major variations in salinity and temperature are horizontal rather than vertical), very little is known about overall circulation patterns in the bays. An examination and evaluation of selected water inputs to and from control points in the bay system could yield information necessary for numerical representations of the hydrodynamics of the Inland Bays.

4. Investigations should be extended to include Little Assawoman Bay if it is to be incorporated into the Inland Bay management system.

MANAGEMENT GOALS

Historic Perspective: 1960'S to 1984

The need to establish management goals for Delaware's Inland Bays has been recognized for nearly two decades. Daiber (1969) noted that biological studies indicated that both Rehoboth and Indian River Bays had been and still were very productive, but that some tributary creeks were seriously degraded. Daiber expressed concern that, in the absence of proper management policies, the quality of the Inland Bays, too, would decline.

The need for a comprehensive management plan for Delaware's Inland Bays was reiterated by Jensen and others (1976). The authors identified information needs and suggested direction for future work "because no comprehensive effort was being made to manage the growth of the areas to ensure that water quality and the natural ecosystem would be maintained and improved." Although a considerable amount of scientific research had been conducted in the Inland Bays, Jensen and others (1976) concluded that "knowledge of the functioning of this area ecosystem is far from complete...furthermore, no systematic attempt has been made to quantify and interrelate components of the area ecosystem in order to identify critical elements which need priority consideration in management decisions."

This viewpoint was supported by Scotto and others (1983). As cited in their report, issues of concern with regard to the perceived deterioration of environmental quality occurring in the Inland Bays system include: (1) shellfish bed closures due to

bacterial contamination; (2) eutrophication of bay waters; (3) lack of a comprehensive examination of long-term costs and benefits of dredging activities; (4) salt-water intrusion in the region's drinking water supply; and (5) nitrate contamination of the groundwater system. These problems persist because "to date, development of the Inland Bays area has been characterized by incremental decision-making guided by a project-by-project approval process... There is no overall plan or coordinated strategy to ensure the wise use, development, and management of the Inland Bays area" (Scotto and others, 1983). The authors proposed establishment of a bipartisan Task Force to recommend goals, objectives, implementation mechanisms, and enforcement strategy for a comprehensive management and development plan for the Inland Bays area.

In October 1983, The Governor's Task Force on the Inland Bays was established. The 31 individuals who comprised the Task Force sought to provide specific and focused recommendations to ensure the preservation of environmental quality of Delaware's Inland Bays. The goals cited in the Task Force's Final Report (July, 1984) include:

- o Land Use Planning: To assure that land use decisions affecting the Inland Bays are made by all levels of government in a comprehensive and environmentally responsible manner that also considers the area's social and economic importance.

- o Treatment Plant Discharges: To develop and implement an effective area-wide wastewater management plan that considers the impact of pipe discharges and other pollutant sources on surface water quality.
- o Agricultural Pollution: To manage fertilizers, pesticides, herbicides, manure, and sediment so that these contaminants will not threaten the ground or surface water quality in the Inland Bays area.
- o Shellfish Closures: To develop a management tool which would allow the State Board of Health to trigger the timely opening and closing of conditionally approved shellfish areas, and which would adequately protect public health and permit greater utilization of the resource.
- o Water Quality Monitoring: To improve long-term management of the Inland Bays' water resources with a more comprehensive and responsive water quality monitoring program.
- o Wetlands: To continue the effective resource management program that has been established to protect wetlands and to eliminate the redundant state-federal permit process.
- o Natural Areas: To ensure that rare and unique natural areas in the Inland Bays region are on DNREC's Inventory of Natural Areas and are permanently protected in their natural state to the extent feasible.
- o Underwater Lands/Recreational Access: To assure that the Inland Bays and their tributaries afford maximum recreational benefits within the confines of sound recreational

planning and that public underwater lands are not indirectly removed from the public domain.

- o Sedimentation and Erosion: To identify the sources and magnitude of sedimentation to determine appropriate erosion control techniques.
- o Dredging: To determine the long-term environmental and economic costs and benefits of all dredging conducted by DNREC in the Inland Bays region, and to consider for state funding only those projects benefiting the public at large.
- o Research Needs: To conduct state-sponsored research and monitoring projects concerning the Inland Bays that are in direct support of established resource management strategies.
- o Public Education and Participation: To ensure that, to the maximum extent possible, all planning and management activities related to the Inland Bays involve public participation, information, and education.

Areas of Concern: 1985

A Research Master Plan workshop was held in September 1985 to coordinate management needs with scientific expertise. A general overview of the workshop is presented in the following section. Although the State has not yet formulated a comprehensive management plan, the following areas of prime concern were articulated by DNREC managers and policy-makers:

- o Circulation and Nutrient Dynamics: Current knowledge in these areas is tentative and needs more definition. These aspects should complement the proposed NOS study on circulation in the Inland Bays.
- o Applied Research and Public Education: An educated and involved public is a great asset; individuals could learn how to minimize their impact on Inland Bay resources.
- o Carrying Capacity of the Inland Bays: It is important to know the critical threshold of nutrients, pollutants, and resource exploitation which can be introduced to the Inland Bays before adverse environmental effects result. Is primary productivity nutrient limited or are other factors such as light limitation important?
- o Recreational Use Conflicts: How can mutually incompatible recreational activities and facilities, such as recreational shellfish harvesting and marina facilities, be accommodated and prioritized?
- o Freshwater Wetlands: The areal extent, value, and importance of Delaware's freshwater wetlands must be examined. How important are they for groundwater discharge? Are they as important as tidal wetlands for stormwater runoff and removal of organics?
- o Sea-Level Rise: What are the economic and environmental effects of the anticipated sea-level rise in the next 10 to 30 years?

- o Non-Point Source Pollution: What are the major contributors for non-point source pollution?
- o Dredging: What are the effects of dredging on water quality and circulation in the Inland Bays system?
- o Shellfish and Recreational Area Closures: The Division of Public Health has an extensive data base on coliform levels in the Inland Bays. Bacteria other than coliform must also be considered. There is also a need for a predictive model of bacterial fluctuation so that closures of shellfish harvest areas and recreational areas can be announced before crisis levels are reached.
- o Water Use Plan: A management strategy analagous to a land use plan that would control certain areas of the Inland Bays for certain uses is needed.
- o Marina Impacts on Shellfish: There is not much scientific information on exactly how marinas affect water quality and shellfish beds. There is also a need to develop a more uniform method to establish buffer zones around the edges of marinas.
- o Fisheries: There is a need for integration of water quality and circulation modeling work with fisheries resources; the role of the Inland Bays as nursery areas should be assessed; and, an economic impact analysis of recreational fishing activities in the Inland Bays areas needs to be updated.

- o Groundwater quality: Groundwater contamination by non-point source pollution from agriculture: Are nutrients that are being discharged to streams via groundwater contributing to water quality problems?

Current Research Projects

A number of research projects are already underway or scheduled to begin in the near future to obtain more detailed information on water quality in the Inland Bays. These studies address several of the areas of concern expressed by DNREC personnel, and follow the recommendations of the Inland Bays Task Force Monitoring Committee. The purpose of the investigations is to provide additional scientific data required for pollution control, restoration of habitats, and resource management decisions. Ongoing research projects are listed here in summary form in order to develop a more thorough and up-to-date overview of the current state of knowledge; more detailed descriptions are available from the Inland Bays Task Force Monitoring Committee and individual DNREC personnel supervising the projects.

While there is some overlap in the scope of the projects, they may be classified into three broad categories: hydrologic investigations; assessment of pollutants; and resource management. The studies deal primarily with water quality. It does not appear that the ongoing projects directly address water circulation in the Inland Bays.

1. Hydrologic Investigations: Studies involving collection and/or analysis of data on surface water and groundwater systems in order to better understand the hydrology of the Inland Bays drainage area:

a. Stream gaging, observation well network, flow measurement, and pollutant loading for the Inland Bays (DGS/USGS).

b. Delaware Stream Watch (DNES).

c. Geochemistry of groundwater in the unconfined aquifer, Sussex County (USGS/DGS).

d. Water supply study for South Coastal and North Coastal Maryland (Maryland Department of Natural Resources, U.S. Army Corps of Engineers).

e. Hydrologic mapping in Eastern Sussex County (DGS).

2. Assessment and Evaluation of Pollutants, Nutrients and other Contaminants Affecting Water Quality and Resources in the Inland Bays System:

a. Desktop evaluation of nutrient loads and impact in the Inland Bays (Dr. W. Ritter, University of Delaware).

b. Geographic information system - computer analysis of multiple layers of spatially oriented environmental data for evaluating

potential groundwater impacts (Dr. A. McDonnell, Pennsylvania State University).

c. Influence of alternative on-site wastewater treatment systems on groundwater (Dr. W. Ritter, University of Delaware).

d. Delaware's Coastal Bays: Man's influence as recorded in the sediments (Dr. R. Biggs, University of Delaware).

e. Examination of the presence of toxic substances in Delaware waters and their impact on designated uses.

f. Effects of chlorinated discharges on freshwater and estuarine aquatic life.

g. Phytoplankton, submerged aquatic vegetation and macroalgae in Delaware's Inland Bays (Dr. K. G. Sellner, Philadelphia Academy of Natural Sciences).

h. Maryland-Delaware saltwater intrusion study (USGS/DGS).

i. Fertilizer and pesticide applications impacts on groundwater quality (USGS).

3. Methods to Improve Water Quality and Management of Inland Bays:

a. Preliminary management plan for monitoring and regulating the suitability of the Inland Bays

for primary contact recreation (Greeley-Polhemus Group).

b. Dredging study for the Inland Bays and tributaries (Betz, Converse, Murdoch, Inc.).

c. Evaluation of lime stabilization and land disposal as a septage management alternative (L. Burton, Dr. W. Ritter, University of Delaware).

d. Statewide Septage Management Plan (Tatman and Lee).

e. Shoreline stabilization pilot program using natural vegetation (E. Garbisch, Environmental Concern, Inc.).

f. Wind-powered aeration systems pilot program, Fenwick Island (Peter A. Freeman, Assoc.).

g. Monitoring program for poultry manure development (Dr. W. Ritter, University of Delaware).

h. Dead bird (chickens) disposal practice (Dr. W. Ritter, University of Delaware).

RESEARCH MASTER PLAN WORKSHOP

General Overview

A research planning workshop was held at the University of Delaware, Lewes, on September 18, 1985 to develop a comprehensive research plan for Delaware's Inland Bays. The purpose of the workshop was to coordinate State management needs with scientific expertise and to determine the need for research in support of resource management in the Inland Bays area. The workshop served as a means of generating a dialogue between the State and University of Delaware personnel in terms of identification of the kind of research and information the State needs in order to make management decisions. The workshop also served to identify research interests and objectives of the University that might fit into the State's management framework. A high degree of interaction between DNREC managers and scientists is essential to ensure that management needs drive the research agenda. Close coordination and planning are required to assure that research projects and assumptions are appropriate, and that the application of the proposed research is clearly established to managers and resource management.

At the workshop, State managers were asked to articulate specific management strategies for the Inland Bays, and to identify priority resource management needs. Although these were not clearly expressed, individual areas of prime concern were described (see previous section of this report). The scientists then presented preliminary ideas on research initiatives which

would permit managers to implement perceived management approaches for the Inland Bays. Descriptions of each of the scientific research projects appear in the next section of this report. After the presentations, discussions were directed toward (1) defining key data needs; (2) evaluating management strategy needs; and (3) prioritizing and integrating research projects. The intent of this meeting was to initiate coordination between State managers and research scientists in an effort to delineate, prioritize and implement key water quality and circulation projects necessary for effective management of Inland Bays resources. Although the workshop did not culminate in formulation of an integrated research/management scenario, it served as a preliminary step towards bringing scientists and managers together. A follow-up workshop, once a management plan has been defined, would result in a more clearly integrated Inland Bays research plan.

Aside from the general outline of research projects and management goals that was developed, a great deal of discussion was generated on the subject of utilizing the predictive qualitative modeling approach vs. basic quantitative data collection. State managers indicated that a good water quality and circulation model would be an effective management tool to tie water quality responses to actions in management. A model is needed to predict effects of changes in specific pollutant inputs on water quality. Such a model would require information on total pollutant loads

from various sources (wetlands, groundwater, discharges) and would calculate steady state concentrations in the ambient waters.

However, research scientists pointed out that there cannot be a reasonable attempt to develop a sophisticated numerical model without some important quantitative basic knowledge about the fundamental operation of the Inland Bays system. Numerical and predictive models which precede basic knowledge are often vulnerable to failure without the support of a quantitative assessment of the system. The model must be based on field verification to answer such basic questions as: What is the impact of nutrients in the system? What are the proportions and limitations of nitrogen compared to phosphorus? How much primary productivity is driven by direct input, how much by recycling? What are the effects of nutrient levels on productivity? It was emphasized that information and data on basic quantities and fundamental information on circulation and chemical and nutrient fluxes are required before qualitative approaches will be satisfactory. Basic points must be addressed first to guide future research efforts and future management policies.

Scientific Research Initiatives

At the planning workshop, research scientists from the University of Delaware presented preliminary outlines of key research initiatives addressing water quality and circulation in the Inland Bays. In their presentations and ensuing discussions, the scientists integrated the research projects, and described how

various components would complement each other. A descriptive account of each proposed research project, based on each scientist's verbal presentation at the workshop, is presented on the following pages.

TITLE: Quantitative Assessment of Historical Data on the Inland Bays

Proposed By: Dr. R. B. Biggs, J. M. Smullen

Project Description: Dr. Biggs made no proposal for new research in the Inland Bays, but rather a recommendation for historic data analysis and interpretation. He recommends that a group of scientists examine existing data to determine what is adequate, what is usable, and move the information to a computer data base. The data should be critically evaluated by a committee of scientists who would screen the data to determine the quality. In this way, management questions may be addressed immediately with available data. In an ongoing parallel program, obvious information gaps should be filled with newly collected data. Ultimately, ongoing analyses can be tied together with historic data to address management needs.

Based on experience with the EPA Chesapeake Bay Program, Biggs advises that state managers and research scientists not overlook data that already exist. During the three year span of the EPA Chesapeake Bay Program, $17 million was spent for new research, while 18 months and $2 million were utilized to develop an historic data base; 90% of management decisions in the Chesapeake Bay were based on the historic data.

Management Application: Immediate access to existing data; ability to answer management questions within a short time frame.

TITLE: Nutrient Dynamics in the Waters of the Small Bays

Proposed By: Dr. J. H. Sharp

Project Description: Dr. Sharp proposed a research project which would examine the nutrient dynamics in the waters of the Inland Bays. There is need for a better understanding of nutrient impact in the bays and a need for a better delineation of what nutrient levels are doing to productivity in the bays. To date, discussion on eutrophication and deteriorating water quality appears to be based upon coliform criteria and estimates of sources of nutrient loadings. Dr. Sharp's proposal involves a critical examination (with field effort) of spatial and seasonal nutrient distribution and dynamics (phytoplankton use and benthic and water column regeneration).

Management Application: Determination of assimilative ("carrying") capacity of bays; setting standards and limits for non-point source and point source pollutant inputs. Basic information on parameters of system necessary for general management strategies.

TITLE: An Investigation of Trace Metal Pollution, History, and Fluxes in the Inland Bays

Proposed By: Dr. T. M. Church, J. R. Scudlark

Project Description: Dr. Church's research would investigate trace metal pollution histories and fluxes (sources, cycling, and sinks), especially the fly ash metalloids in the Indian River system. Two years ago, Dr. Church's field sampling project revealed very high levels of trace metals in the Indian River system. An internal source of these trace metals was indicated, yet it is not known if trace metals in the Inland Bays system are coming from a point source pollutant (e.g. the fly ash pile at Indian River Power Plant), or from general geochemical or biogeochemical processes within the system. Dr. Church proposes that a suite of trace metals such as the metalloids selenium and arsenic (highly mobilized upon contact with sea water) should be thoroughly examined to determine sources, fluxes, sinks, and to determine effects of these metals on target key organisms. For instance, there are many important biological factors for trace metals: shellfish have the potential for contamination by metals which may have been overlooked, and contamination of shellfish beds would lead to detrimental effects on humans.

Management Application: Would provide fundamental information on levels of toxic materials and water quality in the Inland Bays, and would provide additional parameters for setting standards and determining shellfish closures.

TITLE: An Investigation of the Effects of Tributal Tins

Proposed By: Dr. C. E. Epifanio

Project Description: Dr. Epifanio's research interests would answer questions concerning the environmental effects of marinas, especially with regard to tributal tins and organic coppers. These contaminants are commonly found in anti-fouling paints. Toxicities at this time are not well known, but preliminary data shows acute toxicity at parts per trillion levels. These organ-tin and copper substances may well have extremely detrimental effects on shellfish and humans.

Management Application: Would provide quantification of several aspects of environmental impacts of marinas on shellfish, marine organisms, and ultimately, humans.

TITLE: A Numerical Study of Circulation in Delaware's Inland Bays

Proposed By: Dr. J. H. Trowbridge, Dr. N. Kobayashi, Dr. R. A. Dalrymple

Project Description: A numerical method for predicting the hydrodynamic response to tidal forcing, wind forcing, and fresh-water inflow is essential for a quantitative understanding of water quality in Delaware's Inland Bays. Drs. Trowbridge, Kobayashi, and Dalrymple propose to develop the necessary model based on existing techniques, calibrate and test the model against available field measurements and run the model to determine the circulation under a variety of forcing conditions. The model will be extended to include transport of a positive contaminant, and it may be used in studies of chemical and biological processes which are carried out by other College of Marine Studies personnel.

Management Application: Would provide modeel for water quality and circulation management decisions; prediction of dispersal and distribution of pollutants and nutrients.

TITLE: Field Verification of Circulation Model

Proposed By: Dr. K. C. Wong

Project Description: It is important to understand the physical forces controlling circulation patterns in the Inland Bays. Although some observations and measurements are available, additional data on water level fluctuations and wind effects are needed to calibrate and verify water circulation models as the project proposed by Drs. Trowbridge, Kobayashi, and Dalrymple. Dr. Wong proposes to conduct a long-term (fifteen months, including two winter seasons) field effort to acquire necessary field data for model input.

Management Application: Combined with the water circulation model proposed by Drs. Trowbridge, Kobayashi, and Dalrymple, the data collected for field verification will strengthen the application of the model with respect to prediction of dispersal and distribution of nutrients and pollutants in the Inland Bays system.

TITLE: Groundwater Contamination by Non-point Source Pollution from Agriculture

Proposed By: Dr. W. F. Ritter

Project Description: The focus on point source pollution should be redirected toward investigation of non-point source pollution, particularly with regard to the role of agriculture on groundwater contamination. Dr. Ritter proposes to examine the impact of agricultural chemicals on groundwater; the effect of reduction of nitrogen input on the Inland Bays; the effects of best management practices in agriculture on reduction of nutrient fluxes; the role of dissolved nutrients; and the natural identification process. The goal of the proposed study is quantification of non-point source pollution.

Management Application: Establishment of water quality standards; evaluation of best management practices; quantification of how best agricultural management practices are reducing nutrient fluxes.

TITLE: Application of Remote Sensing to Inland Bays Drainage Basin Studies

Proposed By: Dr. V. Klemas

Project Description: The Landstat Thematic Mapper has the spatial resolution and spectral bands for investigating the relationship between land use changes and run-off into the Inland Bays. The Thematic Mapper covers the entire Inland Bays system in a single scene and passes over them every sixteen days. The time coverage is sufficient to monitor coastal vegetation and land use changes. Sediment concentration and organic content of the water column can also be mapped. However, to catch changes over a tidal cycle, a few aircraft overflights may also be required. Turbidity patterns in the water will indicate general flow conditions in the Inland Bays and adjacent waters. Those properties of the water column which cannot be detected remotely will be obtained by synphonized small boat cruises. The synoptic nature of the remotely sensed data will help extrapolate point measurements (from boats) to the entire Inland Bays complex. The final objective of this study is to relate the water quality of the Inland Bays to land use and development in the surrounding drainage basin.

Management Application: Will provide a synoptic view of entire drainage basin, and would correlate land use changes with water quality. Will provide a low cost mechanism to monitor changes in baseline conditions.

TITLE: An Investigation of the Effects of Low Oxygen Levels on the Activities and Distribution of the Fishes in the Inland Bays

Proposed By: Dr. K. S. Price, Jr.

Project Description: Dr. Price's proposed study involves an examination of the effects of low oxygen on the activities and distribution of the fishes in the Inland Bays. Bigg's (1983) study showed diurnal oxygen levels below the oxygen levels established by EPA for water quality criteria. This may adversely affect the life, health, and distribution of fish in the small bays, especially at night in the summer. Dr. Price's study would investigate how low oxygen encroachment influences the distribution of important recreational fish such as flounder, and important recreational shellfish such as the hard clam.

Management Application: Would provide integration of water quality and circulation with fisheries management, and would contribute to information necessary for an economic assessment of the fisheries in the Inland Bays.

TITLE: Fish Distribution, Abundance, Growth, and Productivity Patterns as Indicators of Water and Habitat Quality in the Inland Bays

Proposed By: Dr. T. E. Targett

Project Description: Dr. Targett's project would investigate fish distribution, abundance, growth, and productivity patterns as indicators of water and habitat quality in different areas within the Inland Bays. He would utilize biochemical and anatomical techniques to examine long-term growth patterns and short-term growth rates, and would integrate growth and production to use as an indicator of habitat health. This project would span water quality needs with fisheries needs. A study of fish biomass, growth, and production would: 1) update the understanding of utilization of the bays by fish as nursery and adult habitat; and 2) provide functional information on growth patterns and productivity as indicators of fisheries habitat and water quality.

Management Application: Would provide integration of water quality and circulation with fisheries management and would assess role of Inland Bays as nursery areas.

TITLE: The Effect of Benthos on Nutrients and Sediments in the Inland Bays

Proposed By: Dr. D. C. Miller

Project Description: The benthic populations of the Inland Bays would be investigated in an attempt to tie biological processes together with chemical data, especially data on nutrients, or accumulation and deposition of trace metals in the system. Basic natural history information collected on benthos can integrate feeding, growth, and recruitment in the bays with water quality data.

Management Application: Would provide information on the impacts and effects of water quality on benthos in the Inland Bays, and would provide a general evaluation of living resources in the bays.

TITLE: Genetic Structure of Calanoid Copepod Populations in Nearshore Waters

Proposed By: Dr. A. C. Bucklin

Project Description: Dr. Bucklin's research interest is in the dynamics of calanoid copepod populations used as a rapid response indicator. Nearshore copepod populations are excellent indicator species for water quality and circulation patterns.

Management Application: Would provide additional information on general water quality and circulation in the Inland Bays.

Integration of Research Projects and Management Concerns

The integration of scientific research initiatives and management concerns and research initiatives outlined in the September 1985 workshop is a prerequisite for establishment of an overall management plan and associated research agenda for the Inland Bays. Management options and goals must be defined and outlined before research projects can be focused on management needs. Preliminary management objectives for the Inland Bays have been outlined by the Governor's Task Force on the Inland Bays. Although management issues have been identified through the public process of the Task Force, these issues have not yet been prioritized. State managers may currently use these Task Force goals as guidelines, but State management of the Inland Bays is presently more driven by many day-to-day issues that must be dealt with. These issues were identified at the Inland Bays Research Master Plan Workshop, and were outlined in a previous section of this report. These issues can be used as a basis for establishment of a preliminary research agenda.

Although a critical first step towards design of the Inland Bays research program appears to be a clear prioritization of resource management objectives, the State is unable to outline concrete criteria and goals for Inland Bays management at this time. Instead, the State has identified numerous working issues and problems around which general environmental management of the bays presently revolves. Information, research projects, and recommendations should be directed towards solving these issues

and immediate needs. Research initiatives should be directly applicable to management objectives, should provide recommendations for specific use of research data and information, and should include ideas on how research can be used to answer specific questions. Once research projects are integrated with these management issues, prioritization of resource management goals can be achieved. Continued coordination between State managers and research scientists will ensure that research proposals are relevant to management needs, and that an integration of the two can be tied together into a comprehensive management plan for Delaware's Inland Bays.

A preliminary integration of research projects and management needs based on discussions at the Research Master Plan Workshop is presented in Table 4. The individual projects were consolidated into six major groups centered around a unifying theme. The research projects could be conducted concurrently rather than sequentially, thereby providing a broad spectrum of information in a relatively short time period. This would enable managers to utilize the results of the studies in a timely manner. This will be possible only if grant cycles and funding bases are coordinated among various State and federal agencies. Specific management applications of each research project are also identified in Table 4. This summary is limited to the research initiatives presented at the September 1985 workshop. The following section of this report outlines recommendations for a general approach to an integrated research plan for the Inland Bays.

	PROPOSED RESEARCH PROJECT	INVESTIGATOR	MANAGEMENT APPLICATION
1.	Quantitative basin-wide assessment of historic data: Analysis of spatial and temporal adequacy of existing data base; identification of important data; compilation of data base on computer.	Critical evaluation of data quality by committee of potential users of existing data.	Immediate access to existing data base; ability to answer management questions in short time frame.
2. (a)	Nutrient dynamics in the waters of the Inland Bays: Critical examination of spatial and seasonal nutrient distribution and dynamics and productivity in the Inland Bays.	Dr. J. Sharp	Determination of assimilative ("carrying") capacity of the bays; setting standards for pollutant inputs; basic information on parameters of system necessary for every management strategy.
(b)	Trace Metal pollution, history and fluxes in the Inland Bays: Examination of a suite of trace metals and metalloids to determine sources, fluxes, sinks, and environmental effects.	Dr. T. Church, J. Scudlark	Information on levels of toxic material and water quality; additional parameters for setting standards and determining shellfish closures.
(c)	Investigation of the environmental effects of tributal tins and organic copper: Examination of the effects of these substances which are commonly found in anti-fouling paints, to determine the environmental effects of marinas on shellfish.	Dr. C. Epifanio	Quantification of several aspects of environmental impacts of marinas on shellfish and other marine life and ultimately, on human health.
3. (a)	Numerical study of circulation in Delaware's Inland Bays: Development of a model for predicting hydrodynamic response to wind-forcing, tidal forcing, and fresh-water input.	Dr. J. Trowbridge Dr. N. Kobayashi Dr. R. Dalrymple	Predictive model for water quality and circulation management decisions; prediction of dispersal and distribution of pollutants and nutrients; computation of gross exchange rates.

TABLE 4. Summary of Scientific Research Initiatives presented

	PROPOSED RESEARCH PROJECT	INVESTIGATOR	MANAGEMENT APPLICATION
	(b) Field verification of circulation model: Data collection program for calibration and verification of numerical circulation model.	Dr. K. C. Wong	Provides field data for model; allows realistic prediction of water circulation for management decisions.
4.	(a) Groundwater contamination by non-point source pollution from agriculture: Examination of impact of agricultural chemicals on groundwater; effects of nitrogen reduction on the Inland Bays; role dissolved nutrients; nutrient fluxes; natural nitrification process.	Dr. W. Ritter	Establishment of water quality standards; evaluation of best agricultural practices; quantification of non-point source of pollution to Inland Bays.
	(b) Geohydrologic investigations: 1. Detailed hydrogeologic mapping program 2. Geochemistry of groundwater of the unconfined aquifer, Eastern Sussex County. 3. Streamflow measurements on ten streams in the Inland Bays area. 4. Groundwater levels and water quality (particularly salinity).	Delaware Geological Survey (presently underway)	Ground and surface water quality in the Inland Bays; extent of salt-water intrusion in the area's aquifers.
5.	Application of Remote Sensing to Inland Bays drainage basin studies: Investigation of the relationship between land use changes and water quality; mapping of sediment concentration and organic content in the water column; analysis of turbidity patterns and general flow conditions in the Inland Bays.	Dr. V. Klemas	Provides a synoptic view of the entire Inland Bays drainage basin; will permit correlation of land use with changes in water quality; will provide a low cost mechanism to monitor changes in base baseline conditions.

TABLE 4. (Cont'd)
Summary of Scientific Research Initiatives presented at the September 1985 Workshop.

	PROPOSED RESEARCH PROJECT	INVESTIGATOR	MANAGEMENT APPLICATION
6.	(a) Investigation of the effects of low oxygen levels on the activities and distribution of the fishes in the Inland Bays: Analysis of low oxygen encroachment on important recreational finfish and shellfish, especially juveniles.	Dr. K. Price	Integration of water quality and circulation with fisheries management; assesment of role of Inland Bays as nursery areas; determination of economic impact of recreational fisheries.
	(b) Fish distribution, abundance, growth, and productivity patterns as indicators of water and habitat quality in the Inland Bays: Biochemical/anatomical techniques to determine productivity of fishes (juveniles and adults).	Dr. T. Targett	Integration of water quality and circulation with fisheries management; assessment of role of Inland Bays as nursery areas.
	(c) The effect of benthos on nutrients and sediments in the Inland Bays: Examination of the relationship between biological processes (e.g. filtration) and chemical data (nutrients, trace metals).	Dr. D. Miller	Evaluation of impacts and effects of water on benthos; evaluation of living resources in the Inland Bays.
	(d) Genetic structure of calanoid copepod populations in nearshore waters: Analysis of dynamics of copepod populations as indicators of water quality and circulation patterns.	Dr. A. Bucklin	General water quality and circulation in the Inland Bays.

