Nassau-Suffolk Regional Planning Board. Regional Marine Resources C

STATE OF THE ART FOR SELECTED MARINE RESOURCES PROBLEMS ON LONG ISLAND

Prepared by
The Center for the Environment
and Man, Inc.

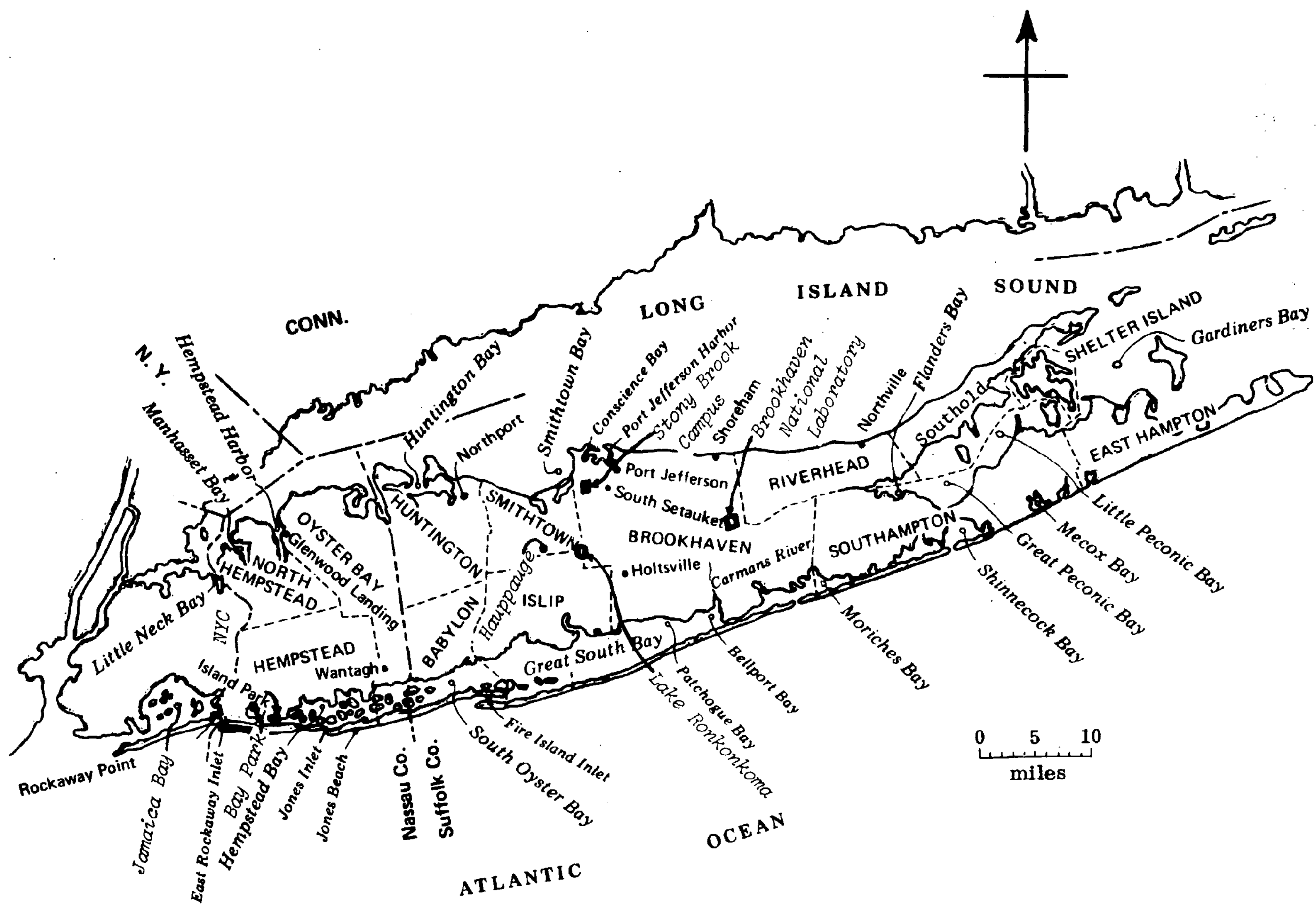
under
Sea Grant Project GH-63
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

February 1972
CEM-4103-456

W. V. McGuinness, Jr.

Regional Marine Resources Council

A COMMITTEE OF THE NASSAU-SUFFOLK REGIONAL PLANNING BOARD



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SOUND
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Hempstead Harbor
Manhasset Bay
Huntington Bay
Northport
Smithtown Bay
Conscience Bay
Port Jefferson Harbor
Stony Brook
Campus
Shoreham
Brookhaven
National
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Northville
Flanders Bay
SHELTER ISLAND
Gardiners Bay
Southold
EAST HAMPTON
Port Jefferson
South Setauket
RIVERHEAD
OYSTER BAY
Glenwood Landing
NORTH
HEMPSTEAD
HUNTINGTON
SMITHTOWN
BROOKHAVEN
Holtsville
Carmans River
SOUTHAMPTON
Little Peconic Bay
Mecox Bay
Great Peconic Bay
Shinnecock Bay
Moriches Bay
Bellport Bay
Patchogue Bay
Lake Ronkonkoma
Great South Bay
ISLIP
Hauppauge
BABYLON
HEMPSTEAD
Wantagh
NYC
Little Neck Bay
Island Park
Rockaway Point
Jamaica Bay
East Rockaway Inlet
Bay Park
Hempstead Bay
Jones Inlet
Jones Beach
Nassau Co.
Suffolk Co.
South Oyster Bay
Fire Island Inlet
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THE CENTER FOR THE ENVIRONMENT AND MAN, INC.
275 Windsor Street Hartford, Connecticut 06120

FOREWORD

This report is part of a series prepared by The Center for the Environment and Man, Inc., for the Regional Marine Resources Council of the Nassau-Suffolk Regional Planning Board under the continuing program: The Development of Methodologies for Planning for the Optimum Use of the Marine Resources of the Coastal Zone. The program is being funded in part by the Sea Grant Program of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and is structured into six functional steps:

Functional Step One (Problems). Identifies, classifies and briefly analyzes the problems that confront planners and decision makers with regard to the area's marine resources.

Functional Step Two (Knowledge Requirements). Categorizes the data and knowledge necessary for making sound decisions with regard to the use of the marine resources.

Functional Step Three (State of the Art). Assesses the availability and adequacy of the necessary data and knowledge.

Functional Step Four (Knowledge Gaps) Determines necessary data collection and research activity.

Functional Step Five (Data Collection and Research Program). Formulates a priority-oriented, marine-related data collection and research program and monitors its implementation.

Functional Step Six (Management Information System). Develops a system for organizing the data and knowledge and provides analyzed information to marine resource planners.

Functional Steps One and Two were completed in previous reports of this series [1a, 1b and 1c] [/1].

The current report is one of seven which together constitute Functional Step Three. Two of these seven reports were completed previously for coastal water quality standards [1d] and for estuarine models [1e]. Four reports addressing selected priority problems were recently prepared for integrated water supply and

[/1] Citations in brackets are listed in Appendix A.

waste disposal [1g], coastal stabilization and protection [1h], dredging [1i], and wetlands [1j].

The current report and all previous reports will contribute to future reports in this series on a proposed research program [1ℓ] (Functional Steps Four and Five), guidelines for planning and policy formulation [1m], and a marine management information system [1n] (Functional Step Six).

Views and conclusions contained in this report are those of The Center for the Environment and Man, Inc. They should not be interpreted necessarily as the official opinion or policy of the Marine Resources Council or the National Oceanic and Atmospheric Administration.

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

SECTION 1 - INTRODUCTION

PURPOSE OF THIS REPORT

The purpose of this report is to assess, under a broad, inter-problem framework, the adequacy and availability of the data and knowledge that we judge to be most relevant to comprehensive planning and policy formulation geared primarily to the highest-priority marine-related problems in Nassau and Suffolk Counties, New York.

The "highest-priority marine-related problems," as selected by the Council, are:

(1) Integrated water supply and waste water treatment and disposal,

(2) Coast stabilization and protection,

(3) Dredging and spoil disposal, and

(4) Wetlands management.

Other problems listed in a previous report [1b] are also considered but with less attention.

STRUCTURE OF THIS REPORT

The structure adopted for this report follows the eight-category, discipline-oriented framework of data and knowledge requirements developed in Functional Step Two [1c]. The first four categories pertain to information on the current situation. They are satisfied by location and time-specific observational and descriptive data for the study area. The last four categories pertain to knowledge of man-environment interactions, and the dynamic processes involved in environmental changes and in their impacts. This knowledge is generally applicable regardless of place and time.

At the end of each category, major data collection and research needs are listed and briefly described. They will be developed in the next report of this series [1ℓ].

Every format has its advantages and limitations. The format adopted here is advantageous because—

- It consolidates inputs from many problem-oriented and miscellaneous sources into a common expandable framework.
- It distinguishes between data (information) about what exists at a particular place and time and knowledge about the processes, interactions, and methodologies involved in applying the data for marine resource management purposes.

- It structures the inputs in terms of recognized scientific disciplines.

On the other hand, the adopted format does not lend itself to unified treatment of a specific problem or phenomenon. For example, data and knowledge pertinent to integrated water supply and waste water disposal problems cut across all eight categories. Those most interested in specific problems will find the earlier problem-oriented reports of this series better suited to their needs. As a second example, salinity phenomena are treated in different parts of the report in terms of existing concentrations, processes that affect these concentrations, effects on marine biota, and monitoring and modeling needs.

CONTENTS OF THIS REPORT

To fill out the framework, this report draws largely but not exclusively upon the earlier reports of the series, particularly the four problem-oriented feeder reports [1g, 1h, 1i, and 1j]. In so doing, criteria for selection were relevance, unity, reasonable brevity and utility.

Relevance was sought by placing the greatest emphasis on the material revealed to be the most important in the previous problem analyses/1.

Unity was sought by fitting this material to a common framework.

Reasonable brevity was sought by employing frequent references to earlier reports of this series and other sources that contain further detail.

Utility was sought by presenting our judgments on the adequacy of the reasonably-available material for comprehensive planning and policy formuation purposes

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/1 For example, a quantified water cycle is emphsized later because it is a basic tool for evaluating competing water supply–waste water disposal alternatives and improving the efficiency of whatever alternative is selected. The changes man is making on the surface of Long Island can have possibly significant effects on this cycle. Current information is considered inadequate to tell just how much man is influencing evapotranspiration losses and direct runoff losses to streams. But only evapotranspiration is cited herein, because of the relevance criterion. Evapotranspiration accounts for about half of all water losses on Long Island and it is important that we know rather accurately how we are affecting this large a loss. On the other hand, even if we were to double or halve direct runoff losses, we would not change overall water availability by more than 1%. Of course, for local purposes, such as sizing culverts, the change would be important, but local problems of this sort are not being emphasized in this report.