TABLE 4. (Cont'd)

Summary of Scientific Research Initiatives presented at the September 1985 Workshop.

INSTITUTIONAL RESEARCH CAPABILITIES

The preceding section on scientific research initiatives represents some preliminary ideas from University of Delaware research scientists. The State had requested research ideas from University scientists to initiate discussion at the September 1985 workshop.

The State also requested inclusion of research institutions including the University of Delaware that might provide similar research capabilities. Discussions with research coordinators in adjoining states have resulted in compilation of the following representative list of research institutions with scientists experienced in water quality, biological, and chemical studies in similar estuarine systems:

University of Delaware

Chesapeake Bay Institute, Johns Hopkins University

Virginia Institute of Marine Science

Anne Arundel Community College

Chesapeake Biological Laboratory,
University of Maryland

Horn Point Environmental Laboratories

Old Dominion University

Academy of Natural Sciences, Philadelphia, PA

Smithsonian Institution

Baltimore Gas & Electric Company

Potomac Electric Power Company

Chesapeake Bay Center for Estuarine
Studies at Edgewater, Maryland

Martin-Marietta Corporation's Environmental Center, Catonsville, Maryland

Drexel University

Rutgers University

Stockton State College

Rider College

The Wetlands Institute of Lehigh University

New Jersey Marine Sciences Consortium

S.U.N.Y. Stony Brook

Research institutions with expertise in the fields of engineering, modeling and circulation studies include among others:

University of Delaware

John Hopkins University

University of Maryland

Lehigh University

Drexel University

S.U.N.Y. Stony Brook

INTERAGENCY COORDINATION

Delaware's Inland Bays are of concern to a number of State and federal agencies. In order to coordinate research efforts, avoid duplication, and maximize available funds, interagency cooperation is strongly recommended. Previous studies have utilized the expertise of agency personnel and/or funding to address areas of mutual concern, and this approach should be continued. The opportunities for cooperation between DNREC and specific agencies are described in the following sections.

National Ocean Service (NOS)

The cooperative hydrographic and circulation surveys for Delaware's Inland Bays proposed by NOS (February, 1985) represents an ideal opportunity for interagency coordination. NOS will provide equipment and technical expertise, and will rely on DNREC personnel and assistance from the University of Delaware to complete the study, with a cost-sharing proposal to provide necessary funding levels. Since NOS has already submitted a summary outline for the proposed work, this specific study will be addressed in detail. The work required for this study may readily be incorporated into the Inland Bays Research Master Plan.

It is possible that much of the work required for the proposed NOS study of the Inland Bays could be coordinated with past, present, and future research in Indian River, Rehoboth and Little Assawoman Bays. In the letter of 2/11/85, NOS indicated that it would work with the State of Delaware in development of cooperative hydrographic and circulation surveys of Delaware's Inland Bays. The end product of the cooperative and

comprehensive effort between State and federal agencies would be a contemporary bathymetric survey and circulation study of the Inland Bays that could be utilized to support management decisions. However, although a hydrographic study of the Bays would provide useful information to the boating public, the depth data would soon become obsolete due to the dynamic nature of sediment transport and deposition within the basin. It is felt that the circulation study would provide more useful information to guide management strategies.

Based on the information reviewed for this paper, there is information available to initiate the development of a plan for the circulation and hydrographic study of Indian River Bay. However, there are only limited data available for the Rehoboth Bay area, and information is essentially lacking with regard to circulation and hydrography in Little Assawoman Bay. Most of the existing work on circulation in the Inland Bays has been conducted in the vicinity of Indian River Inlet. Most of this specific research has been accomplished by the Civil Engineering Department, University of Delaware, under the direction of Dr. Robert A. Dalrymple. Flow-thru circulation between Indian River Bay, Rehoboth Bay and the Little Assawoman Canal has also been done by Dalrymple and others. Other circulation work in the Indian River and Rehoboth Bay area has been conducted by Karpas (1978) and Karpas and Jensen (1977). Although previous work does not represent a comprehensive circulation study of the Inland Bays, the data can be used as "springboards" for future work in that the existing data provide generalized baseline information. Before a statement of work is written for the circulation survey of the

Inland Bays, it is recommended that a synthesis of the research conducted by Dalrymple and others be thoroughly evaluated.

The outline of work provided by NOS includes tasks such as determination of tide gage requirements, and installation and maintenance of tide gages. Again, the Department of Civil Engineering, University of Delaware, has extensive experience in circulation studies of this specific geographic area, and has the equipment and personnel to provide assistance with the tide gage work. Although other potential research institutions were listed in a previous section of this report, the primary contacts for a circulation study in Inland Bays would be Dr. R. A. Dalrymple, Dr. J. H. Trowbridge, Dr. N. Kobayashi and Dr. K. C. Wong.

With regard to the horizontal and vertical elevation control tasks described in the NOS proposal, extensive work has been conducted in this area by the Delaware Geological Survey (DGS) (contact William S. Schenck). Vertical benchmarks in the state have been inventoried and computerized. Vertical benchmark data can be identified by quadrangle map, and a mapped location and written description of the benchmark can be printed. Horizontal control for all of Delaware is complete in the DGS files, but is not as easily accessible by computer.

The hydrographic and circulation work proposed by NOS maybe readily incorporated into the Inland Bays Research Master Plan depending on priorities of State management goals. Some of the work that has been accomplished in the Inland Bays can be applied to the specified NOS tasks. If the NOS project is determined to be a top priority for the State of Delaware, then a basin-wide historical data analysis and development of a circulation model

for the Inland Bays system would be projects that would address NOS outlined requirements. As will be discussed in a later section of this report, both the historic data analysis and circulation model appear to be critical elements to support both specific and general management requirements for the Inland Bays.

Delaware Geological Survey/U.S. Geological Survey (DGS/USGS)

Hydrology studies conducted by the Delaware Geological Survey and U.S. Geological Survey include monitoring programs of surface and groundwater systems in the Inland Bays drainage area, and these are directly relevant to the water quality of the bays. Previous studies by these groups included investigations of stream flow; nitrate contamination of groundwater; water resource data; water quality in well water; salt water intrusion; surface drainage; and subsurface aquifers. Ongoing studies by the DGS and USGS are providing additional detailed data on streamflow, pollutant loading, (including fertilizers pesticides) groundwater geochemistry and salt water intrusion. These projects are listed and described in a previous section. These agencies should be regarded as funding sources for future studies concerning Inland Bays water resources, as well as a source of trained personnel to conduct and/or oversee hydrology investigations.

Delaware Sea Grant College Program

The Delaware Sea Grant College Program is a University-wide program of marine-related research, advisory, and educational services funded by the Office of Sea Grant. The focus of Sea Grant sponsored research is on marine resource use and management. Various studies of Delaware's Inland Bays have received Sea Grant

funding; these include an investigation of the sedimentation record of the Inland Bays, and the influence of alternative on-site wastewater treatment systems on groundwater quality. Additionally, Sea Grant-funded studies of larger estuarine systems such as Delaware Bay can provide information applicable to the Inland Bays. Studies of trace metal pollution, toxic trace element distribution and speciation; microbiology and the nutrient organic cycle; and the effects of sea-level rise on coastal erosion and landform changes can provide understanding of the dynamics of the Inland Bays. It is important to note that the funding cycle for Sea Grant research projects is structured so that proposals must be submitted in May, 1986 to be eligible for funding for the 1987-89 cycle.

RECOMMENDED APPROACH FOR DEVELOPMENT OF AN INLAND BAYS RESEARCH MASTER PLAN

Coordination Between Research and Management

At the present time, the State is in the process of developing an Environmental Management Plan for the Inland Bays. Until this Management Plan is complete, recommendations will focus on relating scientific data towards perceived management needs.

The approach presented in this report is based on the findings, recommendations, and experiences of the EPA Chesapeake Bay Program. The purpose of this report is to define a framework and strategy for the Inland Bays Research Master Plan, to identify the important elements of the plan, and to suggest how research might be integrated into a long-term operational monitoring effort.

There are a number of essential components identified in the Chesapeake Bay Program that are also relevant to development of a Research Master Plan for Delaware's Inland Bays:

- It must have a basin-wide perspective: Monitoring data collected over the years have provided data on water quality and resources in some parts of the bays and their tributaries. However, this information has not been integrated to develop a basin-wide assessment of the changes that have taken place.
- It must utilize historic data and build on present monitoring programs: Based on the literature review conducted for this project, it is evident that results of the scientific work done on the Inland Bays are filed and rarely reused. This can be remedied by creating a data bank for work done on the Inland Bays. All research results should be inte-

grated into data management plans where field measurements will be recorded, quality checked, entered into a computer, and organized into a unified data base. Thus, data will be available for subsequent retrieval and use.

- o It must be problem-oriented: It is necessary to develop a monitoring program to solve perceived problems in the Inland Bays system. For example, descriptive data should allow managers to describe changes occurring over time and to make general trend assessments. Analytical data would allow managers to determine meaningful correlations among these parameters. Interpretive data would permit managers to define cause-and-effect relationships among several variables, to predict changes, and to determine the effects of these changes on the Inland Bays.
- o It must be based on an effective management strategy and plan for the Inland Bays that is developed by State managers: Management goals must be established for the Inland Bays. For example, what is the level of biological productivity and/or water quality that is to be maintained? Is it realistic or even possible to return the Inland Bays to a pristine conditions or the condition 10, 20, or 30 years ago? Goals should be further refined into specific objectives so that the progress made in evaluating the condition and trends of the Inland Bays can be properly assessed and interpreted.
- o It must assume coordination of efforts among State agencies and emphasize communication and cooperation between managers and researchers: In order to ensure that responsible

management decisions are made for the Inland Bays, managers and researchers must work together towards a common goal. Figure 1 illustrates how research and management are interrelated. The first step is definition of management goals for the Inland Bays. The next requirement is a coordinated effort to collect baseline data which will eventually give scientists and managers the capability to detect changes in the environment. If it is subsequently determined that a problem exists, a cooperative effort between management needs and further research is needed to solve the problem. The manager can then utilize the newly acquired scientific information and apply it to new regulations or a new management scheme. In addition, continuation of the specific study will determine whether or not the resulting management action has produced the desired effect that the managers were hoping to achieve. It is recommended that a scientific review committee be established to work with planners in problem identification, preparation of requests for proposals (RFP's), and proposal review. This mechanism would ensure that management needs are served by the proposed projects, and that the scientific merit of the proposed studies is properly assessed.

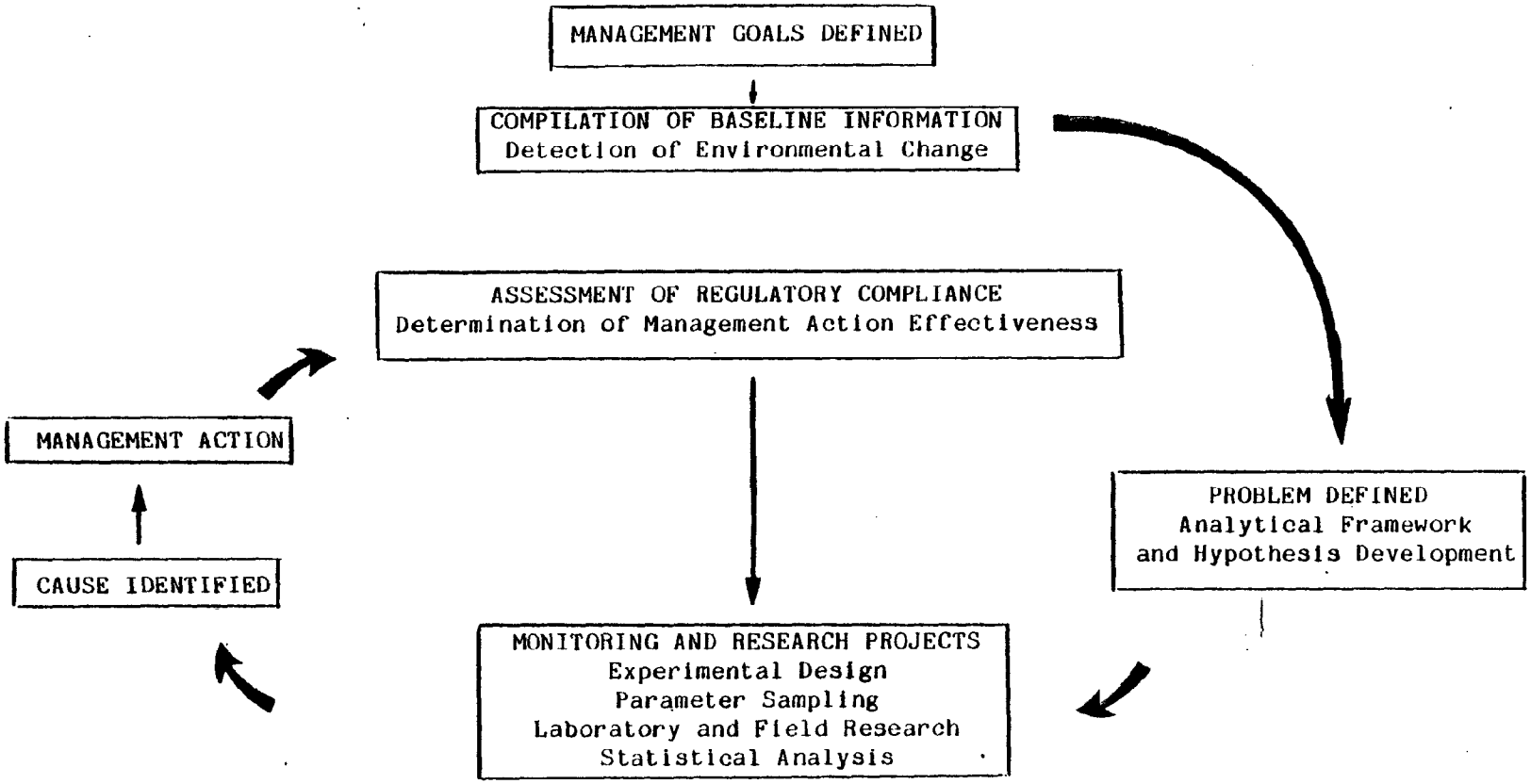

Figure 1. Flow chart depicting integration of management and research (modified from EPA Chesapeake Bay Program)

Prioritization of Research Projects

The following research topics are recommended as priority projects for Inland Bays resource management. They are also considered to be directly applicable to the proposed NOS study of the Inland Bays.

1) Historical Data Analysis

It is recommended that a first step in development of an integrated research plan for the Inland Bays would be a critical evaluation and assessment of existing data. Existing data sets may be sufficient for a first order evaluation of water quality trends in the Inland Bays. The historic data should be evaluated with regard to spatial and temporal adequacy and should be organized, filed, and stored in a computerized "data bank". A basin wide assessment of data availability would enable managers to utilize existing data in an effort to update both water quality and circulation models for the Inland Bays. In other resource management projects, such as the EPA Chesapeake Bay Program, it was discovered that most management decisions were made based on the historic data rather than new research initiatives.

Existing numerical models for the Inland Bays should also be reviewed and evaluated. Several models have already been developed for the Bays (e.g. Jensen, Ritter), but are apparently not being utilized by managers. Could recent (1976-1986) data be used to further fine tune and calibrate the Jensen model? If the Jensen model is not presently used as a management tool for the Inland Bays, the model should be examined and recommendation should be made for its improvement.

2) Circulation Study: Numerical Modeling and Field Verification

A qualitative and quantitative understanding of circulation dynamics in Delaware's Inland Bays is a necessary first step towards effective management of the Bays. The study would provide a predictive model for water quality and circulation management decisions and would allow prediction of dispersal and distribution of pollutants and nutrients. This study could be conducted in conjunction with the proposed NOS project for the Inland Bays.

3) Chemical, Nutrient, and Primary Productivity Study

There is a need for a better understanding of assimilative capacity and nutrient impacts in the bays and a need for a better delineation of the effects of nutrient levels on productivity. This type of basic information does not presently exist. Research in this area would provide answers to questions such as: Is nutrient enrichment a human-induced problem? Can it be remedied through effective management?

It is recommended that these three topics be given priority with regard to currently available CZM/CMP funding.

Summary and Recommendations

It has been widely acknowledged and accepted that the environmental condition of Delaware's Inland Bays should be examined. Recently, the Inland Bays have received much attention through the Department of Natural Resources and Environmental Control (DNREC), the Inland Bays Task Force, and the Inland Bays Monitoring Committee. Many recommendations have been made via the Task Force and the Monitoring Committee, but no comprehensive Environmental Management Plan has yet been formulated for the Inland Bays. Until management goals are established, data and research projects cannot be designed to serve management needs.

The following points are suggested as preliminary steps toward development of a comprehensive Research Master Plan for Delaware's Inland Bays:

1. Establishment of a Management Plan for Delaware's Inland Bays: Refine goals; develop, discuss, and evaluate alternatives; and incorporate into finalized management objectives and strategies.
2. Incorporation of scientific research to support the management plan: Emphasis on evaluation of historic data and filling in data gaps; assessment of existing data and models to determine their usability.
3. Development of environmental profile for existing condition of the Inland Bays, and recognition of the problem(s).
4. Establishment of a scientific review board to develop

RFP's and to evaluate the scientific merit of research proposals.

5. Prioritization of research projects to fit immediate management needs. Preliminary needs perceived in this study could be served by the following studies:

    a. Historical Data Analysis

    b. Circulation Study

    c. Chemical, Nutrient, and Primary Productivity Study

Research topics should be updated continuously, dependent on current management priorities.

APPENDIX

BIBLIOGRAPHIC LISTING

and

ANNOTATED BIBLIOGRAPHY

BIBLIOGRAPHIC LISTING

Biggs, R. B., 1984. Ambient Dissolved Oxygen Concentrations in Delaware's Inland Bays, Final Report to Department of Natural Resources and Environmental Control, Dover, Delaware, 22 p.

Bishop, J. W., 1966. The Abundance of Acartia tonsa with Respect to Temperature, Salinity, and Phytoplankton in Indian River, University of Delaware Research Foundation Mimeo., 20 p.

Boggess, D. H., and J. K. Adams, 1964. Water-table, Surface Drainage, and Engineering Soils Map of the Bethany Beach Area, Delaware, U.S.G.S. Hydrol. Inv. Atlas, HA 122.

Boggess, D. H., J. K. Adams, and C. F. Davis, 1964. Water-table, Surface Drainage, and Engineering Soils Map of the Rehoboth Beach Area, Delaware, U.S.G.S. Hydrol. Inv. Atlas, HA 109.

Bottom, D. L., 1975. A Continuous Flow Through Apparatus for the Measurement of Primary Production in Algal Macrophytes, M. S. Thesis, College of Marine Studies, University of Delaware, 130 p.

Brenum, G., 1976. A Comparative Study of Benthic Communities of Dredged Lagoons, Tidal Creeks, and Areas of Open Bay in Little Assawoman, Indian River, and Rehoboth Bays, Delaware, M.S. Thesis, College of Marine Studies, University of Delaware.

Brookins, K., 1984. Seasonal, Diel, and Tidal Abundance of Brachyuran Larvae in Indian River Inlet, Delaware, 1983, M. S. Thesis, College of Marine Studies, University of Delaware.

Brooks, A. A., 1972. The Influence of a Thermal Effluent on the Phytoplankton Ecology of the Indian River Estuary, Delaware, M. S. Thesis, Johns Hopkins University, 122 p.

Brooks, A. S., 1974. Phytoplankton Entrainment Studies at the Indian River Estuary, Delaware, in: L. D. Jensen, editor, Proceedings of the 2nd workshop on Entrainment and Intake Screening at Johns Hopkins University, Baltimore, MD, 1974, p. 105-111.

Buelow, R. W., D. A. Hunt, P. S. Kelly, and P. M. Klazer, 1966. Indian River Bay Shellfish Growing Study - A Cooperative Study of Pollution Sources, Hydrography and Water Quality in the Western Section of Indian River Bay, Delaware: Conducted 13 September to 26 September 1965, University of Delaware, 40 p.

Bureau of Environmental Health, State of Delaware Division of Public Health, Salinity Data for Indian River and Rehoboth Bays, Office of Division of Public Health, Dover, Delaware.

Buzas, M. A., 1970. Spatial Homogeneity: Statistical Analyses of Unispecies and Multispecies Populations of Foraminifera, Ecology, Vol. 51, No. 5, pg. 874-879.

Campbell, T. G., 1975. The Fishes and Hydrographic Parameters of White Creek, Delaware: A Description and Comparison of 1973-74 to 1957-58, M. S. Thesis, College of Marine Studies, University of Delaware.

Carey, W. L., 1979. Surficial Morphology and Subsurface Stratigraphy of the Flood Tidal Deltas on the Atlantic Coast of Delaware, M. S. Thesis, College of Marine Studies, University of Delaware, 187 p.

Cole, R. W., and L. E. Spence, 1977. Hard Clam Survey of Rehoboth and Indian River Bays: Annual Report to the National Marine Fisheries Service, Contract No. 04-4043-466.

Collins, D. J., 1983. Morphology, Hydrodynamics, and Subsurface Stratigraphy of an Ebb-tidal Delta: Indian River Inlet, Delaware, M. S. Thesis, Geology Department, University of Delaware, Newark, Delaware, 222 p.

Curtis, L. 1969. A Three Year Survey of the Pesticide Content of Shellfish in Delaware's Tidal Waters, Estuarine Monitoring Program, U. S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, 52 p.

Daiber, F. C., 1969. A Summary of Biological Studies on Indian River and Rehoboth Bays with Management Recommendations, State Planning Office, Dover, Delaware, 27 p.

Daiber, F. C., D. Aurand, W. Bailey, and G. Brenum, 1974. Ecological Effects Upon Estuaries Resulting from Lagoon Construction, Dredging, Filling, and Bulkheading, Report to Division of Fish and Wildlife, DNREC; State of Delaware, Project F-25-R, 80 p. + Appendices.

Daiber, F. C., D. Aurand, W. Bailey, R. Feldheim, and K. Thies, 1972. Environmental Impact of Dredge and Fill Operations in Tidal Wetlands Upon Fisheries Biology in Delaware, Report to Division of Fish and Wildlife, DNREC, Delaware, Project F-13-R-15, College of Marine Studies, University of Delaware, Newark, Delaware.

Daiber, F. C., L. L. Thornton, J. M. Tyrawski, T. G. Campbell, and D. R. Jones, 1975. A Summary of the Biological and Hydrographic Data for the Lewes-Rehoboth Bay Area, Report to Delaware State Planning Office, Dover, Delaware, 85 p.

Daiber, F. C., L. L. Thornton, K. Bolster, T. G. Campbell, O. Crichton, G. L. Esposito, D. R. Jones, and J. M. Tyrawski, 1976. An Atlas of Delaware's Wetlands and Estuarine Resources, Compiled for the Delaware State Planning Office, Dover, Delaware, by the College of Marine Studies, Newark, Delaware, Tech. Rept. #2, Delaware Coastal Management Program.

Dalrymple, R. A., D. W. Mann, and N. Kobayashi, 1983. Tidal Flows in Indian River Inlet, June 11, 1983, Research Report No. CE-83-39, Ocean Engineering Group, Dept. of Civil Engineering, University of Delaware, Newark, Delaware.

Davies, R. M., and L. D. Jensen, 1974. Entrainment of Zooplankton at Three Mid-Atlantic Power Plants, in: L. D. Jensen, editor, Proceedings of the 2nd workshop on Entrainment and Intake Screening at Johns Hopkins University, Baltimore, Maryland, 1974., p. 131-155.

Delaware Coastal Management Program, 1977. Delaware Coastal Storm Damage Report, 1923-1974, Technical Report No. 4, Delaware Coastal Management Program, Dover, Delaware, 442 p.

Delaware Department of Natural Resources and Environmental Control, 1980. Delaware 1980 Water Quality Inventory Technical Appendix, Report to Congress through the U. S. Environmental Protection Agency, prepared for the Governor by the Department of Natural Resources and Environmental Control, 386 p.

Delaware Division of Public Health, 1982. Files on Community Drinking Water Wells.

Dennis, W. A., and R. A. Dalrymple, 1978. A Coastal Engineering Analysis of Roosevelt Inlet, Lewes, Delaware, Ocean Engineering Tech. Rept. No. 18/DEL-SG-4-78, Delaware Sea Grant College Program, College of Marine Studies, University of Delaware, Newark, DE, 195 p.

Dennis, W. A., G. A. Lanan, and R. A. Dalrymple, 1978. Case Studies of Delaware's Tidal Inlets: Roosevelt and Indian River Inlets, in: Proc. of the 16th Coastal Eng. Conf., v. 2, pg. 1282-1301.

Denver, J. M., 1983. Configuration of the Base and Thickness of the Unconfined Aquifer in Southeastern Sussex County, Delaware, Delaware Geological Survey Open File Report No. 20, Newark, Delaware, 12 p.

Derickson, W. K., 1970. The Shore Zone Fishes of Rehoboth and Indian River Bays of Delaware, M. S. Thesis, University of Delaware, Newark, DE, 92 p.

Derickson, W. K., and K. S. Price, Jr., 1973. The Fishes of the Shore Zone of Rehoboth and Indian River Bays, Delaware, Transactions of the American Fisheries Society, Vol. 102, No. 3, July 1973, pp. 552-562.

DeSylva, D. P., F. A. Kalber, Jr., and C. N. Shuster, Jr., 1962. Fishes and Ecological Conditions in the Shore Zone of the Delaware River Estuary, With Notes on Other Species Collected in Deeper Water, University of Delaware Marine Laboratory Information Series, Pub. No. 5, 164 p.

Division of Fish and Wildlife, 1979. Shellfisheries Management Plan for Indian River, Indian River Bay, and Rehoboth Bay, DNREC, Dover, DE.

Ecological Analysts, Inc., 1974. Information Relative to Ecological Studies at the Indian River Power Plant and Indian River Estuary, prepared for Delmarva Power and Light Company, Wilmington, DE.

Ecological Analysts, Inc., 1974. Sampling Protocol, Review of Literature, Station Descriptions, and Associated Information Relative to Ecological Studies at the Indian River Power Plant and the Indian River Estuary, prepared for the Delmarva Power and Light Company, Wilmington, DE.

Edinger, J. G., and S. J. Borenstein, 1973. Physical Analysis of the Indian River Estuary, prepared for Edison Electric Institute Cooling Water Research Project (RP-49), 34 p.

Forrest, W. E., and P. N. Walker, 1970. A Proposed Streamflow Program for Maryland and Delaware, U.S. Geological Survey Open File Report, 41 p.

Godfrey, D. B., 1953. The Maritime History of Indian River Bay, Baccalaureate Thesis, University of Delaware, Newark, Delaware, 55 p.

Grant, G. C., 1962. Predation of Bluefish on Young Atlantic Menhaden in Indian River, Delaware, Ches. Sci., V. 3, No. 1, p. 45-47.

Hardisky, M. A., and V. Klemas, 1983. Tidal Wetlands Natural and Human-made Changes from 1973 to 1979 in Delaware: Mapping Techniques and Results, Environmental Management,V. 7, No. 4, p. 339-344.

Hardisky, M. A., V. Klemas, and F. C. Daiber, 1983. Remote Sensing Salt Marsh Biomass and Stress Detection, Adv. Space Res., V. 2, No. 8, p. 219-229.

Hopkins, T. L., 1958. On the Breeding and Occurrence of Opossum Shrimp (Order Mysidacea) in Indian River Inlet, Delaware, M. S. Thesis, University of Delaware, Newark, Delaware, 36 p.

Hopkins, T. L., 1965. Mysid Shrimp Abundance in Surface Waters of Indian River Inlet, Delaware, Ches. Sci., Vol. 6, No. 2, p. 86-91.

Horn, J. G., 1957. The History of the Commercial Fishing Industry in Delaware, M. S. Thesis, College of Marine Studies, University of Delaware, Newark, Delaware.

Howell, R. P., 1931. The Problem of Keeping Indian River Inlet Open, U. S. Engineering Office, Wilmington, Delaware.

Humphries, E. M., 1970. Seasonal Settling of the Hydrozoa and the Ectoprocta in Rehoboth Bay, Delaware, M. S. Thesis, University of Delaware, 218 p.

Humphries, E. M., and F. C. Daiber, 1968. Shellfish Survey of Indian River Bay and Rehoboth Bay, Delaware, Technical Report, Northeast Marine Health Sciences Laboratory, Narragansett, RI.

Indian River Inlet Commission, 1931. Report of the Indian River Inlet Commission to the 103rd Assembly of the State of Delaware, U. S. Engineers Office, Wilmington, Delaware, 36 p.

Jensen, L. D., 1974. Environmental Responses to Thermal Discharges from the Indian River Station, Indian River, Delaware, prepared for Electric Power Research Institute, Cooling Water Discharge Research Project and Delmarva Power & Light Company, EPRI Pub. #74-049-00-3, 205 p.

Jensen, L. D., R. M. Davies, R. A. Smith, and A. S. Brooks, 1974. Entrainment of Planktonic Organisms into Cooling Water Systems of Three Mid-Atlantic Thermal Power Plants, in: L. D. Jensen, editor, Proceedings of the 2nd workshop on Entrainment and Intake Screening at Johns Hopkins University, Baltimore, Maryland, 1974, pg. 95-104.

Jensen, P. A., 1977. Task Report 2355. Analysis of Water Quality Data and Land-use Water Quality Relationships, prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by the University of Delaware, Newark, Delaware, CMS-C-3-77.

Jensen, P. A., 1980. Final Report: Water Quality Analysis of the Lewes-Rehoboth Canal, Delaware, submitted to Delaware DNREC by Espey, Huston, and Associates, Inc., Austin, TX.

Jensen, P. A., 1981. Draft Report: Analysis of Coliform Bacteria Problems in Indian River Bay, Delaware, submitted to Delaware DNREC by Espey, Huston, and Associates, Inc., Austin, TX.

Jensen, P. A., and M. J. Eshleman, 1976. Review of Existing Point Source Waste Loadings, Final Report on Task 2352, prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by University of Delaware, Newark, DE, CMS-C-5-76.

Jensen, P. A., and J. M. Tyrawski, 1976. Water Quality Model for Coastal Sussex County, Report on Task 2359, prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by College of Marine Studies, University of Delaware, Newark, DE.

Jensen, P. A., and J. M. Tyrawski, 1977. Report on Task 2359C; Water Quality Modeling and Analysis, prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by Sea Grant Marine Advisory Program, College of Marine Studies, University of Delaware, Newark, DE, CMS-C-6-77.

Jensen, P. A., and J. M. Tyrawski, 1978. Wetlands and Water Quality, Coastal Zone 1978 Proceedings, Vol. 2, p. 1145-1164, March 14-16, 1978, San Fransisco, ASCE, NY.

Jensen, P. A., and T. Weeks, 1977. Task Report #2324, Analysis and Estimation of Discharges from Water Front Septic Tanks, Tidal Marshes, and Recreational Boating, prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by the University of Delaware, Newark, DE.

Jensen, P. A., L. M. Hauck, and C. Wethe, 1981. Executive Summary Analysis of Coliform Bacteria Problems in Indian River Bay, Delaware, submitted to Delaware DNREC, 11 p.

Jensen, P. A., K. S. Price, Jr., L. V. DiMichele, P. C. Garfield, W. W. Martin, L. L. Thornton, and H. W. Otto, 1976. Delaware's Small Bay Resources/A Review of Information Relevant to Management of the Resources of Rehoboth, Indian River, and Little Assawoman Bays, DEL-SG-15-76, College of Marine Studies, University of Delaware, Newark, DE, 93 p.

Jensen, P. A., W. F. Ritter, and J. M. Tyrawski, 1977. Report on Task 2359 (Supplementary) Coliform Bacteria Loading and Dynamics, prepared for Coastal Sussex Water Quality Program and Delaware Coastal Managment Program by College of Marine Studies, University of Delaware, Newark, DE, CMS-C-5-77.

Johnson, T. D., 1981. Differences Between Zooplankton Communities of Three Adjacent Delaware Coastal Water Bodies, M. S. Thesis, University of Delaware, Newark, DE, 100 p.

Johnston, R. H., 1976. Relation of Groundwater to Surface Water in Four Small Basins of the Delaware Coastal Plain, Delaware Geological Survey, Report of Inv. No. 24, 56 p.

Kaplovsky, A. J., and D. B. Aulenbach, 1956. A Comprehensive Study of Pollution and Its Effect on the Waters Within the Indian River Drainage Basin, A Report to the Water Pollution Commission of the State of Delaware, 207 p.

Karpas, R. M., 1978. The Hydrography of Indian River and Rehoboth -- Delaware's Small Bays, M. S. Thesis, University of Delaware, Newark, DE, 179 p.

Karpas, R. M., and P. A. Jensen, 1977. Hydrodynamics of Coastal Sussex County, Report on Task 2331, prepared for Coastal Sussex Water Quality Program by University of Delaware, College of Marine Studies, Sea Grant Advisory Services, and the College of Agricultural Sciences, Department of Agricultural Engineering.

Keulegan, R. G., 1967. Tidal Flow in Entrances: Water-level Fluctuations of Basins in Communication with the Seas, Tech. Bull. No. 14, Committee on Tidal Hydraulics, U.S.A.C.E., 102 p.

Kraft, J. C., and G. Margules, 1969. Correlation of Foraminifera Distribution with Sediment Facies Patterns and Physical Data in Indian River Bay, Coastal Delaware, G.S.A. Spec. Papers No. 121, p. 361.

Kraft, J. C., and G. Margules, 1971. Sediment Patterns, Physical Characters of the Water Mass and Foraminiferida Distribution in Indian River Bay, Coastal Delaware, Southeastern Geology, Vol. 12, No. 4, p. 223-252.

Lanan, G. A., and R. A. Dalrymple, 1977. A Coastal Engineering Study of Indian River Inlet, Delaware, Ocean Engineering Technical Report 14, DEL-SG-5-77, University of Delaware, Newark, DE, 227 p.

Lauffer, J. R., 1982. A Hydrochemical Study of a Shallow Groundwater System Perpheral to Rehoboth Bay, Ph.D. Dissertation, Geology Department, University of Delaware, Newark, DE, 171 p.

Logan, D. T., 1972. The Biological Effects of a Heated Effluent and A Model for Community Structural Change, M. S. Thesis, University of Delaware, Newark, DE, 89 p.

Logan, D. T., and D. Maurer, 1975. Diversity of Marine Invertebrates in a Thermal Effluent, DEL-SG-9-75, College of Marine Studies, University of Delaware, Newark, DE.

Maurer, D., 1977. Estuarine Benthic Invertebrates of Indian River and Rehoboth Bays, Delaware, Int. Revue ges. Hydrobiol. 62, 5, 591-629.

Maurer, D., L. Watling, and G. Aprill, 1974. The Distribution and Ecology of Common Marine and Estuarine Pelecypods in the Delaware Bay Area, The Nautilus, V. 88, No. 2, p. 38-45.

MCA Engineering Corporation, 1974. Water Quality Models for Rivers in Delaware, prepared for the State of Delaware, DNREC, Dover, DE.

Miller, J. C., 1971. Groundwater Geology of the Delaware Atlantic Seashore, Delaware Geological Survey Report of Inv. No. 17, Newark, DE, 33 p.

Miller, J. C., 1972. Nitrate Contamination of the Water-table Aquifer in Delaware, Delaware Geological Survey Report of Inv. No. 20, Newark, DE, 36 p.

National Oceanic and Atmospheric Administration, Monthly Climatological Data: Maryland and Delaware, ISSN 0145-0549, National Climatological Center, Asheville, North Carolina.

Nemerow, N. L., 1969. Baffled Biological Basins for Treating Poultry Plant Wastes, Journal of Water Poll. Cont. Fed., V. 41, pg. 1602-1612.

Orris, P. K., 1972. A Floristic and Ecological Survey of the Benthic Macro-Algae of Rehoboth Bay, Delaware, M. S. Thesis, University of Delaware, Newark, DE,98 p.

Orris, P. K., and J. E. Taylor, 1973. A Floristic and Ecological Survey: The Benthic Macro-Algae of Rehoboth Bay, Delaware, Botanica Marina, Vol. 16, p. 180-192.

Pacheco, A. L., and G. C. Grant, 1965. Studies of the Early Life History of Atlantic Menhaden in Estuarine Nurseries; Part I - Seasonal Occurrence of Juvenile Menhaden and Other Small Fishes in a Tributary Creek of Indian River, Delaware, 1957-1958, U.S. Fish and Wildlife Service, Special Scientific Report - Fisheries No. 504, 32 p.

Perlin, M., C. Y. H. Chen, R. A. Dalrymple, R. G. Dean, and J. C. Kraft, 1983. Sediment Budget and Sand Bypassing System Parameters for Delaware's Atlantic Coast, prepared for Delaware DNREC, Dover, DE, 200 p.

Polis, D., 1975-76b. Assessing Effects of Development on Rehoboth, Indian River, and Little Assawoman Bays, Delaware Sea Grant College Program, R/T 12.

Power Magazine, 1984. Disposing of Powerplant Flyash Can Be Effected in an Environmentally Safe Manner, Power, V. 128, No. 2, Pg. 45-48.

Price, K. S. Jr., and K. Derickson, 1969. A Fish Survey and Ecological Study of Rehoboth and Indian River Bays, University of Delaware Research Foundation Annual Report.

Radle, E. W., 1971. A Partial Life History of the Winter Flounder (Pseudopleuronectes americanus) Exposed to Thermal Addition in an Estuary, Indian River Bay, Delaware, M. S. Thesis, University of Delaware, Newark, DE, 74 p.

Ritter, W. F., 1977. Modeling Nonpoint Source Pollution in Coastal Sussex County, Final Report, Task 2351, Coastal Sussex County Water Quality Management Program, 65 p.

Ritter, W. F., and A. E. M. Chirnside, 1982. Groundwater Quality in Selected Areas of Kent and Sussex County, Delaware, Report to Delaware DNREC, Dover, DE, 229 p.

Ritter, W. F., and P. A. Jensen, 1979. Water Quality Modeling in the Delaware Coastal Plain Region, in Best Management Practices for Agriculture and Siliviculture: Proc. of the 1978 Cornell Agricultural Waste Management Conf., p. 507-540.

Ritter, W. F., and G. Scheffler, 1977. Monitoring Nonpoint Source Pollution in Coastal Sussex County, Final Report for Task 2332, Coastal Sussex Water Quality Management Program, 104 p.

Robertson, F. W., 1977. The Quality and Potential Problems of Groundwater in Coastal Sussex County, Delaware, Water Resources Center, University of Delaware, Newark, DE.

Scotton, L. W., 1970. Occurrence and Distribution of Larval Fishes in the Rehoboth and Indian River Bays of Delaware, M. S. Thesis, University of Delaware, Newark, DE, 66 p.

Shore Protection Board, Office of Chief Engineer, 1936. Report on the Probable Effect on the Beaches for Ten Miles Either Side of the Proposed Improvement at Indian River Inlet, Delaware, U. S. Army Corps of Engineers; Shore Protection Board.

Slaughter, T. H., 1962. Beach-Area Water Supplies Between Ocean City, Maryland, and Rehoboth Beach, Delaware, U.S.G.S. Water Supply Paper, No. 1619-T, p. T1-T10.

Smith, R. A., A. S. Brooks, and L. D. Jensen, 1974. Effects of Condenser Entrainment on Algal Photosynthesis at Mid-Atlantic Power Plants, in: L. D. Jensen, editor, Entrainment and Intake Screening Proceedings of the 2nd Entrainment and Intake Screening Workshop held at Johns Hopkins University, Baltimore, Maryland, 1974, p. 113-122.

State of Delaware Agencies, 1969. Environmental Study of the Rehoboth, Indian River, and Assawoman Bays, prepared for State of Delaware by the State Game and Fish Commission, State Park Commission, State Planning Office, Marine Labs, University of Delaware, Water and Air Resources Commission, Delaware Geological Survey, 35 p.

Stegner, S. R., 1972. Analog Model Study of Groundwater Flow in the Rehoboth Bay Area, Delaware, Technical Report No. 12, College of Marine Studies, University of Delaware, Newark, DE, 70 p.

Stumpf, R. P., 1983. The Process of Sedimentation on the Surface of a Salt Marsh, Estuarine, Coastal, and Shelf Sci., V. 17, p. 495-508.

Sundstrom, R. W., and T. E. Pickett, 1969. The Availability of Ground Water in Eastern Sussex County, Delaware, University of Delaware Water Resources Center, Newark, DE.

Sundstrom, R. W., T. E. Pickett, and R. D. Varrin, 1976. Hydrology, Geology, and Mineral Resources of the Coastal Zone of Delaware, Technical Report No. 3, Delaware Coastal Zone Management Program, Delaware State Planning Office, Dover, DE, 245 p.

Swisher, M. L., 1982. The Rates and Causes of Shore Erosion Around a Transgressive Coastal Lagoon, Rehoboth Bay, Delaware, M. S. Thesis, College of Marine Studies, University of Delaware, Newark, DE, 210 p.

Talley, J. H., 1977. The Storm of October 13-15, 1977, Unpublished Report, Delaware Geological Survey, University of Delaware, Newark, DE.

Talley, J. H., 1984. Summary Report and Data Compilation of the Storm of March 28-29, 1984, in Delaware, Unpublished Report, Delaware Geological Survey, University of Delaware, Newark, DE, 19 p.

Thompson, W. W., and R. A. Dalrymple, 1976. A History of Indian River Inlet, Delaware, Shore and Beach, Vol. 44, No. 2, July 1976, p. 24-31.

Thornton, L. L., 1975. Laboratory Experiments on the Oxygen Consumption and Resistence to Low Oxygen Levels of Certain Estuarine Fishes, M. S. Thesis, University of Delaware, Newark, DE, 82 p.

Tinsman, J. C., 1973. The Effects of Thermal Effluent on the American Oyster, Crassostrea virginica. in Indian River Bay, Delaware, M. S. Thesis, University of Delaware, Newark, DE, 127 p.

Toomey, D. W., and G. L. Esposito, 1977. Task Rept. 2322: Natural Environmental Baseline Inventory - "Critical Natural Areas" of the Coastal Sussex Water Quality Program, State of Delaware, DNREC, 71 p.

U. S. Army Corps of Engineers, 1974. Indian River Inlet, Project Maintenance, Sussex County, Delaware, Army Engineering District, Philadelphia, PA, #ELR-74-0164, 51 p.

U. S. Army Corps of Engineers, Philadelphia District, 1921-1969. Map File Index - On Indian River Bay, Delaware.

U. S. Army Corps of Engineers, Philadelphia District, 1938. Technical Studies of Inlets; Absecon Inlet and Indian River Inlet, U.S. Army Corps of Engineers, Philadelphia District.

U. S. Congress, 1892. Preliminary Examination of Indian River, Delaware, Senate Executive Document No. 176, 47th Congress, 1st Session.

U.S. Congress, 1912. Preliminary Examination of Indian River Inlet, Delaware, House Document No. 1055, 62nd Congress, 3rd Session.

U. S. Congress, 1937. Report on Indian River Inlet and Bay, Delaware, Committee on Rivers and Harbors, Document No. 41, 75th Congress, 1st Session.

U. S. Department of Agriculture Soil Conservation Service in Cooperation with Delaware Agriculture Experimental Station, 1974. Soil Survey of Sussex County, Delaware.

U. S. Department of the Interior, 1974-1983. Water Resources Data for Maryland and Delaware: Part 1. Surface Water Records, U. S. Department of Interior, Geological Survey, 138 p.

Vargas, J. A., 1979. Predation and Community Structure of Soft-bottom Benthos in Rehoboth Bay, Delaware, M. S. Thesis, College of Marine Studies, Lewes, DE, 108 p.

Warlen, S. M., 1964. Some Aspects of the Life History of Cyprinodon variegatus Lacepede 1803, in Southern Delaware, M. S. Thesis, University of Delaware, Newark, DE, 40 p.

Watling, L., 1976. Analysis of Structural Variations in a Shallow Estuarine Deposit-Feeding Community, Marine Studies Library, CMS-2-76.

Watling, L., and D. Maurer, 1972. Shallow Water Hydroids of the Delaware Bay Region, J. Nat. Hist., 1972, Vol. 6, p. 643-649, or DEL-SG-6-73.

Watling, L., J. Lindsay, R. Smith, and D. Maurer, 1974. The Distribution of Isopoda in the Delaware Bay Region, Int. Revue ges Hydrobiol., 59 (3), p. 343-351.

Webber, C. M., 1984. Survey of Quality of Domestic Well Water Supplies in South Coastal Delaware, Water Supply Branch, DNREC Report.

Wethe, C. A., and K. DeSombre, 1980. A Mini-Study of Balders Pond Near Indian River Inlet, Delaware, Technical Report MSL-80-01, College of Marine Studies, University of Delaware, Lewes, Delaware.

Winget, R. R., 1970. Some Population Dynamics of Blue Crab and Hard Clams in Indian River and Rehoboth Bays and the American Lobster in Delaware Bay, Delaware, Annual Progress Rept., Department of Natural Resources and Environmental Control, Dover, DE, 90 p.

Woodruff, K. D., 1969. The Occurrence of Saline Groundwater in Delaware Aquifers, Delaware Geological Survey Report of Inv. No. 13, Newark, Delaware, 45 p.

Woodruff, K. D., 1970. General Ground-water Quality in Freshwater Aquifers of Delaware, Delaware Geological Survey Report of Inv. No. 15, Newark, Delaware, 22 p.

Zaneveld, J. S., 1972. The Benthic Marine Algae of Delaware, U.S.A., Ches. Sci., V. 13, No. 2, p. 120-138.

ANNOTATED BIBLIOGRAPHY

ANNOTATED BIBLIOGRAPHY

This annotated bibliography represents the initiation of the development of a comprehensive, basin-wide data base for Delaware's Inland Bays. The annotations made here-in are intended to provide a preliminary indication of available data on water quality and circulation in the Inland Bays. Descriptions of data and analyses are brief and simple. The quality or "usability" of the data should be determined by scientists using the information for a specific purpose or project. Some of the references were not available for review at the time the annotated bibliography was prepared, but are listed to inform the reader about these existing reports.

Again, the authors wish to thank Alice Hall, Librarian, and Dorothy Allen, Library Assistant, for their help in locating many of the obscure references. Most of the hard-to-locate references have now been filed in the Cannon Library, College of Marine Studies, University of Delaware, Lewes, Delaware. The authors also wish to thank Julie Tigue and Tammy Bunting for their persistence in typing the annotations and manuscript.

For future reference purposes, many reference locations are cited as either Cannon Library or Morris Library. These refer to:

Cannon Library
College of Marine Studies
University of Delaware
Lewes, Delaware 19958

and

Morris Library
University of Delaware
Newark, Delaware 19716

AUTHOR:	Biggs, R. B.
DATE:	1984
TITLE:	Ambient Dissolved Oxygen Concentrations in Delaware's Inland Bays
BIBLIOGRAPHICAL INFORMATION:	Final Report to Department of Natural Resources and Environmental Control, Dover, Delaware, 22p.
ABSTRACT:	Ambient dissolved oxygen concentrations were measured at dawn during August, 1983 in Rehoboth and Indian River Bays. Dissolved oxygen values were below the state's minimum water quality standard of 5 mg/L 59% of the time in Indian River Bay; 17% in Rehoboth Bay. Absolute values of apparent net daytime photosynthesis and nighttime respiration are very high. Indian River Bay is more stressed than Rehoboth Bay; annual nutrient load to Indian River Bay is twice that to Rehoboth Bay.
GEOGRAPHIC AREA:	Indian River Bay, Rehoboth Bay, Lewes-Rehoboth Canal
PERIOD OF STUDY:	August, 1983
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Dissolved oxygen; salinity; temperature; total nitrogen; total phosphorus; chlorophyll a; conductivity. Dissolved oxygen monitored at dawn at 19 stations; hourly over a 24 hour period at 5 stations. Dissolved oxygen measured 1 m above bottom, micro-Winkler technique.
QUALITATIVE ASSESSMENT:	Presentation of data on non-point sources and loading to Indian River and Rehoboth Bays; dissolved oxygen data presented as concentration and percent saturation; water column respiration estimated; gas transfer coefficient computed; calculations of apparent net daytime photosynthesis and night respiration presented. All stations in Rehoboth-Indian River Bays; no studies conducted in Little Assawoman Bay.
REPORT OR REFERENCE LOCATION:	Department of Natural Resources and Environmental Control, Dover, Delaware
DESCRIPTORS:	DISSOLVED OXYGEN; WATER QUALITY; EUTROPHICATION; NUTRIENT ENRICHMENT

AUTHOR: Bishop, J. W.

DATE: 1966

TITLE: The Abundance of Acartia tonsa with Respect to Temperature, Salinity, and Phytoplankton in Indian River

BIBLIOGRAPHICAL INFORMATION: University of Delaware Research Foundation Mimeo., 20p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Boggess, D.H., and J.K. Adams
DATE:	1964
TITLE:	Water-table, Surface Drainage, and Engineering Soils Map of the Bethany Beach Area, Delaware
BIBLIOGRAPHICAL INFORMATION:	USGS Hydrol. Inv. Atlas, HA 122
ABSTRACT:	1:24,000 scale map showing surficial soil units, with additional information on their engineering properties, origin, size characteristics; soil sampling sites; well observations; water-table contours; bay bathymetry and land topography
GEOGRAPHIC AREA:	Bethany Beach and vicinity, including Indian River Bay and Little Assawoman Bay (Lat. 38° 27' to 38° 37' 30" N; Long. 75° 00' to 75° 07' 30" W)
PERIOD OF STUDY:	Various data sets, 1950-1962
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Soil characteristics (size, liquid limit, plasticity index, maximum density, minimum moisture, engineering properties, origin), water depths in Indian River and Little Assawoman Bays and their tributaries. Depth to water in 13 water-table wells (1950-1962); hydrographic data, topographic contours (USGS 1954 Base Map).
QUALITATIVE ASSESSMENT:	Some information may be out of date (i.e. water depths in bays). Most data collected in 1950's and early 1960's - some may still be valid and useful for groundwater resources in Inland Bays system, Indian Bay and Little Assawoman Bays.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark
DESCRIPTORS:	SOILS MAP, WATER TABLE DEPTHS, ENGINEERING CHARACTERISTICS OF SOILS

AUTHOR:	Boggess, D.H., J.K. Adams, and C.F. Davis
DATE:	1964
TITLE:	Water-table, Surface Drainage, and Engineering Soils Map of the Rehoboth Beach Area, Delaware
BIBLIOGRAPHICAL INFORMATION:	USGS Hydrol. Inv. Atlas, HA 109
ABSTRACT:	1:24,000 scale map showing surficial soil units, with additional data on their engineering properties, origin, size characteristics, soil sampling sites, well observations, water-table contours, bay bathymetry and land topography.
GEOGRAPHIC AREA:	Rehoboth Beach and vicinity, including Rehoboth Bay. (Lat. 39° 37' 30" to 38°45 00' N; Long 75° 03' to 75° 15' W)
PERIOD OF STUDY:	Historical data utilized: 1950-1962
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Soil characteristics (size, liquid limit, plasticity index, maximum density, minimum moisture, engineering properties, origin); water depths in Rehoboth Bay and tributaries; depth to water in 13 wells (1950-1962); topographic contours (1954 USGS Base Map)
QUALITATIVE ASSESSMENT:	Some information (i.e. water depths in bay) out of date. Most information valid and useful with regard to groundwater resources in the Inland Bays system, Rehoboth Bay area.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark, Delaware
DESCRIPTORS:	SOILS MAPS, WATER-TABLE DEPTHS, ENGINEERING CHARACTERISTICS OF SOIL

AUTHOR: Bottom, D. L.

DATE: 1975

TITLE: A Continuous Flow Through Apparatus for the Measurement of Primary Production in Algal Macrophytes

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, College of Marine Studies, University of Delaware, 130p.

ABSTRACT: A continuous flow-through apparatus for the in situ determination of primary production in macrophytic algae was developed. The flow-through technique yields a better estimate of daily production than is possible from short-term incubations of a closed system averaged for the full day. Potential problems often cited in the use of static "bell jar" techniques, such as supersaturation, build up of metabolites, nutrient depletion, and lack of water flow may be avoided by the present flow-through method. Production monitored by changes in dissolved oxygen. Field studies were conducted to determine the reliability and capabilities of the final design.

GEOGRAPHIC AREA: Rehoboth Bay

PERIOD OF STUDY: Summer, 1974

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Attempts were made to continuously measure changes in dissolved oxygen. Environmental parameters measured: salinity (refractometer), water temperature (thermometer), relative stage of tide, light conditions (photometer), CO_2 samples (method of Sharp). Dissolved oxygen measured with YSI Model 54 oxygen meter and probe. Also, 300 ml. samples taken at half hour increments. Samples fixed and analyzed in lab with oxide modification of Winkler method.

QUALITATIVE ASSESSMENT: Six field experiments conducted for periods of three to twelve hours. Graphs of dissolved oxygen levels and production rates. Correlates relative tide, salinity, dissolved oxygen, production, temperature, and subsurface light levels.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #53

DESCRIPTORS: DISSOLVED OXYGEN, PRODUCTIVITY

AUTHOR: Brenum, G.

DATE: 1976

TITLE: A Comparative Study of Benthic Communities of Dredged Lagoons, Tidal Creeks, and Areas of Open Bay in Little Assawoman, Indian River, and Rehoboth Bays, Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, College of Marine Studies, University of Delaware

ABSTRACT: Benthic communities of dredged lagoons, tidal creeks, and areas of open bay in Inland Bays were studied to evaluate biotic and environmental conditions of the dredged areas. Conditions of altered creeks were compared to "natural" areas. Dredged lagoon stations had significantly lower annual densities, number of species, and species eveness than tidal creek and open bay stations.

GEOGRAPHIC AREA: Indian River, Rehoboth, and Little Assawoman Bays

PERIOD OF STUDY: 1973-1975

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Environmental parameters: salinity, temperature, dissolved oxygen, particle size and volatile content of sediments. Benthic samples.

Benthic - Peterson grab with six replicates each station

Salinity - Salinometer, Dissolved oxygen, Winkler method

Sediments - dry sieving and pipette analysis

QUALITATIVE ASSESSMENT: 35 stations in 8 study areas in the bays. Statistical analyses conducted to determine eveness of distribution of number individual samples. Appendices - Lists of species, densities for all stations and sampling periods. Compared total number individuals and number of species per station vs. salinity, temperature, and dissolved oxygen. Discussions of faunal composition and species dominance.

All chemical data collected in this study available in Daiber, 1974. Discussion of ecological effects upon estuaries resulting from lagoon construction, etc. Graphs and discussion comparing salinity, temperature, dissolved oxygen data for each bay area. General discussion comparing environmental parameters of the 3-bay area.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #62

DESCRIPTORS: DREDGED LAGOONS, BENTHIC COMMUNITIES, WATER QUALITY

AUTHOR:	Brookins, K.
DATE:	1984
TITLE:	Seasonal, Diel, and Tidal Abundance of Brachyuran Larvae in Indian River Inlet, Delaware, 1983
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, College of Marine Studies, University of Delaware
ABSTRACT:	Larvae of seven brachyuran crab taxa were sampled and identified from Indian River Inlet, Delaware. Seasonal peaks in abundance were noted at specific diel-tidal patterns (day-ebb, etc.).
GEOGRAPHIC AREA:	Indian River Inlet, Delaware
PERIOD OF STUDY:	June, July, August 1983 70 hours sampling 6-9 September 1983
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Plankton, temperature (thermometer), salinity-(refractometer) June-August Physical parameters: salinity, temperature, surface current velocities, 6-9 September Samples taken with metered plankton net; Submersible salinometers; timed drifter releases. Statistical analyses - Mann-Whitney U-test; Kruskal-Wallis test
QUALITATIVE ASSESSMENT:	Surface samples conducted weekly June, July, and August on ebb tides. Surface and bottom samples every 2 hours for 70 hours: 6-9 September (6 tidal cycles). Table of temperature and salinity of surface waters during ebb tide June 30 - August 25, 1983. June-August ranges 28-32‰ salinity, 20-25°C temperature. September maximum velocity 1 m/s (problems with current measurements). Temperature 22-29°C, salinity 29-31‰. Clear separation of day-ebb phases from other phases.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #242
DESCRIPTORS:	INDIAN RIVER INLET, TIDES

AUTHOR: Brooks, A. S.

DATE: 1972

TITLE: The Influence of a Thermal Effluent on the Phytoplankton Ecology of the Indian River Estuary, Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, Johns Hopkins University, 1972, 122 p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Brooks, A. S.

DATE: 1974

TITLE: Phytoplankton entrainment studies at the Indian River Estuary, Delaware

BIBLIOGRAPHICAL INFORMATION: In: L. D. Jensen, editor, Proceedings of the 2nd workshop on Entrainment and Intake Screening at Johns Hopkins University, Baltimore, MD, 1974. p. 105-111.

ABSTRACT: Phytoplankton entrainment studies on the Indian River Estuary attempt to evaluate problems associated with entrainment and effects on the ecology of the surrounding water body. These effects include: 1) complete mortality of phytoplankton and resultant high organic load in the system and associated removal of primary producers from the community. Entrainment may also affect species composition of an area and metabolic activity of primary producers (and general productivity of the estuary). Effects of power plant entrainment on phytoplankton were found to be seasonal.

GEOGRAPHIC AREA: Indian River Estuary, Delaware

PERIOD OF STUDY: January 1970 - October 1971

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Used rate of ^{14}C uptake by phytoplankton as indicator of viability and productivity of phytoplankton community before and after entrainment. Also temperature and pressure change effect on phytoplankton.

Strickland and Parsons (1968) methods for ^{14}C uptake procedures. Chlorophyll a determinations SCOR-UNESCO method (1966).

QUALITATIVE ASSESSMENT: Graphs detailing seasonal records of intake temperature and chlorophyll a concentrations; and graph of seasonal record of intake temperature and ^{14}C uptake. Report does discuss effects of temperature elevations produced by power plant on estuary as whole.