It is also important to recognize what this report does not attempt to be:

(1) It is not a source of basic data and knowledge. Instead of attempting to report information encyclopedically, this report identifies the most essential material and briefly assesses its general adequacy.

(2) It is not a response to every item in the full framework. For example , subcategory VI-A, as described in Functional Step Two [1c], seeks an assessment of the adequacy and availability of information on the influence of 11 selected parameters on more than 25 species, for each stage of their life cycles. A complete response to this one subcategory alone would entail more than 1,000 assessments, many of which are complex in themselves.

USERS OF THIS REPORT

This report is being prepared primarily for its sponsors, the Regional Marine Resources Council and its parent body, the Nassau-Suffolk Regional Planning Board. The interests of the Council are bi-county and coastal. The interests of the Board are bi-county and comprehensive, covering the long-range preservation, use and development of the entire area, inland as well as coastal. The report reflects these interests by emphasizing coastal dimensions but recognizing them to be subordinate parts of larger problems. This report is an overview. It seeks to provide perspective on data and knowledge adequacy for formulating broad public policy.

In addition to serving the needs of its primary audience, it is hoped that the report will also provide considerable, useful material for the two county governments, local governments, academic institutions, and all others interested in Long Island's coastal resources.

Although the data assessment in the first four categories is specific to the bi-county area, the methodology and many of the assessments should have application to other coastal locations throughout the nation. The knowledge assessment in the last four categories should be particularly applicable outside the bi-county area.

SECTION 2 - INFORMATION ASSESSMENT

CATEGORY I - INFORMATION ABOUT CURRENT HUMAN ACTIONS AND NATURAL FORCES AFFECTING THE ENVIRONMENT

I-A Waste Disposal

Quantitatively, Appendix B of a previous report [1g] examined the flow of water through man's current water supply and waste water disposal system from the time it is pumped from the ground until it eventually reaches the ground, salt water or atmosphere. The system was considered as a series of eight phases and quantitative entries were estimated for each: the acquisition, treatment, transmission, distribution and use of potable fresh water and the collection, treatment and disposal of waste water. The adequacy of the data upon which the estimates were based was assessed in the cited report, and deficiencies are itemized under "water usage" in Category I-D of this report.

The bi-county totals can be broken down to geological subdivisions by consulting numerous fragmentary sources [2 through 15] or by proceeding more systematically as follows:

Residential waste water. Cesspool wastes can be distributed geographically by using population density data [5d, 5k, 5ℓ] and average per capita discharges. Sewered wastes can be distributed geographically by plotting outfall locations and average rates of flow. The data necessary to make this distribution is available from the two county governments and the Nassau-Suffolk Regional Planning Board.

Industrial waste water. Industrial use of fresh water is relatively low in the bi-county area (less than one-quarter of total usage). Most of this industrial water is used for cooling purposes and recharged into the aquifer in the general vicinity of its withdrawal [1g]. If desired, this withdrawal and recharge can be distributed geographically with acceptable accuracy by analyzing surveillance records maintained by the two county governments for all major industrial users.

Agricultural waste water. Agricultural usage represents only about 5% of total usage, and most (about 80%) of this usage is dissipated as evapotranspiration. The small remainder can be considered essentially all groundwater recharge [1g].

Qualitatively, Appendix C of the same report [1g] examined the eight phases in terms of contaminants entering and leaving the hydrological cycle. Currently available information was much too scattered and incomplete to portray quantitatively the concentrations of selected contaminants (e.g., nitrogen, phosphorus, or carbon) at each phase in the cycle, particularly during the waste water phases. It is especially important to be able to trace nitrogen because of its demonstrated potential to contaminate aquifers [16] and induce eutrophication in poorly flushed estuaries [17]. It would also be useful to collect, collate and publish data on industrial discharges. Even though the quantity of such discharges may be small, no perspective can be formed about the quality of their effluent without such information.

Alternative methods of accomplishing each of the eight phases were identified, evaluated and costed in the earlier report [1g]. The unit cost data developed for that purpose deserve further refinement because of their relevance to the several-billion-dollar decisions that must be made in selecting Long Island's basic water supply-waste water disposal strategy.

<u>Solid waste disposal</u> practices on Long Island were summarized in a previous report in this series [1b]. Disposal is accomplished with incinerators and landfills. The number, size and location of these incinerators and landfills have been inventoried [5f]. Disposal processes can affect the bi-county's coastal area in several indirect ways [1b]:

(1) Leachates from landfills can contaminate the groundwater that ultimately reaches coastal waters. Proper drainage and sealing of landfill surfaces can prevent or minimize the leaching [18]. The quantity and quality of these leachates, at their source and as they eventually enter coastal waters, are not well enough known to assess their coastal significance. However, it would appear that, to the extent that leachates become significant, they would impact upon the Island's water supply much sooner and much more importantly than upon coastal water quality.

(2) In adjacent Kings and Queens Counties in the past, wetlands were common sites for solid waste landfills, e.g., the Flushing Meadows site of the World's Fair. Apparently this method is not currently being practiced in the bi-county area.

(3) Offshore dumping of solid wastes has been discontinued in Long Island Sound [20]. A considerable quantity of solid wastes, including sludge originating principally from the New York Metropolitan Area, is being dumped in known disposal sites in New York Bight [13e, 21, 22, 23, 24]. Data on the quantities, locations and timing are available from the files of the New York District, U.S. Army Corps of Engineers. However, there appears to be little information available on the specific physical and chemical composition of these wastes [21].

(4) Discarded automobile bodies and tires, construction rubble, and concrete have been used to construct artiticial reefs off the south shore to increase fishing opportunities [25]. This experiment is worth reviewing to determine the stability of the reef and its effectiveness in attracting and supporting fish.

(5) The incineration of wastes contributes to general air quality deterioration, but from a coastal zone point of view, the key issues relate to leachates from incinerator residue fill and the disposal of waste water effluents resulting from quenching and stack-gas scrubbing operations. The extent to which these effluents are contributing to local water quality deterioration is unknown [1b], but that their widespread effect is not great might be inferred from an examination of water quality surveys cited later in Category II-B.

Thermal waste problems on Long Island were summarized in a previous report in this series [1b]. This type of waste can originate from many sources. Inland, the most important source is industrial cooling recharge wells cited earlier in this subcategory under "industrial waste water." Some local rises in groundwater temperature have been observed in the vicinity of these recharge locations [2, 3]. Along the coast, the most important current sources, by far, are the conventional steam electric power plants on the north shore at Port Jefferson, Northport and Glenwood Landing [20].

A contingency plan developed by the Coast Guard [26] locates the most likely sources of oil spills—the vicinity of onshore storage and tanker loading facilities. Another likely source harder to localize is passing tankers which use the Sound to transport refined petroleum products up coast from New Jersey.

Aside from oil spills, the total quantity of pollutants originating from vessels is probably relatively small [27, 28, 29] /1. However, it is directly introduced into coastal waters and is offensive in marinas and also in shellfish areas which must be closed because of the nearby discharge of fresh human wastes [20, 30]. By using available data on boat registrations [5a, 31] and making some estimates on boat utilization, it should be possible to estimate the future order-of-magnitude significance of this source. Such perspectives are of little utility, however, since current federal and state programs anticipate the control of this source of wastes in the near future [28, 29].

Dredging operations are known to increase turbidity, and the resuspension of oxygen-consuming bottom sediments in the water column. With some local and temporary exceptions, this source of pollution is probably minor in the bi-county area [1b, 1i].

Waste water from duck farms and chemical pesticides were assessed in a previous report [1b].

I-B Resource Utilization

The uses of the coastal zone considered herein are: (1) extraction of living resources (or fishing), (2) extraction of non-living resources (or mineral extraction), (3) return of resources (or waste disposal), (4) enjoyment (or recreation and aesthetic satisfaction), (5) transportation (or navigation), and (6) land use. /2 Each of these major classes of uses can easily be broken down into numerous sub-classes.

The availability and adequacy of data and knowledge about this set of coastal uses is assessed under several categories in this report:

/1 According to one estimate "Pollution from small craft—is still considered to be only 1/10 of 1% of the (national) pollution problem." [28]

/2 The alternative expressions in parenthesis are more commonly used terms which describe the major uses in simpler but less precise ways. For example, "fishing" does not include the harvest of kelp and other vegetative matter, or the harvest of bloodworms and some other marine animals. However, "fishing" is adequate for most practical purposes because these other examples are relatively insignificant, at least on Long Island.

- Category I-B considers the current levels of observed usage by place and time.

- Category IV-A considers levels of future demand, to include methods for estimating that demand[1].

- Category VII considers the impact of environmental characteristics on demand.

Commercial landings on shellfish and finfish for each of eight delineated coastal areas by individual species are reported annually by weight and dockside value and monthly by weight [32, 33].

Information on the sports fish catch is scattered and fragmentary [1b], but it probably could be assembled with an order-of-magnitude accuracy. Even without such a survey, however, it is clear that the sports fish catch is major [34], at least in relation to the commercial catch. In 1965 for example, for the "North Atlantic Region" (New England and New York in this case) the total sports catch was rapidly approaching half the total commercial catch, by weight [32, 35]. By almost any method of assessing the "value" of the sports catch, it must have greatly surpassed the commercial catch with its average dockside value of about 10 cents a pound. For example, on a national basis, the expenditures of the 8.7 million coastal sports fishermen in 1964 have been estimated at twice the dockside value of the U.S. commercial fishing harvest in that year [36, 37].

Very little sand and gravel is currently being mined in Long Island's coastal waters [13e, 38]. The extent of the effort can be estimated by reviewing the dredging permit files of the U.S. Army Corps of Engineers [1i].

Information on the current recreational use of Long Island's beaches and parks has been reported by many sources [1b, 5a, 39c, 40, 41a, 41b, 42, 43]. These sources provide a synoptic overview [39c], extended overall treatment [42] and in-depth local analysis [43]. Notwithstanding the reports, there is apparently no single complete

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[1] Strictly speaking, all prediction methods should be covered in Category VIII; however, to minimize fragmentation, editorial license is taken by considering future demands and methodologies for predicting them in the same place, Category IV-A.

source of beach-by-beach attendance data collected and reported in the unified, defined way that is necessary to lay a base for comprehensive recreation planning.