REPORT OR REFERENCE LOCATION: Cannon Library, TS 164.J45

DESCRIPTORS: PHYTOPLANKTON, WATER QUALITY, POWER PLANT

AUTHOR: Buelow, R. W., D. A. Hunt, P. S. Kelly, and P. M. Klazer

DATE: 1966

TITLE: Indian River Bay Shellfish Growing Study - A Cooperative Study of Pollution Sources, Hydrography and Water Quality in the Western Section of Indian River Bay, Delaware: Conducted 13 September to 26 September 1965

BIBLIOGRAPHICAL INFORMATION: University of Delaware, 40 p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Bureau of Environmental Health, State of Delaware Division of Public Health

DATE: Continuous

TITLE: Salinity Data for Indian River and Rehoboth Bays

BIBLIOGRAPHICAL INFORMATION: These data are on file in the Offices of Division of Public Health, Dover, Delaware 19903

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Buzas, M. A.
DATE:	1970
TITLE:	Spatial Homogeneity: Statistical Analyses of Unispecies and Multispecies Populations of Foraminifera
BIBLIOGRAPHICAL INFORMATION:	Ecology, Vol. 51, No. 5, pg. 874-879
ABSTRACT:	Conducted statistical analyses of unispecies and multispecies populations of foraminifera. Determined that the study area is inhomogeneous with respect to three of the four species studied.
GEOGRAPHIC AREA:	Rehoboth Bay, Delaware
PERIOD OF STUDY:	Only 1 sampling period at each station
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Only foraminifera sampled. 16 stations, 10 miles apart in 4 x 4 grid sampled with 5 replicates. Living individuals of 4 species of foraminifera enumerated. No methods detailed. Statistical analyses only.
QUALITATIVE ASSESSMENT:	No water quality data measured. Only useful as far as indication of foraminifera populations in Rehoboth Bay.
REPORT OR REFERENCE LOCATION:	Cannon Library, QH 540.E28
DESCRIPTORS:	FORAMINIFERA, STATISTICS

AUTHOR: Campbell, T. G.

DATE: 1975

TITLE: The Fishes and Hydrographic Parameters of White Creek, Delaware: A Description and Comparison of 1973-74 to 1957-58

BIBLIOGRAPHICAL INFORMATION: CMS Master's Thesis, College of Marine Studies, University of Delaware

ABSTRACT: A fish survey using seine net was conducted at 8 stations in White Creek from April 1973 - June 1974. Hydrographic data collected simultaneously with fish data. Current study is compared to 1957-1958 study: hydrographic data and fish data are quantitatively compared. Concluded that no change has occurred in the near-shore fish community of White Creek as a result of increased land usage or other perturbation.

GEOGRAPHIC AREA: White Creek, DE (Tributary to Indian River Bay)

PERIOD OF STUDY: April 1973 - June 1974 (Samples collected on weekly basis)

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Fish data, hydrographic data, wind and tide data, surface temperature, salinity, pH, nutrients, total phosphorus, orthophosphate, nitrate, ammonia, dissolved oxygen

Single haul seine for fish collection. Turbidity: 8" secchi disc. Standard methods utilized and detailed in methods section. Statistical analyses conducted and diversity indices calculated; predictive model for number of species based on hydrographic data.

QUALITATIVE ASSESSMENT: 8 sampling stations; 52 sampling days. (Same locations as used in 1957-58 study). Study conceived as duplication of Pacheco and Grant's study of White's Creek. All collection procedures (except sampling frequency) duplicate those used in 1957-58 study. Detailed discussion of hydrography and fish parameters, and direct comparison with earilier study (1957-58) and changes in land use and other environment parameters. Appendices detail all data collected.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #54

DESCRIPTORS: HYDROGRAPHY, FISH SURVEY

AUTHOR: Carey, W. L.

DATE: 1979

TITLE: Surficial Morphology and Subsurface Stratigraphy of the Flood Tidal Deltas on the Atlantic Coast of Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, College of Marine Studies, University of Delaware, Newark, DE, 187p.

ABSTRACT: In this study, modern depositional processes operating on the Indian River Inlet flood tidal delta were determined through an investigation of hydrography and surficial sediment patterns. Internal geometry and depositional history of the delta were determined through examination of sediment structures, sediment parameters, and stratigraphic relationships found in vibra cores. Tidal hydraulic measurements indicate that ebb tidal velocities and duration exceed those of flood flow. The time-velocity asymmetry of tidal currents in the area exerts control on the surficial morphology of the flood tidal delta.

GEOGRAPHIC AREA: Indian River Inlet, and Indian River and Rehoboth Bays

PERIOD OF STUDY: Spring, Summer, Fall 1978

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Sediment cores - 3 dimensional stratigraphy; current velocity and direction - general oceanics model 2010 film recording tilt current meter and Marsh McBirney electromagnetic current meter; sediment samples - various coring devices, settling tube and sieve methods. Historical analysis of shoals and inlet migration through air photos, charts, and maps.

QUALITATIVE ASSESSMENT: Current measurements at 2 stations: velocity and direction of tidal currents recorded every 30 minutes of a 2 week period. Other current measurements at 3 stations: hourly velocity and direction measurements made over 10-13 hour tidal cycle. Tables and charts provide current velocity and direction averages. Sediment data in table form in Appendix. General discussion of inlet hydraulics, tidal current trends, direction and dominance. Primarily

	discussion of sediment distribution and cores taken in flood tidal delta area. Includes discussion on effects of currents on delta sediments.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #123
DESCRIPTORS:	CIRCULATION, SEDIMENTS, FLOOD TIDAL DELTA

AUTHOR: Cole, R. W., and L. E. Spence

DATE: 1977

TITLE: Hard Clam Survey of Rehoboth and Indian River Bays: Annual Report to the National Marine Fisheries Service

BIBLIOGRAPHICAL INFORMATION: Contract No. 04-4043-466

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

Reference should be available from the Division of Fish and Wildlife, Department of Natural Resources and Environmental Control, Dover, Delaware 19903

DESCRIPTORS:

AUTHOR:	Collins, D. J.
DATE:	1983
TITLE:	Morphology, Hydrodynamics, and Subsurface Stratigraphy of an Ebb-tidal delta:Indian River Inlet, Delaware
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, Geology Department, University of Delaware, Newark, Delaware, 222 p.
ABSTRACT:	Indian River Inlet has formed an extensive offshore ebb-tidal delta following inlet stabilization in 1938. Growth of the delta occurs via large-scale progradational foreset delta deposits. Delta contains 4.6 x 10^6 m^3 of sand; grows at a rate of 95,000 m^3/yr.
GEOGRAPHIC AREA:	Indian River Inlet, Delaware
PERIOD OF STUDY:	1981
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Seismic reflection profiles (18); 4 sediment cores, current measurements (2 stations); bathymetry.
QUALITATIVE ASSESSMENT:	Changes in ebb-tidal delta morphology over time based on historic map data (1954-1980) calculated; bathymetric contour map constructed; volumetric changes in ebb-tidal delta (1935-1982) determined; subsurface stratigraphy and hydrodynamics described.
REPORT OR REFERENCE LOCATION:	Morris Library, QE 999 1983 C712
DESCRIPTORS:	EBB-TIDAL DELTA, MORPHOLOGY, STRATIGRAPHY, HYDRODYNAMICS

AUTHOR: Curtis, L.

DATE: 1969

TITLE: A Three Year Survey of the Pesticide Content of Shellfish in Delaware's Tidal Waters

BIBLIOGRAPHICAL INFORMATION: Estuarine Monitoring Program, U.S. Dept. of Interior, F & W Service, B. Comm. Fisheries, 52p.

ABSTRACT: It has been shown that shellfish are able to concentrate pesticides in their tissues at levels much higher than are found in the environment. As the pollution is reduced or cleaned up, pesticide residues will be flushed at regular rates from the tissues. It is possible then, to use body residue concentrations as an indication of the relative amounts of pesticides added to the environment and the approximate time of their administration. It seems fairly certain that the concentration of chlorinated hydrocarbon pesticides in shellfish tissue is decreasing.

GEOGRAPHIC AREA: Delaware Tidal Waters (3 stations in Inland Bays)

PERIOD OF STUDY: October 1966 - August 1969 (35 months)

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

Shellfish - Crassostrea virginica
Modiolus demissus
Mercenaria mercenaria
Pesticide Determinations - DDD, DDE, DDT

Pesticide determination - gas chromatography with electron capture detection

QUALITATIVE ASSESSMENT: (DATA GAPS, QUALITY CONTROL LENGTH OF RECORD, # OF DATA POINTS, FORMAT OF DATA, ETC.)

9 stations total. 2 stations Rehoboth Bay. 1 station Indian River Bay. Monthly sampling 1966-1969. Rehoboth Bay - M. mercenaria free of detectable pesticides. Thompson's Island, June 1967 - August 1969. Prior to June 1967 pesticides were present, but at low levels. Arrowhead Pt - ditto.. Indian River Bay - M. demissus. high DDT, DDD levels, build up of pesticides from winter into late summer, then

drop occurs. Pesticide concentration at each station provided in Appendix.

REPORT OR REFERENCE LOCATION: Larry Curtis, Air-Sea Interaction Lab, College of Marine Studies, Lewes

DESCRIPTORS: PESTICIDES, SHELLFISH, WATER QUALITY

AUTHOR:	Daiber, F. C.
DATE:	1969
TITLE:	A Summary of Biological Studies on Indian River and Rehoboth Bays With Management Recommendations
BIBLIOGRAPHICAL INFORMATION:	State Planning Office, Dover, Delaware, 27 p.
ABSTRACT:	Biological studies indicate that both Rehoboth and Indian River Bays have been and still are (in 1969) very productive. Plankton content is high, especially in summer. Productivity varies seasonally and spatially. Both bays have diverse algal and benthic invertebrate populations; fish abundance fluctuates. However, some tributary creeks are seriously degraded and lack fauna.
GEOGRAPHIC AREA:	Rehoboth Bay, Indian River Bay
PERIOD OF STUDY:	Varies
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Compilation of existing data on: salinity, temperature, D.O., plankton, substrate, benthic fauna (including shellfish resources) fouling organisms; macroscopic algae; fish, pesticide levels.
QUALITATIVE ASSESSMENT:	Thorough summary and assessment of existing (pre-1969) scientific data. No information presented on Little Assawoman Bay, however. Includes six recommendations for resource management.
REPORT OR REFERENCE LOCATION:	Cannon Library, TD 224. D3 D34
DESCRIPTORS:	BIOLOGICAL STUDIES, DATA SUMMARY, RESOURCE MANAGEMENT

AUTHOR:	Daiber, F. C., D. Aurand, W. Bailey, and G. Brenum
DATE:	1974
TITLE:	Ecological Effects Upon Estuaries Resulting from Lagoon Construction, Dredging, Filling, and Bulkheading
BIBLIOGRAPHICAL INFORMATION:	Report to Div. of Fish and Wildlife, DNREC; State of Delaware, Project F-25-R, 80 p. + Appendices
ABSTRACT:	Natural and artificial lagoon systems in Inland Bays examined on a seasonal basis for water chemistry, flushing, benthic invertebrates, fish, coliform bacteria, BOD. Preliminary conclusions suggest that lagoon systems do not seem to be distinctly poorer biological habitats; natural areas are already stressed.
GEOGRAPHIC AREA:	Rehoboth, Indian River and Little Assawoman Bays (18 locations, 62 stations)
PERIOD OF STUDY:	1973-1974
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Salinity (salinometer) DO (modified Winkler reaction) temperature, flushing (dye studies and numerical model), benthic invertebrates (Peterson grab samples, 220 cm^2), fish (baited traps).
QUALITATIVE ASSESSMENT:	Extensive data tabulation on water parameters and ecology; statistical analysis of data. Seasonal observations of natural/artificial areas. Includes section on management recommendations.
REPORT OR REFERENCE LOCATION:	Available from DNREC, Dover, Delaware
DESCRIPTORS:	ESTUARINE ECOLOGY, ESTUARINE WATER QUALITY, CIRCULATION, MANAGEMENT RECOMMENDATIONS

AUTHOR:	Daiber, F. C., D. Aurand, W. Bailey, R. Feldheim, and K. Thies
DATE:	1972
TITLE:	Environmental Impact of Dredge and Fill Operations in Tidal Wetlands Upon Fisheries Biology in Delaware
BIBLIOGRAPHICAL INFORMATION:	Report to Division of Fish and Wildlife, DNREC, DE, project F-13-R-15, College of Marine Studies, University of Delaware, Newark, DE
ABSTRACT:	4 artificial lagoon systems and natural embayments were examined in Little Assawoman and Indian River Bays. There are physical, chemical, and biotic differences between artificial lagoons and natural areas. Lack of good circulation is causative agent for the differences. Artificial lagoons exhibit poorer water quality due to reduced water circulation and enhanced thermal and oxygen stratification.
GEOGRAPHIC AREA:	Little Assawoman and Indian River Bays, DE. South Bethany, Dirickson's Creek, White's Creek, Pot Nets
PERIOD OF STUDY:	Summer, 1972
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Temperature, oxygen, salinity, phosphorus measurements, pH, secchi disk, nitrogen, chlorophyll, circulation, fish populations, benthic invertebrates. 17 sampling stations established; biweekly field collections for water chemistry analysis. Salinity-salinometer, oxygen-modified Winkler titration, pH-specific ion meter, chlorophyll, phosphorus, nitrogen-Strickland & Parsons, 1968 methods.
QUALITATIVE ASSESSMENT:	All chemical and physical data collected are included in appendix and summarized in Tables 1-16. Very thorough and detailed summary of data and methods description - appears to be a reproducible study. Short term, but intensive study.
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	ARTIFICAL LAGOONS, WATER QUALITY CIRCULATION

AUTHOR:	Daiber, F. C., L. L. Thornton, J. M. Tyrawski, T. G. Campbell, and D. R. Jones
DATE:	1975
TITLE:	A Summary of the Biological and Hydrographic Data for the Lewes-Rehoboth Bay Area
BIBLIOGRAPHICAL INFORMATION:	Rept. to Delaware State Planning Office, Dover, DE, 85p.
ABSTRACT:	This report describes the estuarine biota of the Lewes-Rehoboth Bay area, including studies on physical and chemical aspects of these areas. Report separated into two parts: Hydrographic Summary and Biological Summary.
GEOGRAPHIC AREA:	Lewes-Rehoboth Bay area
PERIOD OF STUDY:	Report is based on scientific evidence accumulated over a 25 year period.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Hydrographic - Flushing and circulation; salinity; temperature; dissolved oxygen, nutrients; pH, pollutants Biological - algae and phytoplankton; emergent grasses; zooplankton; ichthyoplankton; finfish; benthic invertebrates; crustaceans; fouling organisms; microbiology; waterfowl. Methods not detailed
QUALITATIVE ASSESSMENT:	Appendix I - List species of flora and fauna Appendix II - Distribution of fish and shellfish Good summary of available data - very detailed in coverage and discussion
REPORT OR REFERENCE LOCATION:	Cannon Library, TD 224.D3 D34
DESCRIPTORS:	SUMMARY OF HYDROGRAPHIC, BIOLOGIC DATA

AUTHOR:	Daiber, F. C., L. L. Thornton, K. Bolster, T. G. Campbell, O. Crichton, G. L. Esposito, D. R. Jones, and J. M. Tyrawski
DATE:	1976
TITLE:	An Atlas of Delaware's Wetlands and Estuarine Resources
BIBLIOGRAPHICAL INFORMATION:	Compiled for the Delaware State Planning Office, Dover, DE, by the College of Marine Studies, Newark, DE. Tech. Rept. #2, DE Coastal Management Program.
ABSTRACT:	This report describes the importance of wetlands, wetland vegetation, wetlands classification, and mapping in the State of Delaware, and general characteristics of wetlands areas.
GEOGRAPHIC AREA:	State of Delaware (Rehoboth, Indian River, Little Assawoman Bays)
PERIOD OF STUDY:	1974 and previous data
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Drainage areas in state, vegetative zones in Delaware. General discussion of environmental parameters and their relationships to estuarine organisms, including dissolved oxygen, temperature, turbidity, salinity, tidal flushing, and toxic materials. No methods described.
QUALITATIVE ASSESSMENT:	Paper provides thorough overview of wetlands in Delaware (as of 1974). No raw data included; just discussions of previous work. Includes discussion of wetland characteristics, of spoil disposal, dredge impacts, and ditching of wetlands. Contains discussion of relationship between wetlands and estuarine water quality. Includes listing and description of Delaware estuarine resources and their distribution throughout the State.
REPORT OR REFERENCE LOCATION:	Cannon Library, GB .459.4 D49
DESCRIPTORS:	WETLANDS

AUTHOR:	Dalrymple, R. A., D. W. Mann, and N. Kobayashi
DATE:	1983
TITLE:	Tidal Flows in Indian River Inlet, June 11, 1983
BIBLIOGRAPHICAL INFORMATION:	Research Report No. CE-83-39, Ocean Engineering Group, Dept. of Civil Engineering, University of Delaware, Newark, DE
ABSTRACT:	The determination of tidal flows into Indian River Inlet and the corresponding tidal prism were determined for June 11, 1983 based on current meter measurements taken over a tidal cycle.
GEOGRAPHIC AREA:	Indian River Inlet
PERIOD OF STUDY:	June 11, 1983 - 12.5 hour tidal cycle
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Tidal current measures over flood channel, ebb channel, and shoals Tides - tide gauge at U.S. Coast Guard Harbor. Level recorded every 15 minutes. (Corrected to NGVD). Velocity measurements - Endeco 110 ducted impellor current meters. Current readings taken every 15 minutes. Tidal currents measured at 3 locations across inlet channel.
QUALITATIVE ASSESSMENT:	Current velocities measured every 15 minutes at 4 or more different depths and at each of 3 stations. Current velocity profiles included. Raw data also included for velocity and tidal data. Current meter readings were fit to a logarithmic velocity profile through use of equation. Tidal flow calculations made.
REPORT OR REFERENCE LOCATION:	University of Delaware, Civil Engineering Dept., or State of Delaware, Division of Soil and Water Conservation
DESCRIPTORS:	INLET TIDAL CURRENTS, TIDE HEIGHTS, TIDAL PRISM

AUTHOR: Davies, R. M., and L. D. Jensen

DATE: 1974

TITLE: Entrainment of Zooplankton at Three Mid-Atlantic Power Plants

BIBLIOGRAPHICAL INFORMATION: In: L.D. Jensen, Editor, Proceedings of the 2nd workshop on Entrainment and Intake Screening at Johns Hopkins University, Baltimore, MD, 1974. p. 131-155.

ABSTRACT: Principle objective of this research was to examine the response of zooplankton to the combined entrainment effects of temperature rise, rapid pressure change, mechanical abrasion, and biocidal action at 3 mid-Atlantic power plants.

GEOGRAPHIC AREA: Indian River Estuary

PERIOD OF STUDY: 1970-1971

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Collected representative samples of zooplankton population immediately before and after passing through the plant. Also collected samples up and down river for determination of general zooplankton distribution.

Zooplankton populations sampled with high capacity submersible pump (detailed description of pumping procedure). Scant data on ambient water temperature and chlorination at sampling site.

QUALITATIVE ASSESSMENT: Tables detailing sampling conditions in relation to zooplankton populations, species list and density of zooplankton collected at Indian River Power Plant. Graphs relating ambient temperature to mobility of copepod life stages, and thermal die-away profiles of surface waters. Data on distribution of total zooplankton numbers and species and coefficient of similarity between stations in relation to water quality. Study discusses primarily area directly adjacent to power plant, but there is some general discussion on zooplankton in Indian River in general.

REPORT OR REFERENCE LOCATION: Cannon Library, TJ 164.545

DESCRIPTORS: ZOOPLANKTON, WATER QUALITY, POWER PLANT

AUTHOR:	Delaware Coastal Management Program
DATE:	1977
TITLE:	Delaware Coastal Storm Damage Report, 1923-1974
BIBLIOGRAPHICAL INFORMATION:	Technical Report No. 4, Delaware Coastal Management Program, Dover, Delaware 442 p.
ABSTRACT:	Chronicle of coastal storms in Delaware, 1923-1974, with narrative description of storm damage to various communities; community flooding studies; residents' perception of coastal storm hazards.
GEOGRAPHIC AREA:	Delaware Coast
PERIOD OF STUDY:	1923-1974
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Storm frequency, tide heights (4 stations); maximum fetch/wave forecasting, questionnaire survey of residents.
QUALITATIVE ASSESSMENT:	Report includes maps of locations and types of storm damage (structural; flooding; overwash).
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	STORM DAMAGE, COASTAL FLOODING, HAZARD AWARENESS

AUTHOR:	Delaware Department of Natural Resources and Environmental Control
DATE:	1980
TITLE:	Delaware 1980 Water Quality Inventory Technical Appendix
BIBLIOGRAPHICAL INFORMATION:	Report to Congress through the U.S. Environmental Protection Agency, prepared for the Governor by the Department of Natural Resources and Environmental Control, 386p.
ABSTRACT:	This technical appendix provides statistical data on the water quality parameters analyzed in the state 1980 Water Quality Inventory Rept. The data consist of maximum, median, and minimum values of parameters analyzed for various sampling stations.
GEOGRAPHIC AREA:	Indian River, Little Assawoman Bay
PERIOD OF STUDY:	October 1978 - September 1979
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Saturation, dissolved oxygen, BODs, color, turbidity, pH, alkalinity, acidity, hardness, chloride, total phosphorus, phenol, total SSP residue, nonvol. SSP residue, vol. ssp residue, total residue, nonvol. residue. Iron, copper, manganese, chromium, silver, calcium, zinc, lead, nickel, cadmium, FC, FS, nitrate, and nitrogen. Methods not described in this paper.
QUALITATIVE ASSESSMENT:	Data listed in tabular form reporting maximum, median, and minimum values of parameters at sampling stations. Does not indicate number of sampling days represented by data for each sampling station. Indian River - 21 stations; Little Assawoman Bay - 8 stations
REPORT OR REFERENCE LOCATION:	Delaware Department of Natural Resources and Environmental Control
DESCRIPTORS:	WATER QUALITY

AUTHOR: Delaware Division of Public Health

DATE: 1982

TITLE: Files on Community Drinking Water Wells

BIBLIOGRAPHICAL INFORMATION:

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: Data available from the Division of Public Health, Dover, Delaware 19903

DESCRIPTORS:

AUTHOR:	Dennis, W. A., and R. A. Dalrymple
DATE:	1978
TITLE:	A Coastal Engineering Analysis of Roosevelt Inlet, Lewes, Delaware
BIBLIOGRAPHICAL INFORMATION:	Ocean Engineering Tech. Rept. No. 18/DEL-SG-4-78, Delaware Sea Grant College Program, College of Marine Studies, University of Delaware, Newark, Delaware, 195 p.
ABSTRACT:	This report presents a one-dimensional model of the hydraulics of Roosevelt Inlet, encompassing all bays and waterways (including Rehoboth and Indian River Bays) from Indian River Inlet to Roosevelt Inlet. The model predicts net southerly flow through the system from Roosevelt Inlet to Indian River Inlet, and shows good agreement with field data. Southerly flow attributed to (1) shape of the discharge curve; (2) friction in the Lewes-Rehoboth Canal; and (3) mass transport associated with progressive waves.
GEOGRAPHIC AREA:	Indian River Inlet to Roosevelt Inlet/Broadkill River, including Rehoboth Bay and Indian River Bay
PERIOD OF STUDY:	1977-1978
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Field data: tides, currents, discharge Predictive model based on equations of motion and continuity (freshwater inflow and wind neglected, but may be easily added).
QUALITATIVE ASSESSMENT:	The predictive model provides output on tides, currents, discharge, location of tidal division line, and mean pumping of water through the system. However, mass is not conserved within the system (outflow exceeds input by 18%, due to computer accuracy in performing integration routine over a tidal cycle).
REPORT OR REFERENCE LOCATION:	Available from Delaware Sea Grant College Program, DEL-SG-4-78, College of Marine Studies, University of Delaware, Newark, Delaware.
DESCRIPTORS:	HYDRAULIC MODELING; WATER CIRCULATION

AUTHOR:	Dennis, W. A., G. A. Lanan, and R. A. Dalrymple
DATE:	1978
TITLE:	Case Studies of Delaware's Tidal Inlets: Roosevelt and Indian River Inlets
BIBLIOGRAPHICAL INFORMATION:	In: Proc. of the 16th Coastal Eng. Conf. v. 2, pg. 1282-1301
ABSTRACT:	Studies were undertaken to document past and present characteristics and trends of Delaware's two major tidal inlets. The results of a one-dimensional hydraulic model, as well as field measurements, predict the presence of a mean southerly flow through the canal and bay system which connects the two inlets. This flow is shown to have a substantial effect on the behavior and stability of these entrance ways, causing major assymmetries on the depositional patterns at each location.
GEOGRAPHIC AREA:	Indian River Inlet, Roosevelt Inlet
PERIOD OF STUDY:	June 1977
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Discussion of inlet stabilization and resulting problems down drift erosion, jetty corrosion, channel bank erosion, and channel enlargement. Numerical model developed - simulates tides and cross-sectionally averaged currents at any location within system. Explains development of numerical model. Tide and current measurements recorded. Includes stability curves and prism-area curves for inlets.
QUALITATIVE ASSESSMENT:	Generally the model showed good correlation with field data, but underpredicted the peak discharges and overpredicted the peak tidal amplitudes. No effort was made to calibrate model to exactly predict field measurements since the simplicity of the model would preclude such accuracy.
REPORT OR REFERENCE LOCATION:	Morris Library, TC 203.C65
DESCRIPTORS:	INLETS, TIDAL FLOW, MODEL

AUTHOR:	Denver, J. M.
DATE:	1983
TITLE:	Configuration of the Base and Thickness of the Unconfined Aquifer in Southeastern Sussex County, Delaware
BIBLIOGRAPHICAL INFORMATION:	Delaware Geological Survey Open File Report No. 20, Newark, Delaware, 12 p.
ABSTRACT:	This report presents information on the thickness and configuration of the base of the unconfined aquifer in southeastern Sussex County, which provides much of the water used in this region, and which is the first to be affected by pollution or waste disposal problems.
GEOGRAPHIC AREA:	Southeastern Sussex County, Delaware
PERIOD OF STUDY:	Not applicable.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Contour maps; geologic sections (lithology, thickness); geophysical data (gamma logs, electric logs); 6 test holes drilled to supplement available data.
QUALITATIVE ASSESSMENT:	Report presents 5 geologic sections showing the base of the aquifer, which ranges in depth from -30 ft to > - 175 ft (NGVD). Data useful for water resources planning; locating water supply wells in the unconfined aquifer.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark, Delaware
DESCRIPTORS:	WATER RESOURCES, GEOHYDROLOGY, GROUNDWATER

AUTHOR: Derickson, W. K.

DATE: 1970

TITLE: The Shore Zone Fishes of Rehoboth and Indian River Bays of Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, University of Delaware, Newark, Delaware, 92p.

ABSTRACT: Fish species and population studies conducted in Indian River and Rehoboth Bays show that many of the 38 species caught probably use the bays as nursery and feeding grounds, especially juveniles of the species. Comparison with past studies show that changes have occurred in fish populations, probably resulting from increased pollution and general environmental degradation which is having deleterious effects on the bays as nursery grounds.

GEOGRAPHIC AREA: Indian River and Rehoboth Bays, DE

PERIOD OF STUDY: 10 monthly collections between June 1968 and May 1969

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: 10 monthly collections made at 19 stations in Indian River and Rehoboth Bays. Fish population data collected along with salinities, oxygen, and temperatures. Also, seasonal abundance, spawning condition, and developmental stages recorded.

Seine net for fish collection. Biomass calculations made with length-weight relationship formula. Salinity-salinometer. Oxygen-Winkler technique.

QUALITATIVE ASSESSMENT: Statistical analyses conducted to compare numbers of fish with physical parameters at each station to obtain prediction equations. Lots of data can be pulled together from this thesis. Includes tables describing fish species numbers and abundance; relationship of total number of fish to temperature. Determined 2 salinity gradients in each bay, temperature gradients, sites ranges, etc. Good discussion on physical and biological changes and interactions in bays.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #38

DESCRIPTORS: FISH, POLLUTION, EFFECTS, BASELINE STUDY

AUTHOR: Derickson, W. K., and K. S. Price, Jr.

DATE: 1973

TITLE: The Fishes of the Shore Zone of Rehoboth and Indian River Bays, Delaware

BIBLIOGRAPHICAL INFORMATION: Transactions of the American Fisheries Society, Vol. 102, No. 3, July 1973, pp. 552-562.

ABSTRACT: This study was a survey of fish fauna and physical parameters of Rehoboth and Indian River Bays. Used information to 1) detemine roll of bays in lives of the most abundant species and 2) compare past and present conditions in area to explain any changes that have occurred. Bays serve as residences for 5 of the most abundant species, and as feeding and nursery grounds for remaining species. Physical factors control abundance and distribution.

GEOGRAPHIC AREA: Indian River and Rehoboth Bays, Delaware

PERIOD OF STUDY: June 1968 - April 1970

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Fish population sampling; substrate type; salinity; dissolved oxygen; water temperature; water depth; tidal stage; weather

Monthly collections made at 18 stations with seines. 7 physical parameters recorded at each station. Salinity determined in lab with salinometer; dissolved oxygen determined with modified Winkler technique.

QUALITATIVE ASSESSMENT: 20 collections from 18 stations in Indian River and Rehoboth Bays. Obtained total population estimates for each species by determining efficiency of method (52%), and multiplying figures to total bay shore zone area. Made monthly biomass estimates by length-weight relationship found in literature. Student t-test used to detect significant differences in data between collection years. Table 4 compares the number of fish, fish species, mean temperature, and mean salinity at each station. Table 8 is a summary of all physical characteristics at each station with indication of pollution source for each station. Can compare 1970 and 1957 studies

(Price, and Pacheco and Grant): 3 times as many fish and twice as many fish species collected in 1957 study. Reduction due, in part, to increased pollution load. Pollution has greater effect on species that use bays as nursery and feeding ground than on those 5 most abundant species which are residents.

REPORT OR REFERENCE LOCATION: Morris Library, SH1.A47

DESCRIPTORS: FISH POPULATION SURVEY, WATER QUALITY, POLLUTION SOURCES

AUTHOR:	DeSylva, D. P., F. A. Kalber, Jr., and C. N. Shuster, Jr.
DATE:	1962
TITLE:	Fishes and Ecological Conditions in the Shore Zone of the Delaware River Estuary, With Notes on Other Species Collected in Deeper Water.
BIBLIOGRAPHICAL INFORMATION:	University of Delaware Marine Laboratory Information Series, Pub. No. 5, 164 p.
ABSTRACT:	Investigation of parameters of conditions under which various fish species are found in Delaware Bay and vicinity, including ichthyoplankton at Indian River Inlet.
GEOGRAPHIC AREA:	Delaware Estuary and adjacent areas of Atlantic Coast
PERIOD OF STUDY:	August 1958 - February 1960
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	20 sites sampled in 1958; 16 sites sampled every two months. 54,000 fish collected using haul seine (1/4" mesh), identified, measured (total length in cm), stomach contents analyzed. Water temperature, salinity, oxygen saturation, water turbidity measured. Clouds, tide condition, plant associations, bottom types, animals, surf, sea depth observed.
QUALITATIVE ASSESSMENT:	Fish populations (types) presented as annotated listing. Tables listing other data. Excellent list of previous studies. Authors state that "critical analysis of the relationship of these fishes to their environment has not been made".
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	FISH POPULATIONS, ESTUARINE PRODUCTIVITY

AUTHOR:	Division of Fish and Wildlife
DATE:	1979
TITLE:	Shellfisheries Management Plan for Indian River, Indian River Bay and Rehoboth Bay
BIBLIOGRAPHICAL INFORMATION:	DNREC, Dover, Delaware
ABSTRACT:	Shellfish survey of bivalves (oysters, mussels, hard clams, soft clams) and management recommendations to insure maximum utilization and continuation of hard clam resources in Indian River and Rehoboth Bays. Clam population dominated by "older" clams set in 1960's; minimal recruitment since then. Oysters now dependent on stocks from other sources.
GEOGRAPHIC AREA:	Indian River; Indian River Bay; Rehoboth Bay
PERIOD OF STUDY:	August 1975 - August 1976
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	500 yard grid established; 338 stations. Scuba divers used hand-held venturi dredge to collect 1 m^2 sample size to depth of 12" in water depths of 1-18 feet. Numbers of hard clams, length, bottom type, depth recorded.
QUALITATIVE ASSESSMENT:	Data tabulation in following format: station #, bottom type, depth, clam density (#/m^2) brief history and present status of shellfish closures; conditional areas in bays. Description of shellfish resources since 1940's for both commercial and recreational shellfishing.
REPORT OR REFERENCE LOCATION:	Cannon Library; and Division of Fish and Wildlife, DNREC, Dover, DE.
DESCRIPTORS:	SHELLFISH SURVEY, HARD CLAMS, SHELLFISH MANAGEMENT

AUTHOR: Ecological Analysts, Inc.

DATE: 1974

TITLE: Information Relative to Ecological Studies at the Indian River Power Plant and Indian River Estuary

BIBLIOGRAPHICAL INFORMATION:

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: Report on file at the Delmarva Power and Light Company, Wilmington, Delaware

This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Ecological Analysts, Inc.

DATE: 1974

TITLE: Sampling Protocol, Review of Literature, Station Descriptions, and Associated Information Relative to Ecological Studies at the Indian River Power Plant and the Indian River Estuary

BIBLIOGRAPHICAL INFORMATION:

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: Report on file at the Delmarva Power and Light Company, Wilmington, Delaware.

This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Edinger, J. G., and S. J. Borenstein
DATE:	1973
TITLE:	Physical Analysis of the Indian River Estuary
BIBLIOGRAPHICAL INFORMATION:	Prepared for Edison Electric Institute Cooling Water Research Project (RP-49), 34 p.
ABSTRACT:	This study is an analysis of physical, hydrographic, and temperature data from the Indian River area. It is an examination of different types of salt and heat balances for application to estuarine systems. The objectives of this study are to 1) develop from the physical data a qualitative description of the major hydrographic features in the estuary, 2) develop a series of quantitative predictions of increasing complexity for comparison and evaluation, and 3) develop parameters from physical data required for biological assessment.
GEOGRAPHIC AREA:	Indian River
PERIOD OF STUDY:	June 1967 - May 1968; some over previous 4 years, 1968-1971; some intense studies over 1 year
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Cross-sectional surveys of depths, wind speed and direction, precipitation (rain gauge), evaporation (calculated), temperature (non-reversing thermometer), salinity (index of refraction) water flow (flow meter). No other details provided on methods.
QUALITATIVE ASSESSMENT:	Weekly average values provided for data collected June 1967 - May 1968. Provides time-space representations of vertically averaged and weekly averaged salinity and temperature. Also table of summary of physical parameters of each week of survey, Summer, 1967. Discussion of salinity stratification and hydraulic mechanism affecting stratification. Conducts one dimensional and two dimensional (two layer) analysis of Indian River Estuary. Discussion of effects of physical parameters on biological organisms.
EPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	HYDROGRAPHY, HYDRAULICS

AUTHOR: Forrest, W. E., and P. N. Walker

DATE: 1970

TITLE: A Proposed Streamflow Program for Maryland and Delaware

BIBLIOGRAPHICAL INFORMATION: — U.S. Geological Survey Open File Report, 41 p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Godfrey, D. B.

DATE: 1953

TITLE: The Maritime History of Indian River Bay

BIBLIOGRAPHICAL INFORMATION: Baccalaureate Thesis, University of Delaware, Newark, Delaware, 55 p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: Report is on file in the Archives of Morris Library.

This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Grant, G.C.
DATE:	1962
TITLE:	Predation of Bluefish on Young Atlantic Menhaden in Indian River, Delaware
BIBLIOGRAPHICAL INFORMATION:	Ches. Sci., V. 3, No. 1, p. 45-47
ABSTRACT:	Stomach contents of 262 bluefish examined to determine predation. Silversides ranked first in stomachs, menhaden second.
GEOGRAPHIC AREA:	Indian River, Delaware
PERIOD OF STUDY:	1956-58 (summers)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	262 bluefish collected using beach seines, plankton nets, gill nets; length measured; stomach contents analyzed.
QUALITATIVE ASSESSMENT:	Data presented as tabulation of stomach contents; lengths of menhaden ingested by bluefish of different lengths.
REPORT OR REFERENCE LOCATION:	Morris Library, QH 95.5 .A1 .C53
DESCRIPTORS:	BLUEFISH PREDATION, MENHADEN (PREY)

AUTHOR:	Hardisky, M. A., and V. Klemas
DATE:	1983
TITLE:	Tidal Wetlands Natural and Human-made Changes from 1973 to 1979 in Delaware: Mapping Techniques and Results
BIBLIOGRAPHICAL INFORMATION:	Environmental Management, V. 7, No. 4, p. 339-344
ABSTRACT:	Areal changes in Delaware's coastal wetlands monitored over 6 years by color and color-infrared photography. Human activities destroyed 8.1 ha annually; natural erosion destroyed 3.9 ha annually; 2.8 ha formed annually by natural processes. Net loss of 55.1 ha estimated for 1973-1979.
GEOGRAPHIC AREA:	Delaware
PERIOD OF STUDY:	1973-1979
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Aerial photos, color - color infrared film, altitude of 1829 m; scale 1:12,000; enlarged to B. W. 1:2400. Plants distinguished on basis of color, texture. Areas of wetlands determined using planimeter.
QUALITATIVE ASSESSMENT:	Marsh building as well as erosion occurred in Indian River Bay area. Human-made wetlands loss decreased significantly following wetlands legislation (1954-1971: 179.7 ha lost annually; 1973-1979: 8.1 ha lost annually).
REPORT OR REFERENCE LOCATION:	Morris Library, TD169.E6
DESCRIPTORS:	WETLANDS CHANGES, WETLANDS MAPPING, REMOTE SENSING

AUTHOR:	Hardisky, M. A., V. Klemas, and F. C. Daiber
DATE:	1983
TITLE:	Remote Sensing Salt Marsh Biomass and Stress Detection
BIBLIOGRAPHICAL INFORMATION:	Adv. Space Res., V. 2, No. 8, p. 219-229
ABSTRACT:	Variations in biomass of Spartina alterniflora correlated to changes in spectral radiance. Negative stresses (increased soil salinity, inc. Copper, Zinc) yielded reductions in biomass; positive stresses (freshwater and sewage effluent additions) produced an increased biomass.
GEOGRAPHIC AREA:	Lewes, Delaware and vicinity
PERIOD OF STUDY:	1980-81
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Hand-held radiometer used to gather spectral radiance data; configured to match bands 3, 4, and 5 of Landsat-D Thematic mapper. Primary productivity estimated by comparing harvest estimate and spectral radiance indices. Measurements of soil salinity (refractometer); moisture content of leaves (fresh vs. dry weight); heavy metals (copper, zinc) in plants; soil nutrients (N, P) from sewage.
QUALITATIVE ASSESSMENT:	Data presented as graphs comparing trends in variables over time; tabulation of zinc, copper content; canopy biomass; net primary production. This method saves time and is non-destructive (vs. harvest) to obtain biomass values.
REPORT OR REFERENCE LOCATION:	Morris Library, TL787.A362
DESCRIPTORS:	REMOTE SENSING, MARSH PRODUCTIVITY, BIOMASS VALUES OF WETLANDS

AUTHOR:	Hopkins, T. L.
DATE:	1958
TITLE:	On the Breeding and Occurrence of Opossum Shrimp (Order Mysidacea) in Indian River Inlet, Delaware.
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, University of Delaware, Newark, Delaware, 36 p.
ABSTRACT:	4 species of mysids were found in plankton. Samples taken at night flood-tides at Indian River Inlet. Populations and distributions were found to fluctuate seasonally and annually. These fluctuations may be influenced by temperature and salinity.
GEOGRAPHIC AREA:	Indian River Inlet, Delaware
PERIOD OF STUDY:	Qualitative Data - September 2, 1955 - January 7, 1958 Quantitative Data - July 17, 1956 - January 7, 1958
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Mysid samples collected on flood-tide at night. Temperature, salinity. Nylon plankton net used. Salinity - Knudsen method; temperature - thermometer.
QUALITATIVE ASSESSMENT:	Samples collected biweekly September 17, 1956 until January 7, 1958. Provides graphs of salinity and temperature at time of towing, but no raw data. Primarily discussion of mysid samples and distribution. Not much information on environmental parameters.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #60
DESCRIPTORS:	PLANKTON (TEMPERATURE, SALINITY)

AUTHOR:	Hopkins, T.L.
DATE:	1965
TITLE:	Mysid Shrimp Abundance in Surface Waters of Indian River Inlet, Delaware
BIBLIOGRAPHICAL INFORMATION:	Ches. Sci., Vol. 6, No. 2, p. 86-91
ABSTRACT:	Analysis of mysid species composition, reproductive periods, and diurnal and seasonal abundance in Indian River Inlet, Delaware. Neomysis americana represents 80% of mysid population, most numerous in surface waters during darkness; most abundant from April-November; reproduces 3 generations/year, serves as source of food for fish.
GEOGRAPHIC AREA:	Indian River Inlet, Delaware
PERIOD OF STUDY:	1956-1957
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Mysid shrimp collected bi-weekly using plankton nets. Sampling done on flood tide at night. Water parameters measured include temperature, flood tide salinities, chlorinity (silver nitrate titration), Atlas current meter.
QUALITATIVE ASSESSMENT:	Graphic presentation of diurnal, seasonal species abundances. Water parameters given only as a range of values.
REPORT OR REFERENCE LOCATION:	Cannon Library, QH 95, 5 A1.C53
DESCRIPTORS:	MYSID SHRIMP, INDIAN RIVER INLET WATER PARAMETERS

AUTHOR: Horn, J. G.

DATE: 1957

TITLE: The History of the Commercial Fishing Industry in Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, College of Marine Studies, Newark, Delaware

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Howell, R. P.

DATE: 1931

TITLE: The Problem of Keeping Indian River Inlet Open

BIBLIOGRAPHICAL INFORMATION: U.S. Engineering Office, Wilmington, Delaware

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Humphries, E. M.
DATE:	1970
TITLE:	Seasonal Settling of the Hydrozoa and the Ectoprocta in Rehoboth Bay, Delaware
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, University of Delaware, 218 p.
ABSTRACT:	The seasonal and spatial distribution of hydroids and ectoprocts at Rehoboth Bay Marina, DE, were studied. It was found that seasons of attachment correspond with seasonal temperature changes.
GEOGRAPHIC AREA:	Rehoboth Bay, Delaware
PERIOD OF STUDY:	October 9, 1967 - November 15, 1968
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Bottom and surface salinity and temperature; water depth, tidal surveys, climatological data Salinity - hydrometer Turbidity - Coleman nepho-colorimeter Tidal Surveys - comparison of water level to fixed points Lab analyses of hydrozoa and ectoprocta.
QUALITATIVE ASSESSMENT:	6 stations on southern pier of Rehoboth Bay Marina. Monthly data collection. Detailed discussions of tides and water levels. Salinity ranges 27.3‰ - 32‰ Water Temperature - 0°C - 27°C Graphs and tables included detailing water levels, hydrographic data, salinity and precipitation data, temperature data, and turibidity and wind data 1967-1968. Summaries of physical data and degree of fluctuations.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #13
DESCRIPTORS:	SETTLING, REHOBOTH BAY, HYDROGRAPHIC DATA

AUTHOR:	Humphries, E. M., and F. C. Daiber
DATE:	1968
TITLE:	Shellfish Survey of Indian River Bay and Rehoboth Bay, Delaware
BIBLIOGRAPHICAL INFORMATION:	Technical Report, Northeast Marine Health Sciences Laboratory, Narragansett, RI.
ABSTRACT:	Shellfish survey of Indian River and Rehoboth Bays conducted to evaluate concentration of various shellfish (primarily hard clams) in relation to domestic pollution concentrations. In Rehoboth Bay, 19% of clams occur in "prohibited" areas, in Indian River Bay, only 3% do.
GEOGRAPHIC AREA:	Indian River Bay, Rehoboth Bay
PERIOD OF STUDY:	June 1967
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Shellfish collected using tongs along transect lines (393 stations); bacteriological data; sewage treatment plant data.
QUALITATIVE ASSESSMENT:	Report presents density-distribution charts showing location of size groups of hard clams. Authors state that "bacteriological and resource data in this report may be easily converted into a storage - retrieval system such as the National Register of Shellfish growing areas".
REPORT OR REFERENCE LOCATION:	Cannon Library, SH 365, D4 H85
DESCRIPTORS:	SHELLFISH RESOURCES, BACTERIOLOGICAL DATA

AUTHOR: Indian River Inlet Commission

DATE: 1931

TITLE: Report of the Indian River Inlet Commission to the 103rd Assembly of the State of Delaware

BIBLIOGRAPHICAL INFORMATION: U.S. Engineers Office, Wilmington, Delaware, 36 p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Jensen, L. D.

DATE: 1974

TITLE: Environmental Responses to Thermal Discharges from the Indian River Station, Indian River, Delaware

BIBLIOGRAPHICAL INFORMATION: Prepared for Electric Power Research Institute, Cooling Water Discharge Research Project and Delmarva Power & Light Company, EPRI Pub. #74-049-00-3, 205 p.

ABSTRACT: This report presents a compilation and interpretation of water quality and biological data collected from the Indian River estuary to evaluate the influence of the Indian River Power Plant of DP&L. The studies involve a detailed examination of water quality, nutrients, and temperature in the Indian River estuary.

GEOGRAPHIC AREA: Indian River estuary

PERIOD OF STUDY: 1966-1971

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Water quality, temperature, salinity, dissolved oxygen, alkalinity, pH, nutrients, phosphorus, nitrate, ammonia. Data presented in form of tables, graphs, and discussion section. Detailed description of all methods in each chapter of book.

QUALITATIVE ASSESSMENT: Twenty stations sampled routinely; regular summer weekly synoptic surveys for temperature, salinity; bimonthly field trips. Detailed study of the upper parts of the Indian River estuary, with data and discussions on phytoplankton and primary productivity; benthic invertebrates; fish populations; zooplankton entrainment; meteorological data.

REPORT OR REFERENCE LOCATION: Morris Library, TD 427.H4 J46

DESCRIPTORS: INDIAN RIVER ESTUARY; WATER QUALITY

AUTHOR: Jensen, L. D., R. M. Davies, R. A. Smith, and A. S. Brooks

DATE: 1974

TITLE: Entrainment of Planktonic Organisms into Cooling Water Systems of Three- Mid-Atlantic Thermal Power Plants

BIBLIOGRAPHICAL INFORMATION: In: L. D. Jensen, Editor, Proceedings of the 2nd Workshop on Entrainment and Intake Screening at Johns Hopkins University, Baltimore, MD, 1974, pg. 95-104.

ABSTRACT: Purpose of research was to quantitatively examine in field studies the plankton entrainment into cooling water. Emphasis confined to precisely measuring immediate effect of intake temperature and temperature rise during entrainment as well as delayed effects of condenser discharge into mixing areas.

GEOGRAPHIC AREA: Indian River, Delaware

PERIOD OF STUDY: 1970-1971

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: River flow, tidal exchange, turbidity, salinity, pH, total alkalinity, dissolved oxygen, ammonia nitrogen, nitrate, nitrogen, orthophosphate

Does not detail methods, but has tables of temperature and chlorination data, etc.

QUALITATIVE ASSESSMENT: This paper is general overview of entrainment studies. It does include tables with environmental parameter data for the Indian River Power Station vicinity.

REPORT OR REFERENCE LOCATION: Cannon Library, TJ 164.J45

DESCRIPTORS: WATER QUALITY, HYDROGRAPHY, POWER PLANT

AUTHOR: Jensen, P. A.

DATE: 1977

TITLE: Task Report 2355. Analysis of Water Quality Data and Land-use Water Quality Relationships

BIBLIOGRAPHICAL INFORMATION: Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by the University of Delaware, Newark, DE, CMS C-3-77

ABSTRACT: Review and summary of available water quality data sources and analyzation of sources to determine where surface water quality problems exist. In order of severity, water quality problems are: entire Broadkill River, upper Indian River, Northern Rehoboth Bay, and Lewes/Rehoboth Canal, White Creek/Little Assawoman Canal, and smaller tributaries - Pepper, Herring, and Love Creeks.

GEOGRAPHIC AREA: Indian River Bay, Rehoboth Bay, Little Assawoman Bay, and Broadkill River

PERIOD OF STUDY: Previous studies reviewed and data collected for this study Summer 1976.

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Provides grouping, comparison, and evaluation of data for Broadkill River, Rehoboth Bay, Indian River Bay, and Little Assawoman Bay. General patterns of each parameter discussed.

Rehoboth Bay/Lewes and Rehoboth Canal: Coliform bacteria, BOD, dissolved oxygen, nutrients, chlorophyll. Indian River and Bay: Coliform bacteria, BOD, dissolved oxygen, nutrients, chlorophyll. Little Assawoman Bay: Scant data on coliform bacteria, BOD, dissolved oxygen, nutrients, chlorophyll.

QUALITATIVE ASSESSMENT: Primary critera used for defining water quality problem is coliform bacteria. Synthesized previous data - methods not always comparable, but sufficient data exists to present comprehensive picture of spatial and temporal gradients of the major parameters. Tried to correlate land use and water quality - found

relationships to be superficial. 1976 data summarized in tables included in Appendix. For each basin: water depth, salinity, dissolved oxygen, CHLa, NH_4^+, NO_2^-, NO_3^-, DON, PO_4, TDP, and DOC.

REPORT OR REFERENCE LOCATION: Cannon Library, CMS C-3-77.

DESCRIPTORS: WATER QUALITY, COLIFORM.

AUTHOR: Jensen, P. A.

DATE: 1980

TITLE: Final Report: Water Quality Analysis of the Lewes-Rehoboth Canal, Delaware

BIBLIOGRAPHICAL INFORMATION: Submitted to Delaware Division of Environmental Control. Submitted by Espey, Huston, and Associates, Inc.

ABSTRACT: This report describes water quality analyses on the Lewes and Rehoboth Canal and the bay areas immediately adjacent to the north and south ends of the Canal. The report includes background information on the system, analyses of relevant water quality data, a description of the analytical techniques employed, and analyses of the effects of specified point-source treatment and discharge alternatives. This study utilizes a one-dimensional numerical model to simulate the hydrodynamic and water quality effects of 2 point source water treatment plants.

GEOGRAPHIC AREA: Lewes and Rehoboth Canal, Rehoboth Bay

PERIOD OF STUDY: August 1979 - January 1980

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Tide gauges, salinity, dissolved oxygen, temperature, BOD, coliform bacteria

Current velocity measurements - Endeco type 105 recording current meter in channel cross-sections surveyed

Nutrient observations - NH_3, NO_2, NO_3, PO_4, chlorophyll a; utilizes previous data and field data

Methods not detailed. State data on coliform bacteria utilized. Some discussion on methods for coliform bacteria lab analyses.

QUALITATIVE ASSESSMENT: Data obtained at surface, middle, and bottom locations. All data provided in tabular form; additional statistical analyses on data provided in Appendix. Summary of state-collected data, too. Detailed model using previously collected data may need to be updated.

REPORT OR REFERENCE LOCATION: Delaware Department of Natural Resources and Environmental Control

DESCRIPTORS: WATER QUALITY, HYDRODYNAMICS

AUTHOR:	Jensen, P. A.
DATE:	1981
TITLE:	Draft Report: Analysis of Coliform Bacteria Problems in Indian River Bay, Delaware
BIBLIOGRAPHICAL INFORMATION:	Submitted to the Delaware Department of Natural Resources and Environmental Control. Submitted by Espey, Huston, and Associates, Inc., Austin, TX.
ABSTRACT:	This report analyzes the indicator bacteria levels in the shellfishing areas of Indian River Bay, DE. The analysis includes historical data and trends along with mathematical modeling of coliform levels in the system. The study is organized into 4 broad task areas: analysis and interpretation of historical data; intensive field studies; analysis and integration of data into a numerical model which represents the overall understanding of the system; and use of this model to evaluate alternative management strategies.
GEOGRAPHIC AREA:	Indian River Bay
PERIOD OF STUDY:	Data utilized 1960-1980. Field study: August 18-19, 1980, October 6-17, 1980
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Historical Data: 1960s to present Regular data collection on monthly basis up until 1973. Light, turbidity, rainfall, organic substrate concentration, temperature, salinity, tidal data Previously collected data used from Georgetown Agriculture Extension Station, University of Delaware, and Department of Natural Resources and Environmental Control Field Study: coliform, salinity, secchi disc, temperature, rain gauge, BODs routine, BODs after rain. 24 stations. No details provided on methods.
QUALITATIVE ASSESSMENT:	Complete data files presented in Appendix A. 20 day sampling period. Full data set for each station provided in Appendix B. Noted

differences in data results between Public Health and University of Delaware Labs.

REPORT OR REFERENCE LOCATION: Delaware Department of Natural Resources and Environmental Control

DESCRIPTORS: WATER QUALITY, COLIFORM LEVELS

AUTHOR:	Jensen, P. A., and M. J. Eshleman
DATE:	1976
TITLE:	Review of Existing Point Source Waste Loadings. Final Report on Task 2352.
BIBLIOGRAPHICAL INFORMATION:	CMS-C-5-76, Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program by University of Delaware, Newark, DE
ABSTRACT:	This report presents a tabulation, analysis and graphical presentation of point-source wastewater data collected by DNREC, Technical Services Division. The data span a period of between one to five years, depending on availability. The purpose of the analysis is to document point source waste characteristics for use in water quality modeling studies. The analysis includes an aggregation of point source discharges by basin as well as plots which give some indication of seasonal periodicity of various sources.
GEOGRAPHIC AREA:	Coastal Sussex County (in general)
PERIOD OF STUDY:	1972-1976 (data collected over last 5 years)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Point source effluent data: BOD, COD, NH_3, NO_2, NO_3, KN, TP, SS, NVS, TS, TC, FC, FS Methods not detailed or described. (DNREC data collected on monthly basis).
QUALITATIVE ASSESSMENT:	Point source data were tabulated, averaged, and plotted in terms of waste parameter concentration and mass discharge. The averages and standard deviation of each parameter from each source could be used as input values for the water quality model. A summary of waste loadings in various sub-basins of the study area was also calculated. Includes data sets for each point source, including time and date of sample and effluent data. Also includes data vs. time (years) plots for effluent data at each point source.
REPORT OR REFERENCE LOCATION:	Cannon Library, CMS-C-5-76
DESCRIPTORS:	WATER QUALITY, POINT-SOURCE, EFFLUENT DATA

AUTHOR: Jensen, P. A., and J. M. Tyrawski

DATE: 1976

TITLE: Water Quality Model for Coastal Sussex County Report on Task 2359

BIBLIOGRAPHICAL INFORMATION: Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program. Prepared by College of Marine Studies, University of Delaware, Newark, DE

ABSTRACT: This report describes an estuarine water quality model to be used in the assessment of the water quality impacts of alternative development scenarios. Each component of the model and the method of operation is described in detail with relevant supporting literature. The report includes appendices, a listing of the program, test results of conservation of mass, and an example output for upper Indian River.

GEOGRAPHIC AREA: Inland Bays and Broadkill in general; especially Indian River and Rehoboth Bays

PERIOD OF STUDY: Study utilizes previously collected data. Model is concentrated on summer, fair weather conditions.

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Water quality parameters utilized: ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), phytoplankton, nitrogen, benthic algae, nitrogen, PON, DON, chlorophyll a ratios, algal productivity, temperture, BOD, dissolved oxygen, TC

Assembles previously collected data for synthesis into water quality model. Methods not detailed.

QUALITATIVE ASSESSMENT: Water quality parameters incorporated into the model are considered to be uniformly distributed throughout each study segment. In each segment, 11 water quality parameters are represented.

Perhaps use of additional data to support data input into model will minimize differences Hetween model and actual data. At this point, model does not appear to have incorporated enough data to simulate seasonal water quality parameters in the Inland Bay system.

REPORT OR REFERENCE LOCATION: Cannon Library, CMS-C-6-76

DESCRIPTORS: WATER QUALITY MODEL

AUTHOR:	Jensen, P. A., and J. M. Tyrawski
DATE:	1977
TITLE:	Report on Task 2359C; Water Quality Modeling and Analysis
BIBLIOGRAPHICAL INFORMATION:	Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program. Prepared by Sea Grant Marine Advisory Program, College of Marine Studies, Univesity of Delaware, Newark, DE, CMS-C-6-77.
ABSTRACT:	Purpose was to help evaluate water quality impacts of several alternative development situations. By comparing magnitudes of total nitrogen, BOD, and TC, the following conclusions are made: 1) shoreline septic systems are insignificant sources of pollution when compared with other point sources, wetlands, and upland runoff; 2) wetlands are major determinant of water quality.
GEOGRAPHIC AREA:	Indian River Bay, Rehoboth Bay, Little Assawoman Bay and Broadkill River
PERIOD OF STUDY:	Utilized existing literature. 1976 and earlier.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Estimated nitrogen, BOD, total coliform, tidal flow data from direct flow measurements and 2 dimensional hydrodynamic model (Task 2331), freshwater flow, mixing, modeled nitrogen cycle, BOD, dissolved oxygen, and TC. Methods not detailed, but much data included in tables and figures.
QUALITATIVE ASSESSMENT:	Water quality model used to estimate quantitatively the effects of waste loading changes in the area. Modeling data based on review of existing literature in certain areas, e.g. marsh flux patterns. Data are limited so it is difficult to determine general characteristics for an entire area. Summarized and averaged data from previous studies to use in model. No means to predict major alterations in system. Many useful graphs and tables summarizing previous studies and collected data.
REPORT OR REFERENCE LOCATION:	Cannon Library, CMS-C-6-77
DESCRIPTORS:	WATER QUALITY, MODELS

AUTHOR: Jensen, P. A., and J. M. Tyrawski

DATE: 1978

TITLE: Wetlands and Water Quality

BIBLIOGRAPHICAL INFORMATION: Coastal Zone 1978 Proceedings, Vol. 2, p. 1145-1164, March 14-16, 1978, San Francisco, ASCE, NY.