Good annual data on marine transportation are tabulated by the U.S. Army Corps of Engineers for Manhasset Bay, East Rockaway Inlet, Hempstead Harbor, Huntington Harbor, Fire Island Inlet, Great South Bay, Port Jefferson Harbor, the Patchogue River and miscellaneous other lesser sites [44]. The data include gross tonnages broken down by commodity classes, trips and drafts of vessels.

Existing coastal land use is depicted in a recent inventory [39a] geared to erosion problems. In broad categories, it depicts the ownership, use and physical condition of major reaches of the Long Island shoreline.

Considerable information is available on existing land use in reports of the Nassau-Suffolk Regional Planning Board and the backup files thereto for the bi-county area in categories such as residential, commercial, industrial, agricultural, transportation, vacant and water areas [5]. This material should provide a good base for a land use survey emphasizing the coastal uses. A folio of large-scale maps needs to be prepared identifying each significant coastal use location to include docking facilities for commercial and recreational fish processing facilities, shellfish areas, wetlands by type, mineral extraction areas, waste discharge points, beaches, parks, recreational shellfishing and shore fishing areas, scenic and historic areas, ship channels, port facilities, defense establishments, and residential, vocational, industrial, commercial and institutional sites. For each of these plotted areas, usage data needs to be accumulated in terms such as attendance, estimated dollar and time expenditures, facilities, capacities, direct access and general transportation accessibility.

Water supply and waste water disposal problems are related to all coastal uses that are influenced by water quality. Islandwide land usage has another major effect on the water supply system; it produces physical changes to the surface of Long Island and thereby alters the amount of water lost through evapotranspiration, runoff and infiltration. A previous report [1g] emphasized the need to determine in a gross way just what surface changes man has made and is expected to make in the future and evaluate their significance on evapotranspiration and surface runoff losses, particularly the former.

The problem of shore stabilization and protection [1h] is intimately related to land usage. Without a good understanding of the coastal land use values involved, an intelligent decision cannot be made as the extent of effort justified to preserve and enhance these values. A number of proven engineering and construction techniques are available, but each has decided limitations that must be recognized when employing it. These techniques have been summarized briefly [39c], developed in more depth [39b, 45], and reflected in evaluations of Long Island's problems [1h, 39c, 46].

When structures, such as residences, are built too close to the shore, they can aggravate erosion during storms and, by their injudicious exposure, trigger "demands" for a higher level of protection than would otherwise be required. Unwise encroachment can be controlled by a variety of management techniques [39c] including zoning under the safety principle of police powers, building codes, permits, and the application of flood plain management principles particularly to the barrier islands. The latter approach is being developed by the U.S. Water Resources Council [47] and involves techniques such as delineating high water inundation lines as guides to developers and zoning authorities. A review of existing zoning and building codes, and an inspection of coastal structures is justified to assess the feasibility of these management techniques on Long Island [1h].

Unregulated use of dunes can destroy their protective vegetation and trigger their progressive disintegration [39c, 120]. This abuse has not been identified as a major current threat to beach stability on Long Island, but a review of county and town ordinances and an inspection of the dune line would be necessary to confirm this appraisal.

Since coastal erosion and inundation can be significantly influenced by development, a knowledge of plans for such development is essential. Plans for waste disposal in the backbays, recreational development, new or enlarged navigation channels for shipping, and residential, commercial, and industrial development along vulnerable shorelines can influence decisions on coastal stabilization and protection. Anticipated changes in population, real income, and public values can trigger changes which increase the value and vulnerability of coastal areas to erosion and inundation.

Information of this type is available in fragmentary form from a number of sources, but it needs to be pulled together in a coastal context and portrayed on a map. Basic sources of information are the Nassau-Suffolk Comprehensive Development Plan [5k], other studies of the Nassau-Suffolk Regional Planning Board [5], and the two county governments. The U.S. Army Corps of Engineers can provide long lead-time information on authorized federal coastal protection and navigation projects [48] and short lead-time information on all applications for permits for construction in navigable waters/1. This permit system is considered in some depth in an earlier report [1i].

Dredging problems are also intimately related to every one of the major coastal uses cited earlier—living and non-living resource extraction, waste disposal, recreation and aesthetics, marine transportation, and land use—in ways that are explained in an earlier report [1i]. A common omission in the information needed to evaluate applications for dredging permits was noted in that report: where dredge spoil is to be used as landfill, information is not provided as to the future intended use of the "reclaimed" land.

Wetland preservation problems [1j] are related to many of the uses cited in this subcategory, particularly to fishing, wildlife observations, aesthetics and land use. Coastal land development is frequently antagonistic to wetland preservation.

I-C Natural Forces

The general direction, location, velocity and time patterns of prevailing diurnal tidal surface currents in the coastal waters off the bi-county area are reported by the National Ocean Survey [49]. The information is depicted in tables and charts that show the hourly direction and velocity of the tidal current referenced to the times of high and low water at The Battery in New York City and the times of slack water at The Race off Orient Point. Daily predictions of these reference times are given. Through them and given adjustment factors, tidal currents can be estimated for any particular time and place not significantly influenced by coastal configurations to an accuracy of about 0.1 knots and an orientation of about 10 degrees.

/1 State and local projects along the shore must receive permits granted by the Corps of Engineers. Applications are published and posted for 30 days or more before permits are granted. By writing to the District Engineer, U.S. Army Corps of Engineers, 26 Federal Plaza, New York, N.Y. 10007—Attention: Operations Division, Room 2037, and stating the waterways of interest, citizens or groups can have their names added to the mailing list for public notices for the waterways they name.

Surface currents are the most important kind for marine transportation, but for water quality planning and biological studies they are only one part of the picture. Information on subsurface flows is also important, but it is known only in general terms. Additional information will be required, especially in the Sound, to permit a fundamental understanding of the distribution of salinity, nutrients and pollutants. Two current research projects at the State University of New York (SUNY) on the physical and environmental aspects of Long Island Sound and north shore bays should provide information of the type needed [119].

Wind is also an important factor in influencing water currents and stage heights. Information of this type is available from the U.S. Naval Oceanographic Office [50] in one degree quadrangles (Marsden Square) in terms of frequency using the Douglas sea and swell scales.

The actual currents and water heights induced by the combination of tide, swells and wind can be estimated in terms of frequency from several scattered tidal stations which record the actual conditions. For selected bays and harbors of special importance, such as Great South Bay, a better understanding of existing and predictable circulation patterns can be obtained through numerical or physical models of various complexities. (Modeling was the subject of a previous report [**1e**]. The identification and evaluation of modeling needs will be summarized in Category VIII of this report and developed in further depth in a future report [1ℓ].)

Good data on precipitation, winds, visibility, air temperature and other phenomena are available from numerous sources. The best of these is the National Weather Service because of its ready availability, its length of record (30 to 100 years), its general accuracy and its portrayal in standard digital coded form.

The principal natural forces affecting coastal stabilization and protection are wind, waves and swells, tides, and littoral drift. The combined effect of these forces is felt most severely during storms, particularly during hurricanes. Information on the frequency, intensity and direction of historical storms used as a basis for designing coastal protection works is available from the U.S. Army Corps of Engineers. The probability of a hurricane hitting Long Island in any given year is about one in ten. The most vulnerable coast, by far, is the Atlantic Coast along the south shore. Climatological data on all storms are maintained by the National Weather Service. The same agency provides a storm warning service.

I-D Recapitulation of Data Collection Needs

(1) Water usage data. Collect, edit and correlate quantitative data that depict the flow of water through man's water supply and waste water disposal systems. The data should be used to verify and improve the information developed in Appendix B of a previous report [1g] to include:

- Total pumpage.
- Losses through leakage and undetected unauthorized uses.
- The disaggregation of water usage between residential, industrial and agricultural uses.
- The disaggregation of residential water disposal between treated sewage, untreated sewage, and other types of disposal such as sprinkling.
- The disaggregation of industrial water usage between treated and untreated sewage, cooling and other uses.
- The infiltration of groundwater into sewerage systems, and the exfiltration of sewage into the groundwater.
- The eventual distribution of used water between the atmosphere, streams, bays, sound and ocean.

(2) Waste water inventory. Collect and consolidate information about residential, industrial and agricultural waste water discharges, to include their volumes, locations and representative constitutents, sufficient to permit the results to be portrayed in computerized form and automatically processed.

(3) Unit cost data. Improve the accuracy and breadth of the cost data that are most relevant to evaluation of the economic aspects of alternative water supply-waste water disposal systems. The data should be based upon Appendix D of a previous report [1g].

(4) Ocean dumping data. Collect data on the quantity and constituents of wastes being dumped into New York Bight with particular emphasis on toxic materials and nutrients.

(5) Survey of sports fish catch. Collect and consolidate information to describe the sports fish catch in Long Island waters to include the approximate volume of the catch by major locations and species, and by season, and the estimated "value" of the catch as represented by the dollars and leisure time expended by sportsmen to make the catch.

(6) Beach attendance data. Collect and consolidate information on the attendance at all non-private beaches in the bi-county area to include hourly attendance fluctuations at major beaches, and daily attendance at all beaches, sufficient to permit the results to be portrayed in computerized form on map printouts.

(7) Coastal use survey. Collect necessary information and prepare a folio of large-scale maps identifying each significant coastal use location and summarizing selected usage data relating thereto.

(8) Man-induced surface changes. Collect data on past and current surface changes made by man and estimate their effects on evapotranspiration losses. Project the extent of future surface changes and evaluate their effects on future evapotranspiration losses.

(9) Inventory of land use regulations. Collect and maintain an up-to-date file on all existing state, county and local zoning ordinances and plans, building codes, taxation and cost sharing policies, planning maps, permit policies, orders and acquisition policies and plans, and extract and sort elements thereof that pertain to coastal stabilization and protection.

(10) Inventory of major development plans. Collect from government and other sources a description of all major development plans that can affect the physical stability of the coastline and the need to protect it. Depict this planned development on suitable coastal maps.

(11) Usage of dredged spoil areas. Obtain information on the intended future use of major dredged spoil areas. (This information could most easily be provided as part of permit applications.)

CATEGORY II - INFORMATION ABOUT THE CURRENT PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE ENVIRONMENT

II-A Physical Characteristics of Coastal and Estuarine Areas

As stated earlier, the hydrologic cycle on Long Island, in its natural state and as influenced by man, was described quantitatively in Appendix B of a previous report [1g]. Data on stream flow and groundwater flow is available from the U.S. Geological Survey. The stream flow data reflect actual observations and are excellent for comprehensive planning purposes. The data on groundwater flow consists primarily of rough order-of-magnitude estimates. The accuracy of these estimates can be significantly improved by acquiring better basic data on groundwater levels, piezometric surfaces, horizontal and vertical permeability rates, and geological profiles. Of particular need for use in developing groundwater models is much better information on the locations of selected strata, especially the Gardiners clay, and the offshore transition zone between saline and fresh water [1g].

Basic topographical information from the dune line out to about 30 feet below mean sea level (the maximum depth relevant to shore protection problems) is available from charts of the National Ocean Survey, maps of the U.S. Geologic Survey, and aerial photographs maintained at the Nassau-Suffolk Regional Planning Board and elsewhere. These sources provide information on water surface areas, coastal configurations, water depth and limited information on the physiography and composition of benthic areas. This information is generally accurate for the area as a whole, but details of bottom elevations and exact locations of sand shoals and bars may not be correct, as the wave forces along the ocean front, and the sediment-carrying currents in the bays may alter some of these details. Application to the Corps will probably not improve this situation since the Corps uses the same charts and maps. Therefore, in important locations subject to erosion and accretion, such as offshore sand bars, beaches, inlets, shoals and harbors, where more precise project-type information is required, up-to-date soundings will be required. The U.S. Army Corps of Engineers has described the locations of critical erosion and the erosion history of each reach [39a]. Dynamic seasonal changes not reported in that study, especially along the Atlantic coast, generally cause significant erosion during the winter storm periods and accretion during the long summer swell periods.

The soils of Long Island have been classified, inventoried, interpreted and reported for the Nassau-Suffolk Regional Planning Board [5e] by the Soil Conservation Service of the U.S. Department of Agriculture. In erosion-prone areas along the coast, much more detailed information on grain-size distribution is required, but the collection of this type of information is usually accomplished during surveys for specific projects.

Surveys conducted by the U.S. Army Corps of Engineers have shown that a considerable quantity of sand, adequate for beach nourishment, is located off the North Atlantic Coast [51]. In tests conducted at Sea Girt, New Jersey, the Corps demonstrated the technical feasibility of using offshore sand for beach nourishment and identified several ways that the efficiency of the techniques might be improved [52]. In 1970, a contractor was awarded a $614,000 contract to use an underwater crawler-cutter to rebuild a 1.3-mile stretch of a Florida Beach with sand. Although costs were nearly 50% higher than the costs of obtaining the sand from nearby riverbeds or islands, ecological considerations were judged to be overriding [53]. Whether this experiment succeeds or not, the costs of using offshore sand for beach nourishment purposes can be expected to drop sharply as technology and competition improve [13e].

To evaluate the practical accessibility of offshore sand for use on specific Long Island beaches, a survey is necessary. For example, the feasibility of providing more and larger sandy beaches to replace the narrow, generally-rocky beaches along the north shore would be greatly improved if adequate offshore sand were found to be within economical distance of the beach sites.

Information on shoreline structures that can critically affect circulation, tidal elevations and storm surges is available at a number of locations, most prominently at the New York District of the U.S. Army Corps of Engineers. Interest here is primarily on structures such as jetties that control critical inlets and on groins, major bulkheads and other armament in areas of critical erosion.

Information on Long Island's wetlands was summarized briefly in one of the first reports in this series [1b] and examined in greater depth in a later report [1j]. The

New York Ocean Science Laboratory (NYOSL) at Montauk, as part of a contract to CEM [54] has listed many previous studies, of greatly varying scope and quality, of Long Island salt marshes, salt meadows and other wetlands. Several regional studies [19, 55, 56] tabulate wetland and shoal area acreages by type and rate of loss and portray the information on maps along with other habitat data for wildlife and shellfish. Analysis of these and other wetland studies produces considerable confusion primarily because of definitional inconsistency or obscurity [/1].

For management purposes, such as for the formulation of preservation, enhancement and development strategies, there is a major need to collect and analyze all significant wetland studies of the past, make photographic and on-site surveys, and produce an accurate, well-defined inventory of Long Island's wetlands and related areas by size, type and location. Each of the wetland areas needs to be classified in qualitative groupings that reflect their ecological values [1f, 1h, 1i, 1j]. A wetlands inventory report, soon to be published by the State University of New York (SUNY) at Stony Brook, should fill many of these needs.

NYSOL, under contract to CEM [58], has provided a list of some 60 individual studies cataloged by location, time, length of record and general type of data available for such water quality parameters as water temperature, pH, salinity, dissolved oxygen, turbidity, water

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[/1] This is far more than academic nitpicking; unless "wetland" boundaries are rather precisely and uniformly defined, inventory data can become of dubious usefulness especially if the intent is to develop a meaningful perspective on wetland loss rates. For example, by failing to distinguish between mean low tide and lower low tide as the lower boundaries of "wetlands," one can vary their reported area grossly. Confusion and inconsistency are encountered in defining and intermixing related areas such as "wetlands," "shoal areas," basic areas of important habitat," "important open shoal water habitat," "total estuarine zone habitat," and what constitutes a "loss by dredging and filling." One example, which can probably be traced to definitional problems, occurs in Maryland. According to one widely reported inventory [56], Maryland had a tenth of its 204,000 acres of its coastal wetlands "destroyed" in the 15-year period ending in 1968. In contrast, a recent detailed inventory by the state [57] reported an annual loss rate over a generally similar period of 0.16% of the state's 237,582 acres of coastal wetlands. A quarter of this loss was ascribed to natural erosion and natural succession and the remainder to man primarily for housing development, dredging and spoil disposal, marinas, and public works.

color, plant nutrient levels, coliform bacteria, floating and settleable material, some toxic materials and oil. As stressed by NYOSL, the material is so varied in terms of its vintage and scope that it is of little use for broad planning purposes without a complex coding system. Even then, concentrations vary so significantly from time to time that the ability to make the generalizations necessary for planning will be very difficult.

One way to understand these patterns adequately is with a monitoring system. The system would report the changing concentrations of only the most important parameters. They would be measured only at carefully selected locations where their effects are judged to be most critical to the coastal uses that depend upon water quality, particularly fishing and bathing. A contractor of the U.S. Environmental Protection Agency is currently designing a water quality monitoring system for the New York Bight and adjacent inshore waters as part of a "National Coastal Water Quality Monitoring Network."

Monitoring systems that determine the condition of the water are closely related to modeling systems that predict future water conditions. For example, for nearby Narragansett Bay, Rhode Island, a procedure was developed for striking a rational balance between modeling procedures (that diminish the expense of monitoring) and monitoring programs (that can diminish the expense of modeling) [58].

II-B Physical and Chemical Conditions of Coastal and Estuary Waters

The addition and rejection of contaminants by nature and by man were described in Appendix C of a previous report [1g]. Basic input data are too fragmentary, and basic processes (considered later in Category V) are not well enough understood, to describe the system in quantitative terms, although this probably can be done well enough for planning purposes on an element by element basis, e.g., the nitrogen, carbon, phosphate cycles.

Groundwater quality is generally good in the lower aquifers, but in the Upper Glacial aquifer, significant increases in nitrates and detergents have been reported in recent years [1g, 2, 3, 16, 59, 60], and the potential for rapid deep contamination along the longitudinal axis of the island is substantial [1g].

In some coastal locations, especially in California, where groundwater drawdown is substantial and compressible silt-clay strata are common, major land subsidence (up to 10 feet!) has been reported, and its cause has been authoritatively ascribed entirely to groundwater drawdown [1g]. Drawdown has been comparatively minor on Long Island and the predominantly sandy soil profile would appear to be much less compressible. Nevertheless, it would appear prudent to monitor land elevations periodically using existing or specially designed geodetic bench marks. Land subsidence is usually permanent even if the water table rises later. Some proposed long-range strategies contemplate major drawdowns of groundwater levels [1g].

The U.S. Environmental Protection Agency has reported the results of two surface water quality surveys of Long Island Sound [20]. The first survey, September 29—October 3, 1969, reported on 69 different stations, with a near surface and depth measurement at each station, in terms of 14 parameters: water temperature, conductivity, salinity, chloride, dissolved oxygen, percent saturation, BOD, TOC, turbidity, NO_3-N, PO_4-P, chlorophyll, total coliform and fecal coliform. A second survey in July 1970 was conducted at 118 stations, all at a five-foot depth, in terms of 21 parameters including most of the above plus others. Water quality data in the south shore bays have also been reported in several studies [14, 15].

The County governments have extensive special-purpose monitoring systems. For example, Nassau County takes bathing water quality samples daily at about 30 points along its north shore and about 25 points along its south shore [1g].

II-C Recapitulation of Data Collection Needs

(1) Monitoring groundwater levels. Expand the current system of monitoring wells to improve knowledge of groundwater levels and the piezometric surface of the artesian aquifers, particularly the Magothy.

(2) Onshore geological information. Collect information to determine more accurately the horizontal and vertical permeability rates in the aquifers and the locations of selected strata, especially the Gardiners Clay.

(3) Offshore geological information. To determine the offshore geological profile and thereby improve the predictive capability of groundwater models, make borings off the south coast of western Suffolk County at least to the bottom of the Magothy aquifer, giving particular attention to the location of the Gardiners Clay.

(4) Offshore sand inventory. Conduct an inventory of sand resources off the south and north shores in sufficient detail to assess the feasibility of using this sand for nearby beach nourishment.

(5) Wetlands classification and inventory. Develop a uniform, carefully-defined system for classifying wetlands and shoal areas, and inventory the bi-county area in accordance with that system.

(6) Water quality data bank. Collect, evaluate and collate existing data on the concentration of selected water quality parameters in marine surface waters and integrate the data into a system capable of incorporating newer and better data. This effort should be coördinated with the monitoring system for New York Bight and adjacent inshore waters currently being prepared for the U.S. Environmental Protection Agency (EPA).

(7) Coastal water quality monitoring system. In conjunction with the EPA project, develop a coastal water quality monitoring system for selected marine surface waters such as the south shore bays, Long Island Sound, and the vicinity of offshore dumping sites and outfalls.

(8) Monitoring groundwater quality. Expand the current system of collecting and analyzing water quality samples from wells selected because of their strategic locations and depths. Particular attention should be given to monitoring the rate and depth of contamination in the center part of the interior recharge area.

(9) Monitoring possible land subsidence. Provide a periodic evaluation of possible gradual land subsidence on Long Island by precise measurement of surface elevations at a few selected locations where groundwater levels are declining.