ABSTRACT: Modeling studies using a nitrogen cycle model are developed for water quality investigations in Indian River and Broadkill River. Models are based on data on nutrient fluxes in various other marshes. The examples given in paper (Indian River and Broadkill) suggest that wetlands have a strong impact on observed water quality where the ratio of wetlands to water area is high. Wetland exports of nutrients (nitrogen) appear to be a relatively minor factor in the Indian River Estuary with a large upland runoff nitrogen source, and of no significance to the Broadkill where nutrients are in excess supply.

GEOGRAPHIC AREA: Indian River Estuary, Broadkill River

PERIOD OF STUDY: General modeling simulation based on previously collected data.

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Modeling components: 1) nitrogen cycle (most likely to be limiting in an estuarine environment), 2) BOD, 3) dissolved oxygen, and 4) total coliform bacteria.

Model supported by a series of 24 hr. stations monitoring dissolved oxygen, chlorophyll a, nutrients, and hydrographic parameters.

QUALITATIVE ASSESSMENT: Modeling studies were designed to estimate the changes in total coliform level, dissolved oxygen, and the extent of nutrient enrichment with associated phytoplankton concentrations. This paper includes graphs and charts of model low flow chorophyll a simulations and low flow total coliform simulations on Indian River Bay. Provides average summer flux data, and estimates of maximum concentration data for environmental parameters such as nitrogen, PON, BOD, dissolved oxygen, and TC. Text is primarily presentation of mechanism developed

for and computer analysis of the significance of wetlands to observed water quality parameters.

REPORT OR REFERENCE LOCATION: Morris Library

DESCRIPTORS: WETLANDS, WATER QUALITY

AUTHOR: Jensen, P. A., and T. Weeks

DATE: 1977

TITLE: Task Report #2324. Analysis and Estimation of Discharges from Water Front Septic Tanks, Tidal Marshes, and Recreational Boating

BIBLIOGRAPHICAL INFORMATION: Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program, by the University of Delaware, College of Marine Studies, Newark, DE

ABSTRACT: This report presents estimates of the amount of oxygen-demanding material, nutrients, and indicator bacteria released to coastal Sussex County waters by various beneficial uses of surface waters. These uses include water front housing (septic tanks), tidal wetlands, wildlife habitat areas, and recreational boating. Estimates are made based on an extensive literature review and on one survey of nearshore nutrient gradients. The wetlands appear to equal or exceed point sources in the amount of BODs and nutrients discharged into the system.

GEOGRAPHIC AREA: Broadkill River, Rehoboth Bay, Indian River Bay, White Creek, Little Assawoman Bay

PERIOD OF STUDY: Summary of previous work.

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: BODs, TSS, TVS, Org-N, NH_4^-, NO_2^-N, NO_3^-N, Org-P, PO_4^-P, TC, FC

No methods detailed.

QUALITATIVE ASSESSMENT: Data, estimation procedures, and required assumptions are fully documented. Data summary tables included analysis location and enumeration of waste sources in each water body. The authors note that because of the wide variability and limited data on most of these sources, there is substantial margin for error in the estimates.

REPORT OR REFERENCE LOCATION: Cannon Library, CMS-C-2-77

DESCRIPTORS: WATER QUALITY, COLIFORM BACTERIA

AUTHOR:	Jensen, P. A., L. M. Hauck, and C. Wethe
DATE:	1981
TITLE:	Executive Summary Analysis of Coliform Bacteria Problems in Indian River Bay, DE
BIBLIOGRAPHICAL INFORMATION:	Submitted to Delaware Department of Natural Resources and Environmental Control, 11 p.
ABSTRACT:	This report presents an analysis of coliform bacteria problems in Indian River Bay including: historic trends, statistical relationships, regulatory aspects, intensive data collection, and numerical modeling.
GEOGRAPHIC AREA:	Indian River Bay
PERIOD OF STUDY:	August 1980
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Coliform, salinity, secchi disc, temperature, rain gauge, BODs routine, BODs after rain No methods detailed.
QUALITATIVE ASSESSMENT:	Sampling conducted during two 2-week periods. Approximately 23 stations. Water quality data were combined with rainfall, light intension, coliform levels, tide and other data in a computer file. Data were analyzed, and differences were found between data analyzed by Division of Public Health and by University of Delaware lab. No raw data provided.
REPORT OR REFERENCE LOCATION:	State of Delaware, Department of Natural Resources and Environmental Control
DESCRIPTORS:	WATER QUALITY, COLIFORM BACTERIA

AUTHOR:	Jensen, P. A., K. S. Price, L. V. DiMichele, P. C. Garfield, W. W. Martin, L. L. Thornton, and H. W. Otto
DATE:	1976
TITLE:	Delaware's Small Bay Resources / A Review of Information Relevant to Management of the Resources of Rehoboth, Indian River, and Little Assawoman Bays
BIBLIOGRAPHICAL INFORMATION:	DEL-SG-15-76; College of Marine Studies, Newark, DE, 93 p.
ABSTRACT:	This report reviews information which may have direct or indirect bearing on management of Rehoboth, Indian River, and Little Assawoman Bays. Through compilation and limited analysis of existing data, information needs and suggested direction for future work are identified.
GEOGRAPHIC AREA:	Rehoboth, Indian River, and Little Assawoman Bays
PERIOD OF STUDY:	All work done prior to 1976.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Analyzed water quality data previously collected by Department of Natural Resources and Environmental Control. Collection of scientific information relevant to management of the inland bays area. No methods detailed.
QUALITATIVE ASSESSMENT:	12 stations Indian River and Rehoboth Bays. Provides graphs and summary of water quality data averaged over 1 year (1974). Good synthesis report, including discussion of community attitudes toward development, review of water quality monitoring data, legal basis for development control, review of scientific literature and an annotated bibliography.
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	WATER QUALITY, CIRCULATION

AUTHOR:	Jensen, P. A., W. F. Ritter, and J. M. Tyrawski
DATE:	1977
TITLE:	Report on Task 2359 (Supplementary) Coliform Bacteria Loading and Dynamics
BIBLIOGRAPHICAL INFORMATION:	Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program. Prepared by College of Marine Studies, University of Delaware, Newark, DE, CMS-C-5-77.
ABSTRACT:	Study conducted to provide data on coliform bacteria loadings, dynamics, and distributions. Found that it is unlikely that shoreline septic systems can have significant effect on water quality in major bays - flows are too small and dispersal is over a large volume of water.
GEOGRAPHIC AREA:	Rehoboth, Indian River, Little Assawoman Bays
PERIOD OF STUDY:	June - September 1977
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Groundwater samples collected 3 times along shoreline at 24 homes in Coastal Sussex. MPN test used in turbid water areas; membrane filter procedure used in clear water areas. Portable lab and incubators used. Detailed description of methods. Detailed tables with coliform concentrations, distance from tank to shoreline and depth to water table.
QUALITATIVE ASSESSMENT: (DATA GAPS, QUALITY CONTROL LENGTH OF RECORD, # OF DATA POINTS, FORMAT OF DATA, ETC.)	Sampling conducted at end of dry summer and only locations sampled were those with permission of owner. Samples may not be truly representative of entire septic system population. (Biased sample?) Only 3 months for data collection - realistic scenario? Study could be updated with more information.
REPORT OR REFERENCE LOCATION:	Cannon Library, CMS-C-5-77
DESCRIPTORS:	WATER QUALITY, COLIFORM BACTERIA, SEPTIC SYSTEMS

AUTHOR:	Johnson, T. D.
DATE:	1981
TITLE:	Differences Between Zooplankton Communities of Three Adjacent Delaware Coastal Water Bodies
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, University of Delaware, Newark, 100 p.
ABSTRACT:	The study was designed to apply a measure of community structure to zooplankton communities to determine whether subtle differences could be detected between closely spaced stations.
GEOGRAPHIC AREA:	Indian River and Rehoboth Bays
PERIOD OF STUDY:	December 1979 - October 1980
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Temperature (°C), Salinity (‰), Zooplankton: 0.5 m diameter # 10 mesh net, nitex cloth conical plankton net, or # 20 mesh net. 9 samples taken at surface, 5 samples taken at bottom. Temperature - glass thermometer Salinity - Montedoro-Whitney CTU-3B Conductivity - temperature meter and/or YSI S-C-T meter
QUALITATIVE ASSESSMENT:	3 stations. Samples collected on 9 occasions. (8 special stations in Rehoboth Bay for temperature and salinity samples). Detailed description of hydrography of system using data from Karpas and Jensen, and Ecological Analysts. Data provided on salinity and temperature samples - charts and graphs. Discusses mixing, stratification, circulation with regard to temperature and salinity data.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #160
DESCRIPTORS:	TEMPERATURE, SALINITY, CIRCULATION

AUTHOR:	Johnston, R. H.
DATE:	1976
TITLE:	Relation of Groundwater to Surface Water in Four Small Basins of the Delaware Coastal Plain
BIBLIOGRAPHICAL INFORMATION:	Delaware Geological Survey, Report of Inv. No. 24, 56 p.
ABSTRACT:	Hydrologic analysis of four basins characterized by similar climate, geology, topography, and land use. Streams obtain 80% of flow from groundwater discharge. Close correlation between groundwater stage and stream discharge during base flow conditions.
GEOGRAPHIC AREA:	Includes Nanticoke River Basin, Beaverdam, Sowbridge and Stockley Branches
PERIOD OF STUDY:	1959-68; 1971
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Stream flow data (overland runoff, base-flow components); aquifer transmissivity; hydrographic budget estimations; precipitation, evaporation, depth to groundwater level.
QUALITATIVE ASSESSMENT:	Results include baseflow recession curves; response of stream stage and groundwater levels to storm events. Baseflow results based on appropriate (though realistic) theoretical approach.
REPORT OR REFERENCE LOCATION:	Delaware Geological Survey, Penny Hall, University of Delaware, Newark
DESCRIPTORS:	HYDROGEOLOGY, STREAM FLOW, GROUNDWATER, HYDROLOGIC BUDGET

AUTHOR:	Kaplovsky, A. J., and D. B. Aulenbach
DATE:	1956
TITLE:	A Comprehensive Study of Pollution and Its Effect on the Waters Within the Indian River Drainage Basin
BIBLIOGRAPHICAL INFORMATION:	A Report to the Water Pollution Commission of the State of Delaware, 207 p.
ABSTRACT:	The purpose of the study is to determine the existing pollution within the Indian River Drainage Basin and to make recommendations to improve stream conditions in the best interests of the people residing within the basin.
GEOGRAPHIC AREA:	Indian River Drainage Basin (310 square miles)
PERIOD OF STUDY:	1952 - 1955
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Suspended solids, pH, alkalinity, acidity, BOD, COD, salinity, hardness, total solids, ash weight, turbidity, color, coliform, water flow, temperature Temperature - non-reversing thermometer pH - pH meter Salinity - titration BOD - titration Total solids - dessication Acidity - titration
QUALITATIVE ASSESSMENT:	55 stations in Indian River and Bay. A comprehensive study was made of the Indian River Drainage Basin within Delaware, its sources of pollution and their effect upon State waters within this drainage area. Detailed field and lab measurements were made of existing water quality. Relative contamination was found in specific locations. Detailed studies were made on the pollutional flow pattern in the Lewes-Rehoboth Canal. Very detailed study on water quality. State-of-the-art information and discussion of water quality as it existed in 1956.
REPORT OR REFERENCE LOCATION:	Morris Library, St. Doc. TD 224-C3-A45
DESCRIPTORS:	WATER QUALITY

AUTHOR: Karpas, R. M.

DATE: 1978

TITLE: The Hydrography of Indian River and Rehoboth -- Delaware's Small Bays

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, University of Delaware, Newark, DE, 179 p.

ABSTRACT: The hydrographic regime of Indian River and Rehoboth Bays was examined on several field surveys. The dominant factor in overall circulation was the tidal flow. The wind stress has the potential of being very significant compared to the baroclinic pressure gradient force in setting the water movement patterns, especially in Rehoboth Bay. The vertical salinity gradient of both bays led to their classification as "partially-mixed" systems.

GEOGRAPHIC AREA: Indian River and Rehoboth Bays

PERIOD OF STUDY: Spring and Summer 1976, Summer 1977

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: 5 tide gauges. Several full tidal cycles for hydrographic surveys. Current velocity and direction, salinity, temperature, water level and depth

Currents-Endeco type 110 Remote Reading current meter.
tide levels - tide staff
temperature - bucket thermometers
sounding - lead line
salinity - inductive salinometer or refractometer

QUALITATIVE ASSESSMENT: 22 hydrographic field stations. Sampling done at 3 depths, surface, middle, bottom or at 2 depths, surface, bottom. Schedule of hourly readings at each station. Appendix contains tabulation of all hydrographic field data. In text discussion and interpretation of data, with various data synthesized and summarized in tables. Karpas indicates that the great seasonal variability in freshwater runoff and temperature patterns and hence salinity distribution, tidal/freshwater ratios, and overall circulation, has not been examined extensively

because of limited data. A clearer picture of small bay hydrodynamics would necessarily include a longer term sudy encompassing an annual cycle.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #104

DESCRIPTORS: CIRCULATION

AUTHOR:	Karpas, R. M., and P. A. Jensen
DATE:	1977
TITLE:	Hydrodynamics of Coastal Sussex County, Report on Task 2331.
BIBLIOGRAPHICAL INFORMATION:	Prepared for Coastal Sussex Water Quality Program and Delaware Coastal Management Program. By University of Delaware, College of Marine Studies, Sea Grant Advisory Services, and the College of Agricultural Sciences, Department of Agricultural Engineering.
ABSTRACT:	This report describes the hydrodynamics of Rehoboth, Indian River, and Little Assawoman Bays, and the Broadkill River. It documents salinity and temperature distribution, current velocities, tidal ranges and phase lags, and tidal prisms throughout the systems. Includes hydrodynamics - numerical model calibrated for Indian River and Rehoboth Bays.
GEOGRAPHIC AREA:	Indian River, Rehoboth, Little Assawoman Bays, and Broadkill River.
PERIOD OF STUDY:	Spring and Summer, 1976 - Summer, 1977
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Salinity and temperature distributions; current velocities and directions; tidal ranges and phase lags; and tidal prisms. 5 tide gages established around the bays, several full tidal cycle hydrographic surveys. Current velocities - Endeco type 110 remote reading current meter and savonnius rotor type current meters. Salinity - inductive salinometer, or field refractometer.
QUALITATIVE ASSESSMENT: (DATA GAPS, QUALITY CONTROL LENGTH OF RECORD, # OF DATA POINTS, FORMAT OF DATA, ETC.)	Report includes full listing of hydrographic field data collected for the study. Analyses of salinity and temperature distributions, and surface to bottom variation of these parameters. Detailed discussions of methods and locations of all sampling locations with times of surveys. Detailed tables, maps, and charts describing collected data. One of the most detailed and

comprehensive surveys of Inland Bays hydrodynamics reviewed for this project. Develops model and compares model results with field data.

REPORT OR REFERENCE LOCATION: Cannon Library

DESCRIPTORS: CIRCULATION, HYDRODYNAMICS, TIDAL HYDRAULICS.

AUTHOR: Keulegan, G. H.

DATE: 1967

TITLE: Tidal Flow in Entrances: Water-level Fluctuations of Basins in Communication with Seas.

BIBLIOGRAPHICAL INFORMATION: Tech. Bull. No. 14, Committee on Tidal Hydraulics, U. S. A. C. E., 102 p.

ABSTRACT: This report describes the analytical approach to the problem of defining changes in water level of a basin connected to the ocean by a channel or channels. To illustrate the use of the analytical approach, the case of Indian River, Delaware, is examined in considerable detail.

GEOGRAPHIC AREA: Indian River, Delaware and Rehoboth Bay, Delaware.

PERIOD OF STUDY: 1930, 1948, 1950

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

Tide data - 1948-1950

Tributary discharges (inflows & outflows) (current meter)

Cross-sectional areas, tidal prisms

Current velocities in Inlet - 1939.

Longtime tide data at 2 stations in bays, 1938-1939, and 1948-1950. No detailed methods provided, but summarizes and synthesizes data obtained in earlier studies.

QUALITATIVE ASSESSMENT: Detailed discussions of hydrography of bays, and inlet. Includes historical account of Indian River Inlet. Summarizes 1930 Indian River Inlet Commission data on inflows and outflows and changes in water levels. Mathematical calculations of effects of wind tides on water level and circulation. Mannings Roughness discussed for the Inlet and Lewes and Rehoboth Canal, inertia effect at inlet, hydraulics of the ditches, mathematical calculations of Indian River Bay tides.

Tables of:

1. Longtime mean data of tides in Indian River and Rehoboth Bays.

2. Data on volume of inflow and outflow of Indian River Inlet and Lewes and Rehoboth Canal.

3. Indian River Inlet channel dimensions.

4. Velocity surveys of Indian River Inlet.

REPORT OR REFERENCE LOCATION: Morris Library, U. S. Doc., D. 103. 28/2: 13-16.

DESCRIPTORS: HYDROGRAPHY

AUTHOR: Kraft, J. C., and G. Margules

DATE: 1969

TITLE: Correlation of Foraminifera Distribution with Sediment Facies Patterns and Physical Data in Indian River Bay, Coastal Delaware.

BIBLIOGRAPHICAL INFORMATION: G.S.A. Spec. Papers No. 121, p. 361.

ABSTRACT: The physiographic setting, bottom-sediment facies patterns, and salinity, temperature, pH, Eh, and organic content of water mass and bottom sediments of the Indian River Estuary were compared with the distribution of living benthonic foraminifera. No significant correlation was found between patterns of foraminifera abundance and the distribution of sediment types. Also seemed to be no significant association between species occurrence and the physical parameters observed.

GEOGRAPHIC AREA: Indian River Estuary

PERIOD OF STUDY: Not indicated

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Temperature, salinity, pH, Eh, organic content of water mass and bottom sediments, sediment distribution. Foraminifera.

No methods indicated.

QUALITATIVE ASSESSMENT: Variation in the physical characteristics of the water mass and of the bottom sediments occurs in both diurnal and tidal patterns. Daily variation of bottom-water characteristics was observed to be significantly greater at the western edge of tidal intrusion in Indian River, than in central Indian River Bay.

No raw data included; general summary of earlier work.

REPORT OR REFERENCE LOCATION: Morris Library, QE 1 G46, No. 121.

DESCRIPTORS: FAUNA, WATER QUALITY, SEDIMENTS, FORAMINIFERA

AUTHOR:	Kraft, J. C. and G. Margules
DATE:	1971
TITLE:	Sediment Patterns, Physical Characters of the Water Mass and Foraminiferida Distribution in Indian River Bay, Coastal Delaware
BIBLIOGRAPHICAL INFORMATION:	Southeastern Geology, Vol. 12, No. 4, p. 223-252
ABSTRACT:	The physiographic setting, bottom sediments, and other environmental parameters of Indian River Estuary are compared with the distribution of living Foraminiferida. No significant association between foraminiferida abundance and distribution of sediment types was found. Also, no significant association was determined between species occurrence and physical parameters.
GEOGRAPHIC AREA:	Indian River Bay
PERIOD OF STUDY:	August 2 - September 9, 1966
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Bottom sediments, temperature, pH, Eh, organic content, and distribution of foraminiferida 20 bottom samples - 6-8" core samples. Temperature and salinity - 1' intervals with electrolodeless induction salinometer. pH and Eh from surface water, bottom water, and sediments by portable pH meter
QUALITATIVE ASSESSMENT:	20 sample sites. Detailed study and discussion of variations in physical characters of water mass over tidal and diurnal cycles, especially in mid-east Indian River Bay, and at the western limit of tidal intrusion in Indian River. Detailed graphs documenting salinity variations and temperature variations of entire water mass over 18 hour period. Charts of Eh and pH. Detailed discussion of physical parameters of water mass.
REPORT OR REFERENCE LOCATION:	Morris Library
DESCRIPTORS:	TEMPERATURE, SALINITY, SEDIMENTS

AUTHOR:	Lanan, G. A., and R. A. Dalrymple
DATE:	1977
TITLE:	A Coastal Engineering Study of Indian River Inlet, Delaware
BIBLIOGRAPHICAL INFORMATION:	Ocean Engineering Technical Report 14, DEL-SG-5-77, University of Delaware, Newark, DE, 227p.
ABSTRACT:	A field study was conducted in order to determine the causes of and possible solutions to various coastal engineering problems at Indian River Inlet, Delaware. The major problems present at Indian River Inlet include the erosion of the beach north of the Inlet, the erosion of the channel banks, and the loss of sand onto the ebb tidal shoal. Information for this study was obtained through use of historic charts, hydrographic surveys, sand tracer studies, and tidal and current measurements.
GEOGRAPHIC AREA:	Indian River Inlet
PERIOD OF STUDY:	Summer 1974 - Winter 1975
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Hydrographic survey - Raytheon recording fathometer; sand tracer study for sediment movement; currents - hand held Ott current meter; tidal survey - tide gauge; Stevens type F. elevation recorders; currents - drogues and dyes monitored by aerial photography Volumetric comparisons made between present study data and historical charts and maps. Sand budget calculated.
QUALITATIVE ASSESSMENT:	Raw data provided in numerous charts, tables, and maps through analysis of inlet history and hydraulics. Includes calculations on tidal prism estimate, equilibrium cross-section, and inlet stability. Also, recommendations regarding sand bypassing system and sediment budget.
REPORT OR REFERENCE LOCATION:	Cannon Library, DEL-SG-5-77
DESCRIPTORS:	INDIAN RIVER INLET, TIDAL HYDRAULICS, AND CIRCULATION

AUTHOR:	Lauffer, J. R.
DATE:	1982
TITLE:	A Hydrochemical Study of a Shallow Groundwater System Peripheral to Rehoboth Bay
BIBLIOGRAPHICAL INFORMATION:	Ph.D. Dissertation, Geology Department, University of Delaware, Newark, DE, 171 p.
ABSTRACT:	The geochemical environments of two contrasting (natural vs. developed) settings in Rehoboth Bay area delineated based on field data. Groundwater flow patterns and conceptual flow model developed for this shallow groundwater system.
GEOGRAPHIC AREA:	Rehoboth Bay area: Angola Neck South of Sally Cove (undeveloped) vs. West Bay Park(developed); Big Piney Island.
PERIOD OF STUDY:	April 1975 - April 1976: Semi-Monthly April 1976 - March 1977: Bi-Monthly
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Field measurements of groundwater, temperature, salinity, pH, Eh, (redox potential), specific conductance, chloride, orthophosphate, (H_2PO_4), water level, sediment analysis, groundwater flow pattern analysis.
QUALITATIVE ASSESSMENT:	Statistical analysis of field data with respect to depth, tides, seasonal variations, variations between sites.
REPORT OR REFERENCE LOCATION:	Morris Library, QE 999 1982. L373
DESCRIPTORS:	GROUNDWATER FLOW PATTERNS, GEOHYDROLOGY, GEOCHEMICAL ENVIRONMENTS

AUTHOR:	Logan, D. T.
DATE:	1972
TITLE:	The Biological Effects of a Heated Effluent and A Model for Community Structural Change
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, University of Delaware, Newark, 89p.
ABSTRACT:	This thesis discusses the effect of a thermal effluent on a macrobenthic estuarine invertebrate community. Data indicate that communities in the effluent do not reach the interactive stage. Community structure is found to be related to physical conditions.
GEOGRAPHIC AREA:	Indian River, Delaware
PERIOD OF STUDY:	September 1970 - July 1971 (monthly intervals)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	2 replicates at each station, 4 stations, monthly sampling; dissolved oxygen, sediments, salinity and temperature of surface water, bottom water salinity and temperature sampled until November. Peterson Grab Dissolved oxygen - Hydrolab dissolved oxygen probe Salinity - refractometer or hydrolab Sediments - seive and pipette
QUALITATIVE ASSESSMENT:	4 stations in Indian River. Sampling conducted at monthly intervals. Table summarizing hydrographic measurements (includes some of Derickson, 1970, measurements). Graphs of temperature fluctuations. Most discussion involves community structure and its relationship to the environmental parameters. Raw hydrographic data not included in appendices.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #36
DESCRIPTORS:	POWER PLANT, SALINITY, TEMPERATURE, BENTHIC COMMUNITIES

AUTHOR:	Logan, D. T., and D. Maurer
DATE:	1975
TITLE:	Diversity of Marine Invertebrates in a Thermal Effluent
BIBLIOGRAPHICAL INFORMATION:	DEL-SG-9-75, College of Marine Studies, University of Delaware
ABSTRACT:	This study is an examination of the effect of thermal effluent on an estuarine benthic community; environmental parameters and several community measures, including diversity, were explored. Determined that unusually high diversity exists in a thermal effluent at the mouth of the discharge canal. It was also determined that communities at the mouths of effluent canals, subject to intermittently severe environments, may often be in a noninteractive, pioneer state.
GEOGRAPHIC AREA:	Indian River, Delaware
PERIOD OF STUDY:	September 1970 - July 1971 (monthly sampling intervals)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Salinity, dissolved oxygen, water temperature, sediment samples, benthic organisms 2 replicate bottom samples. Peterson grab used; salinity, dissolved oxygen, and temperature measured in field with hydrolab. Sediments - sieve and pipette analysis.
QUALITATIVE ASSESSMENT:	4 stations; samples taken at monthly intervals. Data for each station were averaged before computing mean grain size and sorting coefficients. Community chacterization: number of individuals, number of species, proportion of indicator species, equitability and jaccard binary coefficient. Graphs of temperature, fluctuations. Brief discussion of physical results; increasing salinity downstream, dissolved oxygen concentration high, variable temperatures. Primarily a discussion of communities, not environmental parameters.
REPORT OR REFERENCE LOCATION:	Cannon Library, DEL-SG-9-75
DESCRIPTORS:	POWER PLANT, SALINITY, TEMPERATURE, DISSOLVED OXYGEN

AUTHOR:	Maurer, D.
DATE:	1977
TITLE:	Estuarine Benthic Invertebrates of Indian River and Rehoboth Bays, Delaware
BIBLIOGRAPHICAL INFORMATION:	Int. Revue ges. Hydrobiol. 62, 5, 591-629.
ABSTRACT:	From 1968-1970, 273 quantitative samples of macroscopic benthic invertebrates were collected seasonally in Indian River and Rehoboth Bays. A total of 103,485 individuals representing 11 phyla and 149 species was taken. The average density (no/m^2) was generally significantly higher in Indian River than Rehoboth Bay. Evenness diversity was normally slightly higher in summer than in winter, and higher in Rehoboth Bay than Indian River Bay. Annual and seasonal changes in density and dominance were substantial.
GEOGRAPHIC AREA:	Indian River and Rehoboth Bays
PERIOD OF STUDY:	1968-1970
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Benthic samples: weighted 0.0662m^2 Peterson grab Sediments - sieve analysis; sediment temperature Temperature and salinity of surface and bottom waters - VanDorn sampler. Salinity - induction salinometer. Hourly surface water temperature and salinity data collected over a 12-hour period at each station.
QUALITATIVE ASSESSMENT:	95 stations were established in a grid pattern. 273 quantitative samples of macroscopic benthic invertebrates were collected during winter and summer collections. Research primarily concerned with the seasonal species composition, density, distribution, diversity, and biomass of estuarine macroscopic invertebrate. General discussion of environment parameters and water quality in the bays.
REPORT OR REFERENCE LOCATION:	Morris Library, QH301.15
DESCRIPTORS:	BENTHIC INVERTEBRATES, TEMPERATURE, SALINITY, SEDIMENTS

AUTHOR:	Maurer, D., L. Watling, and G. Aprill
DATE:	1974
TITLE:	The Distribution and Ecology of Common Marine and Estuarine Pelecypods in the Delaware Bay Area
BIBLIOGRAPHICAL INFORMATION:	The Nautilus, V. 88, No. 2, p. 38-45
ABSTRACT:	Of the 44 common species of marine-estuarine pelecypods of the Delaware Bay region, about half (20) are true estuarine; the others are evenly distributed between euryhaline (11) and stenohaline (12) marine, with only one oligohaline species.
GEOGRAPHIC AREA:	Delaware Coast, including all three Inland Bays
PERIOD OF STUDY:	1967-1973
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Pelecypods (44 species) collected using epibentric dredge, osyter dredge, hard clam dredge, hydraulic surf clam dredge, Van Veen bottom grab, Peterson bottom grab. Samples sieved through 1.0 mm mesh screen, preserved in 10% buffered formalin. Sediments sieved for size analysis. Water temperature, salinity, dissolved oxygen measured.
QUALITATIVE ASSESSMENT:	Results presented in "telescopic form", i.e. summary of ecology of species in each type of environment based on salinity conditions, substrate type. Also list of species, salinity, substrate, and mode of life.
REPORT OR REFERENCE LOCATION:	Cannon Library, QL401.N38
DESCRIPTORS:	ESTUARINE ECOLOGY, WATER PARAMETERS

AUTHOR: MCA Engineering Corporation (for the State of Delaware)

DATE: 1974

TITLE: Water Quality Models for Rivers in Delaware

BIBLIOGRAPHICAL INFORMATION: State of Delaware, Department of Natural Resources and Environmental Control, Dover, Delaware

ABSTRACT: This report presents the development and application of a one-dimensional water quality predictive mathematical model for dissolved oxygen and BOD in each of 3 rivers: Broadkill River, Indian River, and Nanticoke River. The one-dimensional model was successful for the Broadkill and Nanticoke Rivers, but not so successful for Indian River. A 2-dimensional model may be more appropriate for approximating the water quality of the Indian River Estuary. The prinicpal objectives of the report are as follows:

1) Development of a one-dimensional water quality predictive mathematical model for dissolved oxygen and BOD relationships for the main stretches of the rivers.

2) Determination of assimilative capacity of the streams in terms of 5-day BOD and total oxygen demand.

3) Determination of the extent of wastewater treatment (in terms of 5-day BOD) required for existing and proposed discharges at various locations.

GEOGRAPHIC AREA: Broadkill River, Indian River, Nanticoke River (Excludes Rehoboth Bay Region)

PERIOD OF STUDY: Utilized previously collected data: 1950, 1969, 1970, 1971, 1972, 1973

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

Temperature - thermometer
Dissolved oxygen - Winkler method
BOD - standard methods
Chlorides - specific ion probe
Organic N - kjeldahl method
Ammonia N - technicon auto-analyzer

Total N - sum of organic N and ammonia N
Nitrite - technicon auto-analyzer
Nitrate - technicon auto-analyzer
Total coliform - MFT (standard method)
Fecal coliform - MFT (standard method)

Wastewater and water quality data supplied by Department of Natural Resources and Environmental Control. No new data collected by MCA Engineering Corp.

QUALITATIVE ASSESSMENT:

Report contains extensive data in tabular form. Appendix includes: tabulation of wastewater quality data from discharges; tabulation of water quality data of tributaries and freshwater sources, and tabulation of water quality data for verification plots. Also includes flushing time sample calculation for Indian River and discussion of possible nitrification for the Indian River through synthesis of data necessary for water quality modeling study e.g. Indian River cross-sectional areas, depth at MLW, drainage area, dissolved oxygen, and BOD profiles at various temperature and tide conditions, etc.

REPORT OR REFERENCE LOCATION:

Department of Natural Resources and Environmental Control

DESCRIPTORS:

WATER QUALITY

AUTHOR:	Miller, J. C.
DATE:	1971
TITLE:	Groundwater Geology of the Delaware Atlantic Seashore
BIBLIOGRAPHICAL INFORMATION:	Delaware Geological Survey Report of Inv. No. 17, Newark, DE, 33 p.
ABSTRACT:	Present (1971) water use in the Delaware Atlantic Seashore area is approximately 4 million GPD and will reach 9.3 million GPD by the year 2000. Report presents information on the deep aquifers in the Delaware Coastal area and provides recommendations on resource utilization.
GEOGRAPHIC AREA:	Cape Henlopen to Fenwick Island, Delaware
PERIOD OF STUDY:	Not applicable.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Groundwater chemical quality (chloride, iron, total dissolved solids, hardness, ph), draw-down; transmissibility. Units studied include Manokin, Pocomoke, Columbia, Holocene aquifers.
QUALITATIVE ASSESSMENT:	Report presents projections of groundwater availability; prediction of fresh/saltwater interface. "More test holes needed (as of 1971) to Pocomoke and Manokin aquifers to evaluate potential of these units to meet water needs of population" (author).
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark.
DESCRIPTORS:	GROUNDWATER QUALITY, GROUNDWATER MANAGEMENT/UTILIZATION

AUTHOR:	Miller, J. C.
DATE:	1972
TITLE:	Nitrate Contamination of the Water-table Aquifer in Delaware
BIBLIOGRAPHICAL INFORMATION:	Delaware Geological Survey Report of Inv. No. 20, Newark, Delaware, 36 p.
ABSTRACT:	Septic tank effluent disposal in soil places severe strains on groundwater quality. Chemical analyses indicate that many areas in the state have abnormally high nitrate concentrations in groundwater. Other sources of contamination include leaching from croplands where natural/artificial fertilizers are used; percolation from feedlots, poultry farms, barnyards.
GEOGRAPHIC AREA:	New Castle, Kent, and Sussex Counties
PERIOD OF STUDY:	1971-1972
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Nitrate concentrations in well water: nitrate specific ion electrode used for analysis of water from kitchen faucets and outside spigots.
QUALITATIVE ASSESSMENT:	Report provides maps (including Inland Bays area) where groundwater is most likely to be contaminated by nitrate or bacteria. Data tabulation of well number, NO_3, and specific conductance. Preliminary data on sampling in Millsboro, Dagsboro, Frankford and Selbyville areas, Sussex County.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark
DESCRIPTORS:	NITRATE CONTAMINATION, GROUNDWATER CONTAMINATION

AUTHOR:	National Oceanic and Atmospheric Administration (NOAA)
DATE:	Available Monthly
TITLE:	Climatological Data: Maryland and Delaware
BIBLIOGRAPHICAL INFORMATION:	ISSN 0145-0549, National Climatological Center, Asheville, North Carolina
ABSTRACT:	Daily measurements of climatological data (temperature, wind, rainfall)
GEOGRAPHIC AREA:	Sussex County sites: Bridgeville, Georgetown and Lewes
PERIOD OF STUDY:	1947 - present
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Rainfall, temperature (maximum, minimum, 8:00 a.m. reading), wind data (anemometer dial reading), evaporation data.
QUALITATIVE ASSESSMENT:	Data presented in tabulated form.
REPORT OR REFERENCE LOCATION:	Available from University of Delaware Agr. Substation, Georgetown, Delaware
DESCRIPTORS:	CLIMATOLOGICAL DATA, RAINFALL, AIR TEMPERATURE, WIND DATA

AUTHOR: Nemerow, N. L.

DATE: 1969

TITLE: Baffled Biological Basins for Treating Poultry Plant Wastes

BIBLIOGRAPHICAL INFORMATION: Journal of Water Poll. Cont. Fed., V. 41, pg. 1602-1612

ABSTRACT: This paper investigates the water quality problems at Indian River, Delaware, especially in light of the waste disposal of the Townsend Chicken Plant at Millsboro, Delaware. The stream data illustrate lack of positive evidence of the effect of organic loading, especially from the processing plant. It does show, however, bacterial contamination in recreational, fish, and shellfish producing waters.

GEOGRAPHIC AREA: Indian River

PERIOD OF STUDY: Summary of data previously collected 1953-1964

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Temperature, dissolved oxygen, dissolved oxygen sat., salinity, depth (Delaware State Water Pollution Commission), amount of freshwater flow into system (1953-1955), coliform counts.

Methods not indicated. Present data collected by State Water Pollution Commission. Tables summarizing water quality data 1953, 1954; coliform 1961-1964; salinity 1961-1964.

QUALITATIVE ASSESSMENT: 11 stations - one time sampling each year 1953 & 1954

Provides good summary of existing data on water quality in Indian River and Indian River Bay. Comments that there is a paucity of information (meaningful analytical data) concerning the sanitary characteristics of the receiving stream. Evidence of pollution is supported from instances of fish kills rather than direct stream analytical measurements.

REPORT OR REFERENCE LOCATION: Morris Library

DESCRIPTORS: WATER QUALITY, DISSOLVED OXYGEN, COLIFORM BACTERIA

AUTHOR: Orris, P. K.

DATE: 1972

TITLE: A Floristic and Ecological Survey of the Benthic Macro-Algae of Rehoboth Bay, Delaware.

BIBLIOGRAPHICAL INFORMATION: M. S. Thesis, University of Delaware, Newark, Delaware, 98 p.

ABSTRACT: Objectives of the study were to describe, qualitatively and quantitively, the bay's poorly known macro-algae community and to correlate patterns of distribution and seasonal change with environmental parameters. Determined that similarities of temperature and salinity throughout the bay make it unlikely that they are primary fators influencing geographic distribution of the algae. Light may influence distribution. Geographic distribution of aggregations parallels sediment distribution which indicates, indirectly, that water circulation may be important in maintaining integrity of separate aggregations.

GEOGRAPHIC AREA: Rehoboth Bay, Delaware

PERIOD OF STUDY: 14 month period in 1969-1970.

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

Seasonal water temperature; surface & bottom salinities; surface and bottom sediments.
light penetration (secchi disc).
surface and bottom - D.O., nitrate, inorganic phosphate.

Samples taken with modified Caribbean type dredge.
Temperature - (in situ) - reversing thermometer.
Salinity - in lab with salinometer.
Nitrate - brucine method.
D.O. - Winkler method.
Inorganic Phosphate - modified single solution method.

QUALITATIVE ASSESSMENT: 14 months of sampling. 12 sampling sites in Rehoboth Bay. Raw data for monthly samples tabulated in Appendix, including monthly hydrographic data. Detailed records and discussions of environmental parameters.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #20

DESCRIPTORS: SALINITY, TEMPERATURE, NUTRIENTS

AUTHOR:	Orris, P. K., and J. E. Taylor
DATE:	1973
TITLE:	A Floristic and Ecological Survey: The Benthic Macro-algae of Rehoboth Bay, Delaware
BIBLIOGRAPHICAL INFORMATION:	Botanica Marina, Vol. 16, p. 180-192
ABSTRACT:	Benthic macro-algae of Rehoboth Bay were surveyed to describe the community (qualitatively and quantitatively), and to correlate distribution patterns with seasonal change in environmental parameters; 59 taxa recorded, comprising 3 aggregrations based on sediment distribution. Water movement also plays a role in distribution patterns.
GEOGRAPHIC AREA:	Rehoboth Bay and Vicinity
PERIOD OF STUDY:	June 1969 -July 1970
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	12 sites sampled approximately monthly:algal samples (modified Caribbean-type dredge; visual inspection using SCUBA); surface and bottom temperature (protected reversing thermometer); salinity, surface and bottom (Biset-Berman salimometer); light penetration (Secchi disc); water depth (estimated); also DO (modified Winkler method); nitrate (brucine method); inorganic phosphate (modified single solution method).
QUALITATIVE ASSESSMENT:	Graphic presentation of data of monthly average temperatures, salinity, precipitation, DO, total number of benthic algal taxa by stations; statistical analysis conducted on data.
REPORT OR REFERENCE LOCATION:	Cannon Library, QK 564, B66
DESCRIPTORS:	BENTHIC MACRO-ALGAE, WATER QUALITY

AUTHOR:	Pacheco, A. L., and G. C. Grant
DATE:	1965
TITLE:	Studies of the Early Life History of Atlantic Menhaden in Estuarine Nurseries; Part I - Seasonal Occurrence of Juvenile Menhaden and Other Small Fishes in a Tributary Creek of Indian River, Delaware, 1957-1958.
BIBLIOGRAPHICAL INFORMATION:	U. S. Fish and Wildlife Service, Special Scientific Report -- Fisheries No. 504, 32 p.
ABSTRACT:	Monthly occurrences and size ranges of juvenile Atlantic menhaden and other small fishes in a tributary creek of Indian River, Delaware, are summarized from nearly 800 seine collections made over a 15 month period, 1957-1958.
GEOGRAPHIC AREA:	White Creek, Indian River Bay.
PERIOD OF STUDY:	1957-1958 (15 month period)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Fish populations, Temperature, Salinity, D.O. Hydrogen ion concentration, phosphate concentration, plankton volume. Methods not described.
QUALITATIVE ASSESSMENT:	8 sampling locations. 123 sampling days over a 15 month period. Appendix includes listing of raw data: Date, time, station, salinity, seine length, # menhaden, # other fishes. Report deals primarily with distributions and seasonal occurrences of fishes. Hydrographic data and observations are only summarized in this paper. Only temperature and salinity data included in text. No information on other environmental parameters sampled.
REPORT OR REFERENCE LOCATION:	Dr. Kent S. Price, personal copy
DESCRIPTORS:	FISH, WATER QUALITY.

AUTHOR:	Perlin, M., C. Y. H. Chen, R. A. Dalrymple, R. G. Dean, and J. C. Kraft
DATE:	1983
TITLE:	Sediment Budget and Sand Bypassing System Parameters for Delaware's Atlantic Coast
BIBLIOGRAPHICAL INFORMATION:	Prepared for Department of Natural Resources and Environmental Control, Dover, DE, 200p.
ABSTRACT:	A detailed sediment budget for the Atlantic shoreline of Delaware was developed using beach profiles from 1964 and 1982 with particular emphasis on the sediment transport in the vicinity of Indian River Inlet.
GEOGRAPHIC AREA:	Delaware Atlantic Coast (Indian River Inlet)
PERIOD OF STUDY:	Use of previous data 1964-1982
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Analysis of bathymetric changes in beach profiles. Longshore transport estimates. Quantification beach profile changes. Longshore Transport - hindcast results of Wave Information Study, U.S.A.C.E., W.E.S.
QUALITATIVE ASSESSMENT:	2 sets of profiles used to determine sediment transport rates and volumetric erosion (1964 & 1982). Calculated volumetric erosion and accretion and calculated net littoral drift integrated along shoreline. Made several assumptions. Devised sediment budget for Atlantic Coast. Individual sediment budget prepared for Indian River Inlet.
REPORT OR REFERENCE LOCATION:	Delaware Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation.
DESCRIPTORS:	SEDIMENT TRANSPORT, HYDROGRAPHY, INDIAN RIVER INLET

AUTHOR: Polis, D.

DATE: 1975-76b

TITLE: Assessing Effects of Development on Rehoboth, Indian River, and Little Assawoman Bays

BIBLIOGRAPHICAL INFORMATION: Delaware Sea Grant College Program R/T 12

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Power Magazine
DATE:	1984
TITLE:	Disposing of Powerplant Flyash Can Be Effected In An Environmentally Safe Manner
BIBLIOGRAPHICAL INFORMATION:	Power, V. 128, #2, pg. 45-48
ABSTRACT:	Delaware Department of Natural Resources and Environmental Control has indicated preference for dry disposal of flyash over ponding, and Delmarva Power and Light has responded in positive light. Starting in 1982, an effort was made to properly design and perform research into dryash landfill operation.
GEOGRAPHIC AREA:	Indian River Power Plant
PERIOD OF STUDY:	1982-1984
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Ground and surface waters are monitored to allow for early detection of potential groundwater contamination. 25 observation wells. 2 stream-gage stations. Groundwater and surface water quality are monitored quarterly for heavy metals, aluminum, arsenic, barium, bicarbonate, cadmium, calcium, chloride, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, nitrates, pH, temperature, total dissolved solids, total organic carbon, selenium, silver, specific conductance, sulfates, zinc.
QUALITATIVE ASSESSMENT:	Delmarva Power and Light conducted several research studies; hydrogeologic studies, chemical-binder analyses, and leachate test procedures were developed. Results of the column-leachate tests and water-balance calculations were incorporated into the groundwater flow and solute-transport model. Studies confirmed that groundwater flow is away from adjacent private property (but into Indian River Bay?).
REPORT OR REFERENCE LOCATION:	Morris Library, TJ 1.P68
DESCRIPTORS:	POWERPLANT, WATER QUALITY

AUTHOR: Price, K. S., Jr., and K. Derickson

DATE: 1969

TITLE: A Fish Survey and Ecological Study of Rehoboth and Indian River Bays

BIBLIOGRAPHICAL INFORMATION: University of Delaware Research Foundation Annual Report

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Radle, E. W.

DATE: 1971

TITLE: A Partial Life History of the Winter Flounder (Pseudopleuronectes americanus) Exposed to Thermal Addition in an Estuary, Indian River Bay, Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, University of Delaware, Newark, DE, 74p.

ABSTRACT: In November, 1969, approximately 1600 adult winter flounder were tagged with Peterson Disks in Indian River Estuary. Temperature in the estuary during winter are below those reportedly preferred by the adults which suggests that high concentrations of flounder in the area of a heated effluent source are a result of flounder seeking optimal winter temperatures. This study attempts to assess the impact on the thermal effluent on various aspects of the flounder's ecology in the Indian River Estuary.

GEOGRAPHIC AREA: Indian River

PERIOD OF STUDY: June 1969 - May 1970

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Winter flounder - beach haul seine and otter trawl

Surface and bottom - dissolved oxygen (Winkler), temperature and salinity (induction salinometer).

QUALITATIVE ASSESSMENT: 14 stations were sampled monthly June 1969 - May 1970. Raw data included distribution of temperature, salinities, and dissolved oxygen (in table form - surface and bottom data). Discussion of mixing of water in estuary and salinity wedge. Dissolved oxygen levels are high enough that O_2 does not appear to be a critical factor for fish in the estuary. Low O_2 values do occur, but are infrequent and localized. Includes general discussion on effects of temperature on flounder.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #37

DESCRIPTORS: FISH, WATER QUALITY

AUTHOR:	Ritter, W. F.
DATE:	1977
TITLE:	Modeling Nonpoint Source Pollution in Coastal Sussex County
BIBLIOGRAPHICAL INFORMATION:	Final Report, Task 2351, Coastal Sussex County Water Quality Management Program, 65 p.
ABSTRACT:	Report summarizes results of nonpoint source pollution modeling in Sussex County. Includes literature review, outline of model, model calibration, simulation results, pollution from agricultural and urban land, transport of nonpoint source pollutants coupled with hydrologic models.
GEOGRAPHIC AREA:	Eastern Sussex County, Delaware
PERIOD OF STUDY:	Not applicable.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	ARM model by HYDROCOMP and EPA (most widely used runoff model), runoff and nutrient contributions to streams used in this study. Procedure involves selecting values for parameters then adjusting via calibration. Results include calculation of total P, N, orthophosphorus, inorganic nitrogen loads.
QUALITATIVE ASSESSMENT:	"ARM model gave satisfactory results for runoff simulation, but did not give reasonable results for N and P nonpoint source loads" (author). Author recommends testing other models. Questions if enough hydrograph stations are available in study area.
REPORT OR REFERENCE LOCATION:	Available from Department of Agricultural Engineering, University of Delaware, Newark, Delaware.
DESCRIPTORS:	NONPOINT SOURCE POLLUTION, NUTRIENT LOADING

AUTHOR:	Ritter, W. F., and A.E.M. Chirnside
DATE:	1982
TITLE:	Groundwater Quality in Selected Areas of Kent and Sussex County, Delaware
BIBLIOGRAPHICAL INFORMATION:	Report to DNREC, Dover, Delaware, 229 p.
ABSTRACT:	Report presents results of groundwater quality monitoring program. In coastal Sussex, 32% of wells exceeded EPA standards for nitrate; these areas correlated with broiler production; intensive crop production, and/or excessively drained soils. Saltwater intrusion in Long Neck area.
GEOGRAPHIC AREA:	Kent, Sussex Counties, Delaware
PERIOD OF STUDY:	May 1980 - August 1981
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	210 wells, 21 surface water locations sampled 12 times each in Sussex County for: nitrates, ammonia, pH, chlorides; selected samples for total organic carbon, total coliform, fecal coliform, iron, copper, zinc, manganese, lead, cadmium, chromium
QUALITATIVE ASSESSMENT:	Quality control program similar to EPA was used. Tabulation of results of chemical analysis presented; groundwater flow patterns, land-use patterns discussed. Contains "Best Management Practices" for solutions to groundwater pollution problems.
REPORT OR REFERENCE LOCATION:	Available from DNREC, Dover, DE
DESCRIPTORS:	GROUNDWATER QUALITY, NITRATE CONTAMINATION, SALTWATER INTRUSION

AUTHOR:	Ritter, W. F., and P. A. Jensen
DATE:	1979
TITLE:	Water Quality Modeling in the Delaware Coastal Plain Region
BIBLIOGRAPHICAL INFORMATION:	In Best Management Practices for Agriculture and Siliviculture: Proc. of the 1978 Cornell Agricultural Waste Management Conf., p. 507-54.
ABSTRACT:	Summary of modeling of water quality in Sussex County, Delaware yielded acceptable results for simulation of runoff from agricultural watersheds on coastal plain soils for low flow and storm conditions.
GEOGRAPHIC AREA:	Sussex County Area, Delaware
PERIOD OF STUDY:	Monitoring of nonpoint source pollution, April 1976 - September 1977
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	EPA Agricultural Runoff Model (ARM) utilized, in conjunction with a one dimensional water quality model. Input parameters include rainfall, evaporation and 22 others to describe watersned; (included are estuarine nitrogen cycle, BOD, DO, total coliform).
QUALITATIVE ASSESSMENT:	"Selection of input parameters is subjective, based on judgment" (authors). Results based on calibration of model; reasonable agreement obtained between simulated and recorded storm hydrographs. Nutrient subroutine could not be calibrated to produce reasonable results; nitrogen cycle model crude approximation, as estuarine biochemical cycles are complex.
REPORT OR REFERENCE LOCATION:	Available from College of Agriculture, University of Delaware, Newark, Delaware (Department of Agricultural Engineering)
DESCRIPTORS:	WATER QUALITY MODELING, NONPOINT SOURCE LOADING, NITROGEN CYCLE MODELING

AUTHOR:	Ritter, W. F., and G. Scheffler
DATE:	1977
TITLE:	Monitoring nonpoint source pollution in Coastal Sussex County.
BIBLIOGRAPHICAL INFORMATION:	Final Report for Task 2332, Coastal Sussex Water Quality Management Program, 104 p.
ABSTRACT:	Summary of literature on nonpoint source pollution from urban and agricultural sources. Large amounts of nitrogen appear to be lost during late February-March. Nonpoint source pollution represents significant portion of the N, P, COD stream loads in study areas - 60% of N in Inland Bays from nonpoint sources.
GEOGRAPHIC AREA:	Southeastern Sussex County, Delaware
PERIOD OF STUDY:	April 1976 - September 1977
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Samples analyzed for N, P, COD, orthophosphorus, total phosphorus, nitrate, nitrite, nitrogen ammonia, Kjeldahl nitrogen; some for total coliform. Six stream gaging stations established for study. Land use acreages calculated from state planning office maps. Various models used for nonpoint source samples.
QUALITATIVE ASSESSMENT:	Nonpoint source data: loading rates vary with rainfall; long-term sampling program required. Loading rates tabulated in report (COD, total phosphorous, orthosphorus, organic nitrogen, ammonia, nitrate/nitrite). "Monitoring of nonpoint source pollution should be continued to provide better estimates of loads" (authors).
REPORT OR REFERENCE LOCATION:	Available from Department of Agricultural Engineering, University of Delaware, Newark.
DESCRIPTORS:	NONPOINT SOURCE POLLUTION, NUTRIENT LOADING

AUTHOR: Robertson, F. W.

DATE: 1977

TITLE: The Quality and Potential Problems of Groundwater in Coastal Sussex County, Delaware

BIBLIOGRAPHICAL INFORMATION: Water Resources Center, University of Delaware, Newark, Delaware

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Scotton, L. W.
DATE:	1970
TITLE:	Occurrence and Distribution of Larval Fishes in the Rehoboth and Indian River Bays of Delaware
BIBLIOGRAPHICAL INFORMATION:	M.S. Thesis, University of Delaware, Newark, DE, 66p.
ABSTRACT:	Plankton sampling done in Indian River and Rehoboth Bays resulted in collection of larvae of 20 fish species. Most abundant were the bay anchovy Anchoa mitchilli, Menidia menidia, Gobiosoma bosci, and Brevoortia tyrannus. Larvae abundance fluctuated seasonally. Data collected in this survey indicate that the bays are utilized as nursery grounds by numerous species of fish.
GEOGRAPHIC AREA:	Rehoboth and Indian River Bays
PERIOD OF STUDY:	June 1968 - March 1970
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Species and numbers of larve collected. Surface water temperature; surface samples for salinity and BOD analyses. Plankton net utilized. No description of temperature, salinity, and BOD analyses.
QUALITATIVE ASSESSMENT:	18 stations in Rehoboth and Indian River Bays sampled monthly June 1968 - March 1970. (19 months of data). Thorough discussion of larvae and distribution in bay, and comparison of this work with other studies but no correlation of distribution with environmental parameters. Temperature, salinity, and BOD data not included in text or appendix.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #26
DESCRIPTORS:	LARVAL FISH DISTRIBUTION

AUTHOR:	Shore Protection Board, Office of Chief Engineer
DATE:	1936
TITLE:	Report on the Probable Effect on the Beaches for Ten Miles Either Side of the Proposed Improvement at Indian River Inlet, DE
BIBLIOGRAPHICAL INFORMATION:	U.S. Army Corps of Engineers; Shore Protection Board, 1936.
ABSTRACT:	Description of probable effect of proposed improvements at Indian River Inlet on adjacent beaches.
GEOGRAPHIC AREA:	Indian River Inlet
PERIOD OF STUDY:	pre-1936
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Historical changes, sediments, currents Map showing shoreline changes for distance of ten miles each side of proposed improvement. Map showing changes in 6', 12', and 18' depth contours. Current readings in ocean Sand samples Study of wind and weather conditions
QUALITATIVE ASSESSMENT:	Historical account of inlet opening and closures. Data on widths, lengths, and depths of inlet area. Thorough discussion of changes in shoreline, changes in offshore depths, current measurements, and consideration of hydraulics of proposed inlet channel.
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	INDIAN RIVER INLET, SURVEY, HYDROGRAPHY

AUTHOR: Slaughter, T. H.