CATEGORY III - INFORMATION ABOUT THE CURRENT STATE OF THE MARINE RELATED BIOTA

III-A Population Characteristics of Important Shellfish Species by Time and Location

As mentioned in Category I-B, the general location of commercial fin and shellfish fisheries in terms of landings at each of eight delineated coastal areas off the study area is reported by individual species annually by both weight and dockside value and monthly by weight [32, 33]. Since the area of landing does not necessarily correlate with the points of capture; since landings can vary considerably with the intensity of the fishing effort, both domestic and foreign; and since the important sports fish catch is not included; the landing statistics do not reveal a complete picture of the time-space distribution of offshore fish populations. Notwithstanding these deficiencies, the landing statistics do provide a reasonably adequate indirect means by which the fluctuating trends in fish abundance can be charted with ease for broad planning purposes [1b].

The catch varies greatly by species from year to year. The landings data for 1968 and 1969 reveal that the most important shellfish was the hard clam which accounted for two-thirds of the total value. The next most important species in descending order of value were the lobster, sea scallop, oyster, surf clam and bay scallop. The last accounted for 3 percent of the total value. The Long Island shellfish industry is concentrated along the south shore, particularly in Great South Bay; the entire north shore accounts for only about 5 percent of the shellfish catch by value. Monthly variations in the catch by species and general location can also be observed from a study of the data.

III-B Population Characteristics of Important Finfish Species by Time and Location

The sources cited above for shellfish report similar landings data for finfish. Commercially, finfish are much less important than shellfish on Long Island. Their total value ($2—3 million) was only 20 percent of that of shellfish in 1969, and the most valuable species in that year, the yellowtail flounder, had a value equivalent to the least valuable shellfish listed above. Ranking close behind the yellowtail in terms of descending value in 1969 were the striped bass, scup, menhaden and fluke. As was the case with shellfish, the best inferences on finfish numbers and population trends can be made from these published statistics of commercial landings. Most of the commercial finfish catch is in the ocean; the catch, by weight, in Great South Bay is insignificant, and the commercial finfish landings in the entire Long Island part of the Sound represent only 1—2 percent of the Long Island total.

Charts of the Long Island coastal waters have been published showing the popular locations for sports fishing by species [61], and every charter boat operator maintains a continuing "real time" awareness of "where they're biting today."

III-C Population Characteristics of Other Important Marine Fauna

Very little information is available on the population characteristics of an important predator, the oyster drill, but the overall population density is believed to be very low, and the drills appear to be under good control by oyster companies [62]. A little more information is available for another predator, the starfish, particularly as it relates to the growth rate of individuals. Prediction of the yearly starfish population has not been possible even though there is no migration [54]. Surprisingly, comparison of starfish and oyster populations has yielded no meaningful correlation [54]. Apparently these two predators, the oyster drill and starfish, are not as significant in Long Island waters as they are in Chesapeake Bay [13e].

III-D Population Characteristics of Important Marine Plant Species

Important marine plant species include eelgrass, and other grasses, phytoplankton and algae. Eelgrass is considered a nutrient source for fish and a nuisance to boaters and those living nearby who are offended by the odor and mass of its decaying vegetation when it piles up on the shoreline [1b]. It has been measured, occasionally even weekly, by standing crop estimates, by divers and by aerial photography in various parts of the south shore bays [54]. The U.S. Department of Agriculture at its Cape May, New Jersey, Plant Materials Center is studying various types of grasses useful for dune stabilization [63]. A few planktonology studies have been conducted in local areas usually for short summer periods, but the last comprehensive study on phytoplankton was completed in 1956. It emphasized species distribution and annual cycles [54].

III-E Population Characteristics of Important Migratory Birds and Other Wildlife Species

At many locations throughout Long Island, migratory waterfowl populations have been surveyed from the air, and ground observations of waterfowl feeding and resting areas have been reported [54]. Frequently, these observations are part of general surveys of the east coast flyway patterns. New York State has contributed regularly to the U.S. Fish and Wildlife mid-winter waterfowl survey since 1949. The State's Department of Environment Conservation and most universities on the island have on file a considerable mass of unanalyzed raw data. Several excellent, in-depth, long-term studies of wildlife have been made by the U.S. Fish and Wildlife Service as part of erosion control and hurricane protection studies in the vicinity of Coptree Island [121]. The data acquired by weekly flights might be usefully correlated with wind and other climatic data. Johnson at Hofstra University has thoroughly documented the precipitous decline of the rail population in Hempstead, Nassau County, and possible causal factors are being studied. Wildlife studies extending over at least several years have been made in the Jamaica Bay and Hooks Pond regions [54]. It should be noted that all of these studies, and many others that could be mentioned, are either site-specific or species-specific. If the numerous, scattered, fragmentary studies and raw data could be integrated into a more general study, it would provide broad-scale planners and decision makers useful insights on the overall viability of Long Island's coastal wildlife. Particularly needed are basic perspectives, trends and principles. How bad is bad? Is restoration or enhancement possible or feasible? What is involved?

III-F Recapitulation of Data Collection Needs

As indicated in a previous report [1b], "considerably more information is required regarding basic population characteristics, including numbers, size and age distributions and migration patterns. At present, individual species tend to be studied intensively only at widely spaced time intervals and after sharp decreases in commercial recoveries have already been experienced." Some other information deficiencies have been cited above in Category III. Effective management requires more systematic information than now typically exists, in terms of number of species covered; statistical reliability of data, especially as it is related to the intensity of fishing effort; and continuity of observations over time. However, a delineation of the priority data needs pertaining to the population characteristics of the marine-related biota would require a special analysis of a depth not attempted in any of the feeder reports or in any other report we have identified. Such a delineation should consider the experience of the Virginia Institute of Marine Science (VIMS) at Gloucester Point, Virginia. For the coastal waters of Virginia, VIMS periodically publishes predictions of the future abundance of selected commercially-important species based upon selected samplings and analysis of key year groups [114].

CATEGORY IV - INFORMATION ABOUT DESIRED USES OF COASTAL RESOURCES

IV-A Demand for Coastal Uses[/1]

Future demand for all or most coastal uses is affected by many factors including (1) resource availability and "quality," (2) demographic trends, (3) transportation, (4) public values, (5) affluence, (6) leisure, (7) multiple-use conflicts and (8) management controls.

(1) The resource base will probably not change basically[/2], but through intelligent and imaginative planning it can be preserved, improved and reallocated to better serve greatly increasing demands. San Diego [39c] and Jones Beach are two of the many examples of such resourcefulness in response to a predicted demand. More or less independently of man, nature is making major changes that can be foreseen along the Long Island coast, e.g., erosion, accretion, and hurricane damages [1h, 39a]. Some proposed solutions to the island's water supply and waste water disposal needs can significantly change the aquifer and streams that empty into coastal waters [1g]. Overfishing is greatly reducing the harvestable crop of fish in the oceans [64]. In Category VII, the quality of the resource base will be considered further in terms of selected parameters and how they affect the "desirability" of the resource for each use.

(2) Demographic studies are plentiful, but the long-range (say 25—50 years) projections all lack strong credibility[/3]. The Nassau-Suffolk Regional Planning Board has published its own population projections [5d, 5k].

[/1] See the beginning of Category I-B for an explanation of how coastal uses are classified and how they are addressed in several places throughout this report.

[/2] An exception could be wetlands; however, wetland losses may be slowing down [1j].

[/3] Demography is well developed for projecting the future implications of a continuation of observed trends in basic input factors. Demography is not well developed for foreseeing changes in these trends. For example, the past half century has seen rather startling, unpredicted, abrupt changes in birth rates, both up and down. Considering this experience, planners use demographical projections as essential basic inputs, but they use them with caution, particularly beyond two decades.

(3) It is not clear how the average travel times from the home to the desired coastal areas will change in the future. If the strategy advocated in the Comprehensive Development Plan [5i, 5k]—a high speed central transportation corridor—is implemented, it will certainly increase demand for coastal uses in the eastern part of the island to a degree that has not yet been estimated. However, each improvement in transportation facilities on Long Island is usually followed by an increase in traffic that eventually nullifies initial time savings for individual users

(4) Future public values are hard to preduct confidently; an example is the generally unanticipated growth in environmental appreciation in the past decade. However, it seems reasonable to us to assume that in the middle and long-range future, the public will place even more emphasis on non-material values, such as coastal recreation and an aesthetically appealing "natural" environment—if nothing else, as a reaction against increased congestion at home and at work. Sociological sampling is needed to augment the normal techniques of projecting current trends [65].

(5) Affluence is one of the more predictable factors affecting future demand. Per capita income in this part of New York State has been projected to nearly quadruple between now and 2020 [13a]. This increase is measured in constant dollars.

(6) Leisure time is also fairly predictable, at least as it is reflected by a shortening of the average work week. Nationally, per capita, working hours a year are expected to continue to drop, by about 15% or so in the next half century [13a].

(7) Multiple-use conflicts have been known to exist for some time, but the first significant effort to identify these conflicts systematically and categorize them according to their frequency, duration, areal extent and intensity occurred only a few years ago [36]. Competitive, complementary and substitutability relationships between coastal and related inland uses have been cited in a long-range coastal study for this region [13e]. Some efforts to improve one coastal use can adversely effect other coastal uses; these side effects are synopsized in a current coastal management study [39c] and considered in depth in a related study [39b].

(8) Management techniques can influence coastal use demand in many ways such as acquisition, taxation, cost sharing, planning, public services, zoning, subdivision regulation, building codes, ordinances, permits, orders, condemnation and inverse condemnation [39c]. The importance of coastal management was emphasized in the report

of the U.S. Commission on Marine Science, Engineering and Resources [66] and in several other recent national reports [67, 68]. Alternative institutional arrangements for managing natural resources on a regional basis have been analyzed by the U.S. Water Resources Council [69].

Notwithstanding the above-cited inadequacies in the current state of the art for foreseeing the future, the general thrust appears amply clear to us. In our opinion, and skipping over many important qualifiers, current information is adequate to make the following gross, long-range (50 years) prognosis:

Factor	Character of the change
Resource availability	Basically fixed
Population	About doubled
Transportation	Long distance travel much faster, local travel uncertain
Public values	Uncertain, probably increased environmental appreciation
Affluence	About quadrupled
Leisure	About 10—25% less per capita work hours annually
Multiple use conflicts	Greatly increased
Management control	More for public, less for private
Overall coastal usage (a synthesis of above)	UP VERY GREATLY

To be more specific, individual coastal uses will be considered below and some examples will be given of current methodology for relating the above factors, individually and collectively, to future demand. The examples for recreation will be presented in greater depth than the others.

Commercial fishing follows supply. Because finfish of commercial value are relatively scarce in these waters, most effort on increasing supply has concentrated on the more lucrative shellfish industry. If production could be restored to its earlier level, there is no question that a substantial market would exist. Many institutional and other factors have for years kept the level of economic reward for fishermen, both nationally and locally, well below the general pattern of wages in this area. Therefore, it is difficult to estimate how much possible increases in fish abundance would generate more intense fishing effort. There does not appear to be any adequate in-depth survey and analysis of the prospects of the area's fishing industry in these terms. Such an effort can provide a basis for broad planning and management, not only of fishing but of its interrelationship with other industries.

Demand for Long Island's coastally-related, non-living resources is the greatest for fresh water for water supply systems, sea water for power plant cooling, sand and gravel for construction and beach nourishment, and offshore oil and gas (potential). Previous reports in this series considered fresh water demand [1g] (high and quantified) and cooling water demand [1b] (very high but unquantified). Demand for offshore sand and gravel is currently low on Long Island, given the availability of other sources [38]. In the future, the demand on offshore sand sources is expected to increase very rapidly in sand-deficient metropolitan areas and more slowly on sand-plentiful Long Island [13e]. In contrast to sand, which is exported, gravel is relatively scarce and often must be imported to Long Island from the mainland. Geological features off the North Atlantic coast appear favorable to oil and gas [13e]. If this anticipation is borne out by exploratory drilling, regional and national demands for these resources may be high enough to overcome environmental vetoes, but not before considerable study, debate and the provision of rigorous environmental safeguards.

Future demand for the use of the assimilative capacity of the area's marine waters to facilitate waste disposal will vary greatly depending upon which of several major waste disposal strategies are adopted for the future [1g]. Projections of future domestic waste loads can be made by combining population projections with per capita indices developed in regional studies [13c]. The projection of future industrial waste loads would require a special study.

Demand prediction has received much attention over the past two decades in the field of outdoor recreation, mainly through the impetus given by several federally-led comprehensive river basin studies [70] and the formal recognition by the federal government that recreation was indeed a creditable benefit in water resource projects [71, 72]. The significance of many of the eight factors cited above has been analyzed on a factor-by-factor basis [73, 74, 75, 76], on a multi-factor basis [77, 78], and on a regional basis [13d]. New York has attempted to forecast recreation demand based upon ten selected variables—age, income, education, race, population density, home ownership, car ownership, family size, number of children less than twelve years of age in the family, and number of vacation days in the previous year [41d]. The demand relationships developed with some confidence upstate were apparently found to be not at all applicable to the New York metropolitan area and Long Island [39c]. An analysis of a recent household survey [79], an on-site survey [80], and a well-conducted local survey [43] can provide a source of basic insights and material for estimating Long Island's future recreational demands. The household survey, for example, indicates the proportion of residents that do not use the beaches by age groups and the reasons they cite such as overcrowding, inadequate beach maintenance and transportation difficulties.

Detailed statistics on the current level of marine transportation at Long Island ports [44] can be combined with broader regional perspectives on shipping trends [13e] and socio-economic trends [13e] to permit some inferences on future demand. On a sub-regional basis, such projections have been made [13b], but they do not provide a breakout uniquely for the bi-county area. In general, although some local ports are active in the shipment of sand and the receipt of gravel and refined petroleum products [44], marine transportation is not substantial in the bi-county area and recent trends do not point up major increases in this use—unless, as some propose, Long Island's capability is exploited to provide a badly-needed deepwater port to meet regional demands.

Within the North Atlantic region, there is a major unsatisfied demand [13e] for one or more large, offshore oil loading facilities to accommodate the super tankers currently operating at major savings along high-volume routes in many parts of the world [81]. One of the very few places in this region where adequate depths may be found close to shore is the north shore of Long Island. Such a siting has been suggested and strongly opposed. There is, in short, little question of the demand. Whether or not it will be satisfied here, as currently seems possible but unlikely, is a matter for a regional port study [82] involving substantial local participation.

Land use demands throughout the bi-county area are intense and growing. Basic information has been assembled by the Nassau-Suffolk Regional Planning Board [5h] and reflected in its Comprehensive Development Plan [5k]. The plan has no legal force, but it has received the endorsement of one of the counties, Suffolk, and nearly every village, town and civic group of the region. Currently, much coastal land in the southwest quadrant of the bi-county area is used for non-coastal purposes, primarily housing. Without the type of coastal inventory and future demand information suggested earlier, it is not clear to what degree coastal lands must be allocated to coastally-related public uses.

Coastal land use is particularly relevant to the problem of shore protection. The decision as to whether or not a given stretch of shoreline is worth preserving or restoring depends upon its value relative to those other areas that compete for limited funds. The value of a particular section of shore is not immediately obvious, though each individual may make his own prejudicial evaluation without hesitation. For the entire coastline of Long Island, it will be useful to obtain the information from which an evaluation can be made in terms of the general welfare. This has been done to some degree in a beach erosion study of the north shore [115].

A recent study [39c] outlines the relationship between shoreline conditions and coastal uses such as beach recreation, other types of recreation and aesthetic appreciation, resource extraction, waste disposal, transportation, development and ecological use. The key point stressed in the study is that the decision to do anything about coastal erosion and inundation is based primarily upon the use values affected. Important in gaining an appreciation of these values is usage data—the location, extent and intensity of a variety of coastal uses with emphasis on public and private ocean-front areas used for recreational and residential development. From the viewpoint of coastal stabilization and protection, these data are most essential in erosion and inundation prone areas. However, usage data for more stable areas are also pertinent for comprehensive planning. For example, an alternative to combatting erosion at a heavily used area might be to shift usage to a more stable area nearby through the provision of improved access and facilities.

Also, usage data will greatly facilitate cost-effective provision of waste and sewer services. It is shown [1g] that more than half the cost of the integrated water supply and waste water disposal in Long Island can be allocated to water distribution and waste water collection. Closer delineation of development and better design methods are needed to derive greater benefits from this investment.

Other problems intimately related to land use demands along the coast are dredging [1i] and wetlands [1j]. Although dredging is a human activity and as such subject to trends in population just as other activities, the changing public mood in relation to environmental matters is altering the acceptance of dredging and wetland filling considerably. Trends based upon past experience in these areas are likely to be inaccurate. For example, the high rate of wetland filling experienced over the last two decades must necessarily decline, if for no other reason than that most of the remaining wetlands are publically owned [1j].

IV-B Water Quality Standards

Water quality standards have been prescribed by New York State [83] for

- Four classes of fresh surface waters,
- Six classes of tidal salt waters, including two special classes, and
- Three classes of groundwater.

The tidal salt water standards were discussed in a previous report of this series [1d]. Briefly summarized, the highest classification, SA (Shellfish for marketing purposes), has been assigned to all waters in the Sound and Atlantic Ocean and in the major parts of all large bays. Waters with lower usage classifications are found in many of the numerous small indentations along the inland shoreline (not barrier beach shoreline) of the major bays along the south, east and north shores. In these small subestuaries, flushing action is usually the poorest and waste loadings are the heaviest; thus suggesting more intensive localized treatment, relocation of outfalls, and/or improvements in local flushing characteristics.

Information on the observed quality of coastal waters was cited earlier under Category II-B of this report.

Information is obscured as to precisely where the assigned classifications are currently being violated. A number of areas are closed to shellfish harvesting and a few to bathing, but many of them are not classified for these uses. Two coliform violations were found in a 1969 federal survey of Long Island Sound [20], one in Manhasset Bay for SA waters and one in Little Neck Bay for SB waters. In various state, county and interstate surveys conducted between 1966 and 1970 [20], four other SA violations were discovered in Oyster Bay, Cold Spring Harbor, Port Jefferson Harbor, and Huntington-Northport Harbor [20]. The area, duration and degree of violations were not listed for any of these cases. The county governments or the state should consider reporting periodically, on a simple map, where violations are occurring and why they are occurring, as a basic service to the public, and to planners and administrators.

Possibilities for improving the water quality criteria associated with these usage classifications were pointed out [1d] in the areas of coliform bacteria, nutrients, pH, oil and pesticides. The coliform standards are particularly questionable with respect to the level considered significant for bathing and also with respect to the technical and practical adequacy of this method of indexing bacterial pollution [1g]. Temperature criteria for cooling water discharge will differ greatly depending upon whether the objective is to maximize the proportion of heat vented quickly to the atmosphere (this objective encourages surface plumes) or minimize water temperature differentials (this objective encourages deep underwater diffusion and heat entrainment) [84].

IV-C Recapitulation of Data Collection and Research Needs

(1) Future travel times. Collect existing information and plans, and estimate the most probable travel times between strategic points on Long Island, and adjacent areas, at different time horizons in the future.

(2) Future public values. Conduct sociological sampling and research sufficient to provide insights as to likely future changes in public values insofar as they might affect major coastal uses.

(3) Offshore petroleum. Determine the social, economic, environmental and technological impacts upon Long Island (and north-eastern United States) of alternative strategies for extracting, transporting, refining and distributing oil and gas in substantial quantities from anticipated sources off the north-east coast.

(4) Future industrial water requirements. Collect information on current industrial water uses and waste loads, predictions of future technological changes, and master planning data; then estimate future industrial water usage and waste water discharges.

(5) Future coastal usage. Assess the impact of the Nassau-Suffolk Comprehensive Development Plan and future projections associated with its formulation, on the future demand for each major

coastal use, especially recreation and land use. Assess the adequacy of the coastal resource base to meet these demands. Recommend actions to minimize deficiencies or soften their impacts (also includes an examination of the interrelationships between coastal uses).

(6) Information on water quality violations. Report periodically to the public on a simple, easily-read map all locations where assigned usage standards are not being met and the duration, areal extent, severity and causes of the violations.

(7) Adequacy of coliform standards. Evaluate the adequacy of the coliform criterion of 240 MPN per 100 ml, now administratively employed in the bi-county area, for judging the quality of marine waters for bathing purposes.

(8) Adequacy of bacterial pollution indices. Develop a more reliable, easily-measured and unambiguously-interpreted approach to measuring bacterial pollution than the coliform approach now employed.

(9) Adequacy of thermal discharge. Identify and evaluate several alternative heat dissipation objectives (e.g., minimize the total heat entrainment or minimize temperature differentials) and evaluate the adequacy of existing and alternative criteria to foster the attainment of these objectives.

(10) Improving water transport systems design. Improve the techniques of design of water distribution and waste water collection systems and demonstrate their application in cost-effective design of such facilities especially in newly developing areas and in expanding the capacity of existing systems.

SECTION 3 - KNOWLEDGE ASSESSMENT

CATEGORY V - KNOWLEDGE OF PROCESS BY WHICH ACTIONS AND FORCES AFFECT THE PHYSICAL AND CHEMICAL STATUS OF THE ENVIRONMENT

V-A Physical Processes

This category considers the process by which fresh water and associated materials ("contaminants") are transported through the hydrological cycle and suspended, dispersed and deposited in coastal waters. Later, in Category VIII, the use of this knowledge for prediction purposes will be considered.