DATE: 1962

TITLE: Beach-Area Water Supplies Between Ocean City, Maryland, and Rehoboth Beach, Delaware

BIBLIOGRAPHICAL INFORMATION: U.S.G.S. Water Supply Paper 1619-T, p. T1-T10

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Smith, R. A., A. S. Brooks, and L. D. Jensen
DATE:	1974
TITLE:	Effects of Condenser Entrainment on Algal Photosynthesis at Mid-Atlantic Power Plants
BIBLIOGRAPHICAL INFORMATION:	In: L.D.Jensen, ed., Entrainment and Intake Screening Proceedings of the 2nd Entrainment and Intake Screening Workshop held at Johns Hopkins University, Baltimore, MD, p. 113-122.
ABSTRACT:	Study is an investigation of when changes in photosynthetic activity reflect permanent effects (i.e. destruction of algal cells) as opposed to temporary physiological responses to temperature rise.
GEOGRAPHIC AREA:	Indian River Estuary, Delaware
PERIOD OF STUDY:	1970 - 1974
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Compared photosynthetic ^{14}C fixation between intake and discharge samples. Photosynthetic rate measurements based on duplicate light bottle determinations were used to calculate different indices of plant effects.
QUALITATIVE ASSESSMENT:	Many graphs and discussions linking photosynthetic rates and temperatures. No overall discussion of effects of the plant on the estuary as a whole. Includes maps and diagrams depicting estimated changes in algal photosynthesis in Indian River with regard to temperature changes.
REPORT OR REFERENCE LOCATION:	Cannon Library, TJ 164.J45
DESCRIPTORS:	POWER PLANT, PHOTOSYNTHESIS

AUTHOR:	State of Delaware Agencies
DATE:	1969
TITLE:	Environmental Study of the Rehoboth, Indian River, and Assawoman Bays
BIBLIOGRAPHICAL INFORMATION:	Prepared for State of Delaware, 35p. Prepared by State Game and Fish Commission, State Park Commission, State Planning Office, Marine Labs University of Delaware, Water and Air Resources Commission, Delaware Geological Survey
ABSTRACT:	This study represents a joint effect by the State's Natural Resources and Planning agencies to document the need for preserving Delaware's Inland Bay areas and to outline a specific program for achieving that goal.
GEOGRAPHIC AREA:	Inland Bays of Delaware
PERIOD OF STUDY:	Previous data used in discussion (pre-1969)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	No data collected for this summary report; based on existing data and previous reports. No methods described.
QUALITATIVE ASSESSMENT:	Thorough discussions of problem areas which are still applicable in 1985! Discussion of groundwater hydrology, salt water encroachment, wetlands, wells, biological studies (plankton, algae, fish, general productivity, land use trends, 1938-1969). Recommends water quality standards and programs to meet them, ideas on shoreline aquisition, general recommendations for environmental controls.
REPORT OR REFERENCE LOCATION:	Department of Natural Resources and Environmental Control
DESCRIPTORS:	WATER QUALITY, INLAND BAYS

AUTHOR:	Stegner, S. R.
DATE:	1972
TITLE:	Analog Model Study of Groundwater Flow in the Rehoboth Bay Area, Delaware
BIBLIOGRAPHICAL INFORMATION:	Technical Report No. 12, CMS, University of Delaware, Newark, 70p.
ABSTRACT:	Model study of groundwater flow in Rehoboth Bay including interactions between fresh and saline groundwater; stability of groundwater body; and discussion of danger of saltwater pollution.
GEOGRAPHIC AREA:	Rehoboth Bay, Delaware
PERIOD OF STUDY:	1972
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Experimental model: Hele-Shaw viscous flow analog model using rainfall and freshwater head; soil properties (porosity, hydraulic conductivity); 11 experiments conducted utilizing varying input data.
QUALITATIVE ASSESSMENT:	Comparison between model and nature; results of experiments yield predictions of position of fresh/salt interface for open/closed Indian River Inlet.
REPORT OR REFERENCE LOCATION:	Cannon Library, Tech. Rept. #12
DESCRIPTORS:	GROUNDWATER FLOW, SALTWATER INTRUSION

AUTHOR:	Stumpf, R. P.
DATE:	1983
TITLE:	The Process of Sedimentation on the Surface of a Salt Marsh
BIBLIOGRAPHICAL INFORMATION:	Estuarine, Coastal and Shelf Sci., V. 17, p. 495-508
ABSTRACT:	Presentation of hydrography and sedimentation processes and rates in a salt marsh. Storm effects very important in sedimentation process. Seasonal variations in suspended sediment content of creeks. Sedimentation rate of 0.5 mm/yr (since 1917), keeping pace with sea level rise.
GEOGRAPHIC AREA:	Holland Glade Marsh, Sussex County, Delaware
PERIOD OF STUDY:	1980-81
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Current velocities (electromagnetic current meter); dye studies; water temperatures, salinity; suspended sediment content; sedimentation rates; core samples.
QUALITATIVE ASSESSMENT:	Results of field measurements presented in narrative (summary) form; interpretations relevant to sedimentation processes are given.
REPORT OR REFERENCE LOCATION:	Cannon Library, GC96,E85
DESCRIPTORS:	SALT MARSH SEDIMENTATION, SALT MARSH HYDROGRAPHY

AUTHOR: Sundstrom, R. W., and T. E. Pickett

DATE: 1969

TITLE: The Availability of Ground Water in Eastern Sussex County, Delaware

BIBLIOGRAPHICAL INFORMATION: University of Delaware Water Resources Center, Newark, Delaware

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	Sundstrom, R.W., T.E. Pickett, and R.D. Varrin
DATE:	1976
TITLE:	Hydrology, Geology, and Mineral Resources of the Coastal Zone of Delaware
BIBLIOGRAPHICAL INFORMATION:	Technical Report No. 3, Delaware Coastal Zone Management Program, Delaware State Planning Office, Dover, DE, 245 p.
ABSTRACT:	Compilation and discussion of existing data on geology, hydrology and minerals in Delaware, "State of the Art" Summary (1975).
GEOGRAPHIC AREA:	Delaware
PERIOD OF STUDY:	Various periods for various data sets.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Data relevant to water quality/circulation in Inland Bays include: stream flow data (16 years); depth to aquifers; thickness of aquifers; stream average discharge, maximum discharge, minimum discharge; salinity cross-sections of Indian River and Bay (July, 1967); chemistry of groundwater.
QUALITATIVE ASSESSMENT:	Discussion of saltwater intrusion problems in coastal Delaware; data on groundwater quality relevant to Inland Bays region; stream flow data for circulation input.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark, DE.
DESCRIPTORS:	HYDROLOGY, GEOLOGY, MINERAL RESOURCES

AUTHOR:	Swisher, M.L.
DATE:	1982
TITLE:	The Rates and Causes of Shore Erosion Around a Transgressive Coastal Lagoon, Rehoboth Bay, Delaware
BIBLIOGRAPHICAL INFORMATION:	MS Thesis, College of Marine Studies, University of Delaware, Newark, 210 p.
ABSTRACT:	Rehoboth Bay is a low energy transgressive coastal lagoon with average long-term erosion rates <1.0 m/yr with high-frequency short-term fluctuations. Sandy beaches and muddy marsh shorelines respond differently to physical erosional forces.
GEOGRAPHIC AREA:	Rehoboth Bay, Delaware
PERIOD OF STUDY:	1981-82 (field study)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Shoreline changes, 1938-1981 (aerial photo analysis), 15 shoreline sites monitored monthly, 1981-82 (wave data, currents, beach profiles). Nearly 50 sediment cores described (obtained by vibracoring; soil auger; jet wash).
QUALITATIVE ASSESSMENT:	Documentation of effect of physical forces on sediment transport and shore erosion/accretion; discussion of Indian River Inlet stabilization/dredging history; land-use patterns. Erosion-prone areas delineated.
REPORT OR REFERENCE LOCATION:	Cannon Library, Thesis #219
DESCRIPTORS:	SHORE EROSION, COASTAL LAGOON, TRANSGRESSIVE STRATIGRAPHY

AUTHOR:	Talley, J. H.
DATE:	1977
TITLE:	The Storm of October 13-15, 1977
BIBLIOGRAPHICAL INFORMATION:	Unpublished Report, Delaware Geological Survey, University of Delaware, Newark, in Delaware Coastal Storm Damage Report, 1923-74: Tech. Rept. No. 4, Delaware Coastal Management Program, Dover, DE 442 p.
ABSTRACT:	Compilation of tide heights, wind data, precipitation, and observations on washover, flooding and erosion during the October 1977 coastal storm.
GEOGRAPHIC AREA:	Coastal Delaware
PERIOD OF STUDY:	October 13-17, 1977
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Tide gage data (hourly); wind velocity and direction (3 hr. intervals) precipitation data (8 stations).
QUALITATIVE ASSESSMENT:	Tabulation of meteorological data; tide gage data useful for circulation studies.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey; and DNREC, Dover, DE.
DESCRIPTORS:	STORM TIDES, WATER LEVELS, PRECIPITATION, WIND DATA, STORM DAMAGE

AUTHOR:	Talley, J.H.
DATE:	1984
TITLE:	Summary Report and Data Compilation of the Storm of March 28-29, 1984 in Delaware
BIBLIOGRAPHICAL INFORMATION:	Unpublished Report, Delaware Geological Survey, University of Delaware, Newark, Delaware 19 p.
ABSTRACT:	Compilation of data and observations on flooding and coastal erosion for the March 1984 coastal storm.
GEOGRAPHIC AREA:	Coastal Delaware
PERIOD OF STUDY:	March 27-31, 1984
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Tide gage data (3 stations), hourly readings; wind data (4 stations), every 3 hours; barometric pressure (4 stations).
QUALITATIVE ASSESSMENT:	Presentation of actual vs. predicted tide heights; wind, pressure data; observations on washover areas, beach/dune erosion; road flooding; structural damage.
REPORT OR REFERENCE LOCATION:	Available from Delaware Geological Survey, Penny Hall, University of Delaware, Newark, Delaware.
DESCRIPTORS:	STORM TIDES, WATER LEVELS, WIND AND PRESSURE DATA, STORM DAMAGE

AUTHOR:	Thompson, W. W., and R. A. Dalrymple
DATE:	1976
TITLE:	A History of Indian River Inlet, Delaware
BIBLIOGRAPHICAL INFORMATION:	Shore and Beach, Vol. 44, No. 2, July 1976, p. 24-31.
ABSTRACT:	Description of history of Indian River Inlet citing natural openings and closure, general circulation in vicinity, and stabilization of inlet with jetties.
GEOGRAPHIC AREA:	Indian River Inlet, DE
PERIOD OF STUDY:	Historical analysis of inlet and environments 1800 - present.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Historical records of inlet openings and closures. Historical maps document inlet location in 1800, 1843, 1882, 1907.
QUALITATIVE ASSESSMENT:	Historical data and evaluation of inlet openings and closings due to sedimentation, variability in water discharge, etc. Describes U.S. A.C.E. evaluations of tidal prisms, etc. and general effects of canals on inlet - generalized circulation discussion.
REPORT OR REFERENCE LOCATION:	Morris Library
DESCRIPTORS:	INDIAN RIVER INLET, CIRCULATION

AUTHOR: Thornton, L. L.

DATE: 1975

TITLE: Laboratory Experiments on the Oxygen Consumption and Resistence to Low Oxygen Levels of Certain Estuarine Fishes

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, University of Delaware, Newark, DE, 82p.

ABSTRACT: Oxygen requirements for 8 species of estuarine fishes were studied in 3 distinct experiments. A list was drawn up ordering species vulnerability to low oxygen concentrations. Minimum dissolved oxygen concentrations were determined by field sampling in Summer, 1974, in White Creek, Indian River Bay, Delaware. Using information obtained in the laboratory experiments and field data, a comment is made on comparison between a 1957-1958 Bureau of Commercial Fisheries survey and an identical 1973-1974 fish survey of White Creek, to indicate whether dissolved oxygen acts as a limiting factor in the creek.

GEOGRAPHIC AREA: White Creek, Indian River Bay

PERIOD OF STUDY: August 8, 1974 and August 22, 1974. Sunrise, low tide

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Lab experiments on fish. Field data - dissolved oxygen samples, bottom sampling, sunrise, low tide, salinity, and temperature.

Ten sampling locations in White Creek. Nansen bottle for collection then to black bottles. No data on methods for parameters. All analyses conducted at University of Delaware Marine Sediment Laboratory.

QUALITATIVE ASSESSMENT: 2 days of sampling at 10 stations.

Includes graphs:

% saturation - 50-60% at mouth of creek
- 20-30% at head

Temperature > 20°C every station

Salinity - 28.6‰ at mouth
- 10.1‰ at head

Discussion of environmental parameters and fish population, comparing 1957-1958 with 1974-1975. Discussion of effects of pollutional stresses on fish communities.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #52

DESCRIPTORS: DISSOLVED OXYGEN, FISH

AUTHOR: Tinsman, J. C.

DATE: 1973

TITLE: The Effects of Thermal Effluent on the American Oyster, Crassostrea virginica, in Indian River Bay, DE

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, University of Delaware, Newark, DE, 127p.

ABSTRACT: The heated effluent at the power plant had the effect of shortening and modifying the severity of the winter and therefore increasing the growing season. Oysters in the effluent showed the greatest shell growth throughout the study. Meat weights and glycogen concentrations in the effluent were highest of all stations in the winter. Summer conditions in the effluent were severe and meat weights and glycogen concentrations were lower than at other stations.

GEOGRAPHIC AREA: Indian River

PERIOD OF STUDY: June 1970 - May 1971

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Water temperature, salinity, and dissolved oxygen measure in field with Hydrolab, Model IIA. Oyster sampling - shell heights, lengths, widths, meat weights, glycogen concentration.

All data supplemented by extensive continuous temperature data collected by DP & L - Spring driven Foxboro 7 day continuous temperature recorder.

QUALITATIVE ASSESSMENT: 3 stations at Indian River Bay. June-August sampling 2-4 times per month. September-May monthly sampling. Table of weekly mean temperature readings (°C) for 34 weeks of study. Weekly mean temperature data June 1, 1970 - June 6, 1971. Mean salinity (ppt), and mean dissolved oxygen (ppm) provided for 3 stations. Thorough discussion on environmental parameters and effects on oysters (especially temperature).

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #121

DESCRIPTORS: TEMPERATURE, SALINITY, DISSOLVED OXYGEN, SHELLFISH

AUTHOR:	Toomey, D. W., and G. L. Esposito
DATE:	1977
TITLE:	Task Rept. 2322: Natural Environmental Baseline Inventory - "Critical Natural Areas" of the Coastal Sussex Water Quality Program
BIBLIOGRAPHICAL INFORMATION:	State of Delaware, Department of Natural Resources and Environmental Control, 71p.
ABSTRACT:	This report provides documentation and description of critical natural areas in Coastal Sussex County, and also serves as a policy statement regarding the identified areas. The report suggests that the designated areas should be controlled and protected in an effective and thorough manner.
GEOGRAPHIC AREA:	Broadkill River Basin, Indian River Bay Basin, Little Assawoman Bay Basin
PERIOD OF STUDY:	Previous work (1977 and earlier)
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Data on environment of area including discussions on geography, economy, geology, hydrology, meteorology, land use, and water quality of each region. Methods not described.
QUALITATIVE ASSESSMENT:	The report identifies, describes, and summarizes the critical natural areas in Coastal Sussex County utilizing designations of the Delaware Natural Education Society, Department of Natural Resources and Environmental Control 208 Staff, the Delaware Division of Fish and Wildlife, and miscellaneous contributor designations.
REPORT OR REFERENCE LOCATION:	Delaware Department of Natural Resources and Environmental Control
DESCRIPTORS:	INDIAN RIVER BAY BASIN, LITTLE ASSAWOMAN BAY BASIN

AUTHOR: U.S. Army Corps of Engineers

DATE: 1974

TITLE: Indian River Inlet, Project Maintenance, Sussex County, Delaware

BIBLIOGRAPHICAL INFORMATION: Army Engineering District, Philadelphia, PA #ELR-74-0164, 51 p.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR:	U.S. Army Corps of Engineers, Philadelphia District
DATE:	1921-1969
TITLE:	Map File Index - On Indian River Bay, DE
BIBLIOGRAPHICAL INFORMATION:	Obtained from Philadelphia District, USACE
ABSTRACT:	Map file index of surveys.
GEOGRAPHIC AREA:	Indian River Inlet and Bay, DE. Rehoboth Bay, Little Assawoman Bay.
PERIOD OF STUDY:	1921-1969
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Map file of surveys. No methods described.
QUALITATIVE ASSESSMENT:	Information on data available and surveys available from the Philadelphia District, U.S. Army Corps of Engineers.
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	MAP SURVEYS, INLAND BAYS

AUTHOR:	U.S. Army Corps of Engineers, Philadelphia District
DATE:	1938
TITLE:	Technical Studies of Inlets; Absecon Inlet & Indian River Inlet
BIBLIOGRAPHICAL INFORMATION:	U.S. Army Corps of Engineers, Philadelphia District, 1938
ABSTRACT:	Evaluation of considerations made in design of Indian River Inlet, DE.
GEOGRAPHIC AREA:	Indian River Inlet
PERIOD OF STUDY:	pre-1938
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Survey map of inlet area and bay. Current and tide observations made. Observations of ocean currents. No methods described.
QUALITATIVE ASSESSMENT:	Discussion of considerations made in design of inlet channel and jetties, including tidal currents and general hydraulics.
REPORT OR REFERENCE LOCATION:	Cannon Library
DESCRIPTORS:	INLET DESIGN

AUTHOR: U. S. Congress

DATE: 1892

TITLE: Preliminary Examination of Indian River, Delaware

BIBLIOGRAPHICAL INFORMATION: Senate Executive Document No. 176, 47th Congress, 1st Session.

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: On file in archives at Philadelphia District, U.S. Army Corps of Engineers.

This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: U.S. Congress

DATE: 1937

TITLE: Report on Indian River Inlet and Bay, Delaware

BIBLIOGRAPHICAL INFORMATION: Committee on Rives and Harbors, Document No. 41, 75th Congress, 1st Session

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: On file in archives at Philadelphia District, U.S. Army Corps of Engineers.

This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: U.S. Congress

DATE: 1912

TITLE: Preliminary examination of Indian River Inlet, Delaware

BIBLIOGRAPHICAL INFORMATION: House Document No. 1055, 62nd Congress, 3rd Session

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

U.S. Department of Agriculture Soil Conservation Service in cooperation with Delaware Agriculture Experimental Station

1974

Soil Survey of Sussex County, DE

RAPHICAL
TION:

T: This soil survey contains information that can be applied in managing farms and woodlands, in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, residential development, and recreation.

HIC AREA: Sussex County, DE

OF STUDY: 1944-1970 (field work)

DATA COLLECTED,
S CONDUCTED,
USED: Soil types.

Methods not described.

TI ASSESSMENT: Provides general description of soils in Sussex County, including tidal marsh, salty-coastal beach and dune land soils, and tidal marsh, freshwater association soils. Also discusses use and management of soils with regard to general management practices, suitability of soils for wildlife habitat, engineering uses of soils, and town and country planning.

OR REFERENCE LOCATION: Delaware Department of Natural Resources and Environmental Control

TORS: SOILS, PLANNING

AUTHOR: Vargas, J. A.

DATE: 1979

TITLE: Predation and Community Structure of Soft-bottom Benthos in Rehoboth Bay, Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, College of Marine Studies, Lewes, DE, 108p.

ABSTRACT: Primary objective of the study was to evaluate effects of caging upon community structure of subtidal soft bottom benthic fauna. Sampling compared protected and unprotected areas. Computed species densities and diversities, and spatial aggregation. Concludes that disturbance, usually in the form of predation, by way of its influence upon environmental heterogeneity, spatial pattern, and species diversity, regulates community structure of the study area.

GEOGRAPHIC AREA: Rehoboth Bay; eastern shore of Camp Arrowhead

PERIOD OF STUDY: July to November 1977

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Sediment analyses, salinity, dissolved oxygen, water, sediment temperature, benthic species, measurements of community structure.

Salinity - refractometer; dissolved oxygen - Winkler method; silt-phi fractions - pipette analysis; sand - wentworth seiving; statistical analysis - F-test, t-test, chi-square test, regression analysis.

QUALITATIVE ASSESSMENT: Values of environmental parameters presented in table form. Summaries of biological parameters included, too. Lots of species information, but not much correlation between biological and environmental parameters.

Water temperature range 31°C - 4°C
Salinity range - 28.5‰ to 30‰
Dissolved oxygen from 3.3 ppm to 8.38 ppm

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #119

DESCRIPTORS: WATER QUALITY, BENTHIC ORGANISMS

AUTHOR: Warlen, S. M.

DATE: 1964

TITLE: Some Aspects of the Life History of Cyprinodon variegatus Lacépéde 1803, in Southern Delaware

BIBLIOGRAPHICAL INFORMATION: M.S. Thesis, University of Delaware, Newark, DE, 40p.

ABSTRACT: 5740 specimans of Cyprinodon variegatus were collected in the shore zones of Rehoboth and Indian River Bays. Study investigated distribution of the species, age, and growth patterns, reproduction and spawning, food and feeding habits. Environmental parameters were measured to determine typical habitat description. Cyprinodon variegatus appears to be a permanent resident of the shallow brackish waters (0.0 - 5.0 ft) of southern Delaware occurring in salinities which varied from 14.25 - 31.27‰ and water temperatures of 2-33°C.

GEOGRAPHIC AREA: Indian River and Rehoboth Bays

PERIOD OF STUDY: May 12, 1962 - December 20, 1962

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Water depth, fish specimens, temperature, stage of tide, salinity, type of substrate

Fish specimens - 2 man 0.50" stretched mesh push seines.
Salinity-modified Knudsen methods of ion titration. Other hydrographic information was merely noted.

QUALITATIVE ASSESSMENT: Total of 13 collections were made at 8 sites (sampled 2 times a month). Provides tabulated raw data for temperature, salinity, and water depth readings for field stations. Primarily a discussion of the fish Cyprinodon variegatus, but includes some discussion of effects of environmental parameters on distribution. No dissolved oxygen measurements made.

REPORT OR REFERENCE LOCATION: Cannon Library, Thesis #59

DESCRIPTORS: FISH, TEMPERATURE, SALINITY

AUTHOR:	Watling, L.
DATE:	1976
TITLE:	Analysis of Structural Variations In A Shallow Estuarine Deposit-Feeding Community
BIBLIOGRAPHICAL INFORMATION:	Marine Studies Library CMS-2-76
ABSTRACT:	Changes in the structure of an estuarine, subtidal, benthic deposit-feeding community were investigated. Five dominant species were delineated on the basis of their total abundance, % occurrence, and biological index value. A decrease in average niche width and average niche overlap was observed as the community developed during the period of strong larval recruitment.
GEOGRAPHIC AREA:	Rehoboth Bay
PERIOD OF STUDY:	May 1971 - July 1973
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Benthic organisms, air temperature, salinity, water temperature, sediment temperature, one diurnal dissolved oxygen study. Max-min. thermometer used. Other method information not indicated.
QUALITATIVE ASSESSMENT:	3 quantitative samples taken every four weeks from May 1971 - July 1973. Tables of temperature and salinity data May 1971 - July 1973. Table of summary of sediment data.
REPORT OR REFERENCE LOCATION:	Cannon Library, CMS-2-76
DESCRIPTORS:	BENTHIC ORGANISMS, TEMPERATURE, SALINITY

AUTHOR:	Watling, L., and D. Maurer
DATE:	1972
TITLE:	Shallow Water Hydroids of the Delaware Bay Region
BIBLIOGRAPHICAL INFORMATION:	J. Nat. Hist., 1972, Vol. 6: 643-649; or DEL-SG-6-73
ABSTRACT:	This study was undertaken to determine the species composition of hydroids in the shallow waters of the Delaware Bay area, and their distribution with reference to salinity and substrate. Collections were made in water less than 8 m deep in the western portion of Delaware Bay and in Indian River and Rehoboth Bays. The authors conclude that in polyhaline salinities, the distribution of local hydroids is associated more with a hard substrate than salinity.
GEOGRAPHIC AREA:	Delaware, Rehoboth, and Indian River Bays
PERIOD OF STUDY:	Summer 1968, 1969; Winter 1969, 1970
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Five total stations in Indian River and Rehoboth Bays. Hydrographic data compiled from a variety of research projects, and salinity classification follows the Venice System (1958). Hydroids - dredge, Peterson grab, handpicking. Environmental parameters methods not indicated.
QUALITATIVE ASSESSMENT:	Range of temperature, salinity, and substrate type for collecting areas is listed. Five sampling sites in Inland Bays provide maximum and minimum temperature and salinity data for each station. Generally, paper is discussion of hydroid distribution in relation to water quality (temperature and salinity).
REPORT OR REFERENCE LOCATION:	Morris Library, QH 1.568; Cannon Library, DEL-SG-6-73
DESCRIPTORS:	HYDROIDS, TEMPERATURE, SALINITY

AUTHOR:	Watling, L., J. Lindsay, R. Smith, and D. Maurer
DATE:	1974
TITLE:	The Distribution of Isopoda in the Delaware Bay Region
BIBLIOGRAPHICAL INFORMATION:	Int. Revue ges Hydrobiol., 59 (3), p. 343-351
ABSTRACT:	The distributions of 24 marine and estuarine isopods have been reviewed. The research examines the distribution and ecology of the estuarine and marine isopods in the Delaware Bay region. Distribution was related to general ecology of the area, especially with regard to increasing interest in problems of thermal, domestic, and industrial pollution.
GEOGRAPHIC AREA:	Delaware Bay, Rehoboth and Indian River Bay
PERIOD OF STUDY:	Not indicated
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Isopods (biol. sampling), temperature, salinity, dissolved oxygen, sediment size. Methods not detailed for environmental factors, but describes biological sampling.
QUALITATIVE ASSESSMENT:	General discussions on ranges of isopods, salinities and temperatures, but no raw data provided. Sampling stations, frequency of sample, etc. not detailed in this report.
REPORT OR REFERENCE LOCATION:	Morris QH 301.15
DESCRIPTORS:	BIOLOGY-ISOPODS

AUTHOR:	Webber, C. M.
DATE:	1984
TITLE:	Survey of Quality of Domestic Well water Supplies in South Coastal Delaware
BIBLIOGRAPHICAL INFORMATION:	Water Supply Branch, DNREC Report
ABSTRACT:	Analysis of water quality from wells in Fenwick Island and vicinity, Delaware to determine degree of salt-water intrusion.
GEOGRAPHIC AREA:	Fenwick Island, Keen-Wik, Keen-Wik West, Edgewater Acres, Delaware (on/near Little Assawoman Bay)
PERIOD OF STUDY:	August 1984
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	309 samples analyzed: water sampling kits for treated/untreated water given to residents and analyzed by Division of Public Health; Langelier (corrosion) indices calculated; statistical treatment of data. Depth of wells 12-300 feet below ground surface.
QUALITATIVE ASSESSMENT:	Study conducted during peak summer usage when seasonal increase in salinity due to saltwater intrusion was at a maximum.
REPORT OR REFERENCE LOCATION:	DNREC, Dover, DE
DESCRIPTORS:	WELL-WATER QUALITY, SALT-WATER INTRUSION, GROUNDWATER GEOCHEMISTRY

AUTHOR: Wethe, C. A., and K. DeSombre

DATE: 1980

TITLE: A mini-study of Balders Pond near Indian River Inlet, Delaware

BIBLIOGRAPHICAL INFORMATION: Technical Report MSL-80-01, College of Marine Studies, University of Delaware, Lewes, Delaware

ABSTRACT:

GEOGRAPHIC AREA:

PERIOD OF STUDY:

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:

QUALITATIVE ASSESSMENT:

REPORT OR REFERENCE LOCATION: This reference was not available for review at the time the annotated bibliography was prepared.

DESCRIPTORS:

AUTHOR: Winget, R. R.

DATE: 1970

TITLE: Some Population Dynamics of Blue Crab and Hard Clams in Indian River and Rehoboth Bays and the American Lobster in Delaware Bay, Delaware

BIBLIOGRAPHICAL INFORMATION: Annual Progess Rept., Department of Natural Resources and Environmental Control, Dover, DE, 90p.

ABSTRACT: Information concerning C. sapidus in Indian River and Rehoboth Bays suggests that the population dynamics of the blue crab are exceedingly complex. Rehoboth and Indian River Bay population exhibit differences in density and size composition, possibly due to differences in hydrography and substrate composition of these two bays. Numerical data and general observations obtained to date indicate that temperature, salinity, (a major influence of tributaries), substrate, and epifloral density are environmental parameters which have considerable influence on this species.

GEOGRAPHIC AREA: Indian River Bay, Rehoboth Bay, Delaware Bay

PERIOD OF STUDY: August 1969 - July 1970

TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED: Crabs - trapping, seining, direct observation by dives

Clams - raking

Sediment type

Methods not described.

QUALITATIVE ASSESSMENT: This report is primarily a discussion of size-frequency distribution and population densities of blue crabs and hard clams. Includes discussion of effects of environmental parameters on organisms, but no data included on temperature and salinity.

REPORT OR REFERENCE LOCATION: Cannon Library

DESCRIPTORS: CRABS, CLAMS (SHELLFISH), WATER QUALITY

AUTHOR:	Woodruff, K.D.
DATE:	1969
TITLE:	The Occurrence of Saline Groundwater in Delaware Aquifers
BIBLIOGRAPHICAL INFORMATION:	Delaware Geological Survey Report of Inv. No. 13, Newark, Delaware, 45 p.
ABSTRACT:	Evaluation of existing data and chemical analyses pertinent to salt-water problem in aquifers.
GEOGRAPHIC AREA:	Delaware
PERIOD OF STUDY:	1931-1967
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Over 300 wells tested: total depth, depth screened, geologic unit, date, salinity (chloride ion content), fresh/salt-water interface mapped; well locations in all three counties.
QUALITATIVE ASSESSMENT:	Results indicate that there is need for further study to (1) determine fresh/saltwater interface in Piney Point Fm.; (2) refine "generally known" data on chloride distribution in Magothy and Potomac Fms; (3) investigate high chlorides in Rancocas Fm; (4) fresh/saltwater boundaries in Columbia Fm. in coastal areas need to be determined (author).
REPORT OR REFERENCE LOCATION:	Delaware Geological Survey, Penny Hall, University of Delaware, Newark, Delaware
DESCRIPTORS:	GROUNDWATER QUALITY/SALINITY, SALTWATER INTRUSION

AUTHOR:	Woodruff, K. D.
DATE:	1970
TITLE:	General Ground-water Quality in Freshwater Aquifers of Delaware
BIBLIOGRAPHICAL INFORMATION:	Delaware Geological Survey Report of Inv. No. 15, Newark, Delaware, 22 p.
ABSTRACT:	Report presents results of analyses of approximately 150 water quality samples from wells. Results indicate that Delaware's fresh groundwaters are suitable for most purposes.
GEOGRAPHIC AREA:	Delaware
PERIOD OF STUDY:	Not applicable.
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Chemical analysis of water from selected wells (Ca, Mg,Na, SiO_2, Cl, SO_4 total dissolved solids, pH), according to geologic unit; conductivity vs. total dissolved solids (TDS); TDS vs. depth.
QUALITATIVE ASSESSMENT:	This report presents data on approximately 150 water quality samples from wells; data from DGS files collected by DGS, USGS, municipalities, industries; water-well contractors."Further study needed on occurrence of nitrate in groundwater. Need for detailed groundwater flow patterns and chemical quality" (author).
REPORT OR REFERENCE LOCATION:	Delaware Geological Survey, Penny Hall, University of Delaware, Newark, Delaware
DESCRIPTORS:	GROUNDWATER QUALITY

AUTHOR:	Zaneveld, J. S.
DATE:	1972
TITLE:	The Benthic Marine Algae of Delaware, U.S.A.
BIBLIOGRAPHICAL INFORMATION:	Ches. Sci., V. 13, No. 2, p. 120-138
ABSTRACT:	Algal population in Delaware consists of 74 taxa, 69 of which are benthic. Seasonal occurrence indicates a maximum density in June-August.
GEOGRAPHIC AREA:	Delaware Bay, Cape Henlopen area, Lewes-Rehoboth canal; Indian River Inlet jetty; Rehoboth Bay.
PERIOD OF STUDY:	1962-1968
TYPE OF DATA COLLECTED, ANALYSES CONDUCTED, METHODS USED:	Algae collected by hand in eulittoral zone; by SCUBA diving in upper sublittoral zone; by Agassiz-type trawl in lower sublittoral zone. Part of specimens dried, preserved in neutral 4% formaldehyde in seawater; identified; classified. Also a compilation of water temperature, salinity, D.O., oxygen saturation %, and ecological data.
QUALITATIVE ASSESSMENT:	Systematic account of species of microalgae, along with localities at which each species occurs.
REPORT OR REFERENCE LOCATION:	Cannon Library, QH 95 .5A1C53
DESCRIPTORS:	MARINE ALGAE, BENTHIC ALGAE