The processes by which contaminants enter and leave the hydrological cycle, in its natural and its man-influenced forms, are discussed in Appendix C of a previous report in this series [1g]. One of the processes, infiltration, needs to be studied in depth because of its key relationship to several important questions:

(1) To what extent does groundwater pumping affect the movement of water and associated materials through the aquifer and influence salt water intrusion?

(2) To what extent do cesspools and septic tanks affect groundwater quality?

(3) How feasible is the recharge of the aquifer by three proposed methods—ponding, injection and irrigation?

Evaporation and transpiration processes have been studied extensively as basic parts of the discipline of hydrology. However, their individual and combined effects are not known well enough to estimate with acceptable accuracy the loss of about half of Long Island's precipitation [1g].

When the sources of waste are adequately known (Category I-A) and when the desired coastal water quality has been prescribed in satisfactory terms (Category IV-B), knowledge is needed on the rate of transport of the waste particles and their suspension, dispersion, and deposition in the receiving water body. The adequacy of this type of knowledge is poor. For example, it is apparently not known to what degree, if any, contaminated groundwater from liquid and solid waste sources might be entering coastal waters and affecting their quality. Similarly, although several major studies have been made recently off New York Bight [13e, 21—24, 116], it is not known how sludge and chemical wastes there might be affecting the bi-county waters, if at all.

Knowledge of the movement of contaminants can be obtained empirically or theoretically. Empirically, periodic measurements can be made of suspended and deposited materials. By comparing these observations with information on their sources, gross inferences of their movement patterns can be made. Thus, periodic measurements are useful in estimating the gross littoral transport of sand. Dyes are frequently used in water bodies to permit observation, sampling, photographing and subsequent digital computerization of circulation patterns.

Often these observations will be sufficient, but where an understanding of the possible effects of change is required, a more fundamental understanding of the processes involved is usually required.

As indicated in a previous report [1e], the movement of a particle of given mass through water (or any other medium) can be defined if the external forces acting upon the particle are known. This is so whether the particles be nutrients, coliform bacteria, sediments, pesticides, oil or other particulate matter of coastal interest. The principal forces acting upon the particle are the pressure gradient force, the frictional force, the gravitational force and the Coriolis force. The last two are basically constant, but the first two are influenced by many things, principally boundary configurations and density variations caused by changes in temperature, salinity and suspended materials.

Physical processes are particularly relevant to problems of shore protection [1h]. The dynamic nature of the coastal interface between land and water makes obvious the importance of knowing the processes that take place there if responsible decisions are to be made with regard to shoreline use and development. In matters concerning coast stabilization and protection, the processes are those that result in erosion or accretion of a beach, shoaling or scouring at or near inlets or structures, the creation of a resilient shore by engineering or natural means, or its destruction by an overpowering sea. In more specific terms these include:

- The suspension, transport and deposition of sediments by currents, and the structures or natural forms that give them direction and speed;

- Changes that can be effected in the above both by a natural process and by engineering intervention;
- The manner in which shores and engineering structures dissipated the energy released upon them by waves, tides and storm surge.

Because the mechanics of energy dissipation are not well enough understood and the properties of the energy adsorbing surface vary so, most of this knowledge is in the form of empirical formulas and curves [45].

The work of wind, waves, swells, tides and littoral transport, and the design and construction of devices to produce desired results where these forces are active, are treated in a definitive way both qualitatively and quantitatively in a basic text of the U.S. Army Coastal Engineering and Research Center [45]. In addition to a comprehensive, illustrated discussion of all the processes mentioned above, this document contains appendices that provide a glossary of terms, a list of common symbols, a bibliography of 245 references, seventy-six pages of tables and other presentations of pertinent mathematical relationships and derivations. The same material is summarized briefly for light reading in a related report [39b].

Much research, nationally and locally, is currently devoted to the dissipation of large quantities of waste heat from power plants [1b, 85]. The key phenomenon here is density stratification. After an initial period of turbulent mixing near the outfall, the heated water usually moves quickly to the surface and spreads out into a thin and often-large plume of heated water until the heat lost to the atmosphere or water body reduces the thermal differences sufficiently to break up the plume along its edges by wind and wave forces. The basic phenomenon is fairly well understood. Some intensive studies of thermal discharges are focused on predicting the frequency distribution of the plume as it is affected by prevailing climatic factors [86].

V-B Chemical Processes

The suspension, transportation, dispersal and deposition of materials in coastal waters is also affected by internal changes in non-conservative particles. Non-conservative particles are those which undergo changes over time under the influence of various chemical and bio-chemical processes.

Temperature is especially important as a catalyst of chemical and bio-chemical change, so much so that great precautions must be built into sampling and analytical techniques to account for its effects. The solubility of dissolved oxygen and other gases and chemical constituents is greatly influenced by temperature, a phenomenon of major importance for waste disposal and aquatic life. Much research is currently underway on these temperature effects on both theoretical and empirical levels, particularly in relation to the discharges from power plants [87].

The synthesis of chemicals in the aquatic environment is very complex and probably not well understood [54]. Stumm and Morgan provide a good introduction [117] and Horne has briefly summarized current knowledge about the constituents, physical-chemical properties and structure of sea water [118]. Both sources provide extensive bibliographies.

The processes of decomposition, degradation and change in composition of chemicals over time is also complex. The fate of pesticides, oil, dissolved oxygen, phosphorous, nitrogen and other chemicals is involved here. As a general assessment of the state of knowledge, it can be reported that [54]:

- When the specific conditions of exposure of a given chemical can be stated precisely, the fate of that chemical can be predicted.
- In the natural environment, it is often not at all feasible to define these very variable exposure conditions and integrate them into the analysis.

For all its complexity, knowledge of all of these processes as they affect the fate of a non-conservative particle can be theoretically considered adequate. Currently, much more important limitations on accuracy are the practical limits within which detailed input data can be acquired, formularized and manipulated [1e, 88]. These problems are considered in Category VIII-A.

Theoretically, the movement of water and associated conservative and non-conservative materials through aquifers should follow similar rules. However, because of the difficulty of observation and the slowness of movement, groundwater flow is usually estimated more on an order-of-magnitude basis [1g].

A general description of chemical and bio-chemical degradation in water systems, particularly mathematical descriptions, seems unlikely to emerge [54]. Instead, mathematical and physical models usually rely upon assumptions of gross decomposition rates based upon mathematical correlation with observed phenomena.

The effects of mixing and flushing on salinity levels are at best only generally understood. Among the factors involved are temperature, diffusion, advection and wind action. On a grosser scale, the single most significant factor is probably the size of coastal inlets,and their harmonic relationships with local tidal cycles. It is currently difficult to compute salinity concentrations, even with the use of continuity equations, but general regimes in semi-confined coastal waters can be roughly approximated [1e].

V-C Recapitulation of Research Needs

(1) Evapotranspiration processes. Improve the adequacy of current knowledge about evaporation, transpiration, and combined evapotranspiration processes and rates in the bi-county area.

(2) Infiltration processes. Improve the adequacy of current knowledge of infiltration and percolation processes in the bi-county area to include the rate of downward infiltration from the surface and the horizontal and vertical rates of percolation through the aquifers.

(3) Movement of contaminants in groundwater. Improve the adequacy of current knowledge of the processes by which contaminants enter the aquifers, increase, move or decrease therein, and eventually leave the aquifer through seepage to surface water bodies, underflow to the bays and oceans, and through pumpage. Primary emphasis should be placed on selected contaminants such as detergents, nitrogen compounds and pathogens.

(4) Movement of contaminants in bays. Especially if additional major sewage outfalls are considered in the bays, improve the adequacy of existing knowledge of the processes of suspension, transport, and deposition that influence the ultimate fate of major sewage constituents, both conservative and non-conservative, in the bays. The major sewage constituents would include nitrogen and carbon compounds, phosphorus, and parameters such as coliforms, dissolved oxygen, BOD, COD and total dissolved solids.

(5) Movement of contaminants in the ocean. Improve the adequacy of eixsting knowledge of the processes involved (including outfall design and dumping methods) in influencing the fate of major

constituents of sewage and dumped wastes in the vicinity of ocean outfalls and ocean dumping sites.

(6) Salinity changes in bays. Improve the adequacy of current knowledge of the mixing and flushing processes that influence salinity concentrations under potential changes in stream inflow, and in inlet size and location.

CATEGORY VI - KNOWLEDGE OF THE EFFECTS OF PHYSICAL AND CHEMICAL CONDITIONS AND OF ACTIONS AND FORCES ON THE MARINE BIOTA

VI-A Influence of Water Quality Conditions

To increase general understanding of living marine resources and to find ways of protecting and enhancing them, it is important to know how changes in water quality parameters affect marine life. This type of knowledge is especially needed in evaluating the effects of sudden changes, such as the breaching of a barrier island by a storm or the enlarging or clogging of inlets by either man or nature; or major increases and decreases in in-bay waste discharges.

Since the alteration of an inlet's cross-section can change the tidal exchange between the backbay and the ocean, the alteration will affect the flushing qualities of the backbay and thus "improve" or "degrade" water quality throughout the bay. Whether the possible changes in water quality are desirable, unimportant or undesirable depends in substantial part upon the effects of the changes on marine biota of the backbay. Changes in flushing can change all water quality parameters, but the most important to marine biota in this context is probably salinity. Other potentially important changes are in temperature, nutrients, and dissolved oxygen.

Some authorities feel that quantified statements on the salinity ranges (or other parameter ranges) of marine species are misleading oversimplificaaions [89]. In support of this posture, it is easy to point out the numerous synergistic relationships (1) between water quality parameters, such as between salinity and temperature, and (2) within the whole complex marine food chain. A graphic example of the second relationship can be observed in Chesapeake Bay where the down-bay limits of oyster habitation are fixed by the salinity tolerance of the oyster's predators (starfish and oyster drills) [13e].

Notwithstanding these points, most decisions can not wait until the whole complex web is deciphered. Therefore, we will summarize knowledge of observed salinity ranges of selected species in very brief terms that we feel are useful for coastal planning purposes. In reviewing these limits, it should be kept in mind that typical salinity concentrations in Long Island Sound and Great South Bay fall in the general range of 25—30 parts per thousand (ppt) [14, 15, 20].

The most important species to be considered are the hard clam and oysters and the other species that are significantly related to the life cycles of these two species, such as the plankton they feed upon and the predators and disease organisms that consume them. The hard clam is believed to tolerate a range from 17 ppt to the salinity of sea water (about 35 ppt), and thrive at 28 ppt [54]. Corresponding figures for the once commercially-important oyster are believed to be 5, 24, and 28 ppt. The starfish and oyster drill cannot tolerate salinities below 18 and 12 ppt, respectively. In the past two or three years these two predators have increased rapidly in the south shore bays from a rarity to a commonplace [62]. The starfish are the greater threat; the oyster drill population can be adequately controlled by the commercial clammers [62]. Since the starfish and oyster drill cannot tolerate salinities below 18 and 12 ppt, respectively, increases in bay salinity have been cited as the cause of the population increase. Other factors, however, must play an important role because bay salinity is actually somewhat less, not greater, than it was during the drought years in the early 1960's [6], when the starfish population was insignificant [62].

Most marine finfish live in water with high salinity at or close to sea water, but several species, such as striped bass, bluefish, and menhaden, require low salinities for spawning and/or for their juvenile stages [54].

Temperature has probably been studied in more detail than any other water quality parameter. Every species has a thermal range at the borders of which it dies and within which its vitality peaks. The range varies considerably from species to species and less but appreciably for different stages of the life cycles. For the major species on Long Island, these tolerance ranges are generally known, especially at the extremes [54]. Even within its tolerance range, a species can be affected by sudden changes in water temperatures such as those which occur around thermal discharges. Knowledge of this shock effect is being acquired as part of the many thermal studies made nationwide. Since most fish appear to be able to evade the interface, the overall lethal effect may not be great. The sensitivity of migratory marine species to minor temperature changes well within their tolerance range has been cited as the most probable reason for the observed recent migration of the lobster southward into Long Island Sound.

Dredging operations can stir up oxygen-deficient bottom sediments. When these sediments are suspended in the water column, they can temporarily reduce the dissolved oxygen in the vicinity of the dredge [90]. This problem has not been extensively studied in the bi-county area, but it does not appear to be acute there [1i]. In a study of dredging on high oxygen-demand, Long Island duck wastes, no major drop in dissolved oxygen was observed [91].

Finfish generally move to well oxygenated locations. Striped bass seem to do well in fairly polluted waters [54]. Shellfish tolerate a wide range of oxygen levels; some species like the oyster and hard clam can survive for short periods of time without any oxygen [92].

Filter feeders feed primarily on plankton and detritus. Finfish feed on a wide variety of marine life at all trophic levels. Turbidity and pH levels do not seem too important, but some preferences can be detected. For example, bluefish display a preference for the waters off New York Bight where acid wastes are dumped, and oysters feed less when turbidity is very high [54]. The principal effects of turbidity are a decrease in the intensity of light that reaches the bottom and a resulting diminution of photosynthetic processes there. It has been noted that where the bottom was "within the euphotic (lighted) zone, ...high production was possible even with high turbidities." In the bi-county area with its shallow bays, turbidity is probably not a critical factor [1i].

Sedimentation can clog and eventually smother filter feeders. In upper Chesapeake Bay, and other coastal locations where sedimentation is a problem, its effects on benthic life, and the time required for benthic life to recolonize new bottoms, have been observed and reported [92, 93].

Knowledge of the effects of pesticides, radionuclides and heavy metals is mostly general [1b, 54]. Some species, particularly the oyster, hard clam and fluke, have been shown to concentrate some of these toxic substances [67]; however, systematic knowledge of the multiplication effects of these concentrations throughout the complex marine food chain is really only emerging and is not adequate to set rational water quality criteria with confidence [13e, 94].

The biological impacts of discharging secondary wastes by ocean outfall are not well known; current opinions seem to range from "harmful" to "beneficial." More conclusive answers are badly needed by planners [1g]. Similar questions arise with respect to the non-local effects of ocean dumping of sludge and dredgings containing toxic materials [13e, 23].

Knowledge of the effects of oil is also mostly general [54]. It is usually fatal to the waterfowl that land in oil slicks. Its effect on shellfish and finfish is debatable [13e]. Studies after the Torrey Canyon [36, 95] and Santa Barbara [96, 97] oil spills indicated little long-range effect, but studies at Woods Hole [98] reached an opposite conclusion.

VI-B Habitat Requirements

Estuaries are recognized as important habitats for both shellfish and finfish. An "estuarine-related species" is any species that spends any significant part of its life cycle in or passing through estuaries. The most commercially important of these species have been listed [99] and it is possible to see what proportion of the total commercial value they represent in each coastal region using published landings data [32, 33]. Such an analysis [13d], using 1968 as a sample year, revealed that estuarine dependency increases rapidly southward from under 20% in Maine and New Hampshire to 90—100% in the Chesapeake Bay area. In the Long Island area, about 75% of the catch, by value, is estuarine-related.

Some water circulation is essential for filter feeders. Lobster larvae are moved by wind-driven surface currents. Finfish have wide tolerances but strong preferences. The whiting prefers the turbulent surf. The bluefish and striped bass prefer strong currents. The fluke and bass prefer only a little tidal circulation [54].

Oysters in Long Island Sound are found in greatest quantities at depths of about 8 to 10 meters. Surf clams are found in the intertidal zone and bay scallops are found in depths up to 20 meters. Finfish prefer a wide variety of depths, from the near surface bluefish to the bottom-preferring yellowtail flounder and whiting. The young fluke and menhaden prefer shallow estuarine waters, and striped bass spawn in deep river waters. Most species move to shallow water for feeding. Some, like the fluke, move into inshore bays in the summer and to deep water offshore in the winter [54].

Most species prefer soft flat bottoms, but the lobster and striped bass prefer rocky or gravel bottoms [54]. One possible effect of dredging is the creation of potholes along the bottom. Potholes have been portrayed as having biological effects that are all bad [1b, 100] and a mixture of good and bad depending upon the species involved [101]. Dredging operations can be regulated so as to produce or not produce potholes, but intelligent use of this capacity will remain unexploited until current understanding is improved [13e].

VI-C Factors and Processes

The effects of inlets in promoting the biological interchange between the ocean and backbays are not well known except in gross terms [101]. Knowledge of the possible implications of various inlet configuration on the passage of floating eggs, larvae, and young fish would be useful when inlet stabilization plans are being prepared.

The principal competition among fish is for food and thus all species with similar nutrient requirements may be generally considered to compete with each other.

The chief predator of most of the species cited herein is man. All species, except possibly the starfish, have a variety of other predators particularly during the earlier days of their life cycles. Oyster drills and starfish do not appear to be very important predators to oysters [54] as they are in Chesapeake Bay [13e]. Ctenophores feed on oyster larvae and herring, and flatworms feed on the adult oyster. Eels feed on lobster eggs, and fish feed on lobster larvae. Man is the major predator of the adults. Predators of hard clams include jellyfish, starfish and other filter feeders at the larvae stage and man, starfish, blowfish, winkles, conches, drills and crabs at the adult stage [54].

Knowledge of production, energy transfer, and population growth and control is sparse for most species cited [54]. The shellfish particularly are susceptible to a number of parasites and diseases about which not too much is known. The MSX disease, for example, is believed to be more responsible for the insignificant oyster crop in Delaware Bay than any other cause [102].

Current knowledge of eelgrass was summarized in an earlier report [1b]. Knowledge of ways to control its growth is poor and knowledge of the net multi-use impact of such control is poorer (impacts on fish versus impacts on boaters and shoreline users). There is an apparent need to study in situ growth rates to determine what specific conditions promote rapid growth and the effects of increased nutrients, herbicides and pesticides [54].

The productivity of Atlantic coast wetlands has been gauged by the annual production of smooth cordgrass in tons dry weight per acre. On this basis, productivity diminishes sharply from south to north[/1].

No thorough ecology-productivity study of Long Island's wetlands has been conducted [1i, 54]. This points up an apparently important need in that so much of the concern for preserving and enhancing wetlands stems precisely from this ecology-productivity relationship.

Phytoplankton was last studied comprehensively in 1956 emphasizing species distribution and annual cycles. A few planktonology studies have been conducted in small areas usually for a short summer period. Studies on phytoplankton-zooplankton relationships are 15 to 25 years old and are limited to Long Island Sound and Block Island Sound. There might be a need for such studies in economically important embayments to establish relationships of zooplankton to higher tropic layers, pesticide residues and heavy metals.

VI-D Recapitulation of Research Needs

(1) Contaminant effects in bays. Estimate the most likely effects upon marine biota in the bays, of changes in a few selected, significant water quality characteristics.

(2) Salinity effects in bays. Determine the effects upon marine biota of changes in salinity concentrations in the bays at all stages of the life cycles of selected species (e.g., hard clam, oyster, menhaden, sea bass, starfish and oyster drill). Priority attention should be given to evaluating the effects of changes within the 25—35 ppt range over most of the major south shore bays and within the 0—25 ppt range in the immediate vicinity of inflowing streams.

(3) Toxic effects in the food chain. Review existing knowledge of the multiplication effects of introducing toxic material into the food chain and improve this knowledge sufficiently to make possible the rational surveillance and control of these materials as a part of all future waste disposal strategies.

[/1] Between 4 and 10 in Georgia, 2.9 in North Carolina, 2.2 in Virginia, 2.0 in Delaware and 1.3 in New Jersey [13e], 103].

(4) Contaminant effects of ocean outfalls. Resolve current uncertainties as to the widespread impacts of ocean outfalls on ocean ecosystems: adverse, insignificant, or beneficial.

(5) Contaminant effects of ocean dumping. Determine the biological impacts of dumping sludge, and dredgings containing toxic materials, at designated offshore sites with particular attention to the effects outside the disposal area.

(6) Contaminant effects of oil spills. Resolve current uncertainties as to the most probable effects on marine life, other than waterfowl, of oil spills in the vicinity of Long Island.

(7) Effects of potholes. Determine the circumstances in which, out of consideration of marine life, the granting of a dredging permit should direct or encourage the permittee to avoid leaving (or leave) potholes on the dredged bottom.

(8) Effects of inlets on biological exchange. Determine the effects of inlet characteristics in promoting biological interchange between the oceans and embayments, so that these characteristics can be considered in inlet stabilization plans.

(9) Eelgrass control. Examine alternative methods of controlling the growth and spread of eelgrass and develop a plan for employing these methods that takes into account the different needs of fishermen, boaters, shore residents, and other shoreline users.

(10) Ecology-productivity analysis of wetlands. Evaluate the ecological contribution of Long Island wetlands by type and location.

CATEGORY VII - KNOWLEDGE OF THE IMPACT OF PHYSICAL, CHEMICAL AND BIOLOGICAL ENVIRONMENTAL CHARACTERISTICS ON USES OF THE COASTAL RESOURCES[1]

In Category IV-A the demand for coastal uses was considered to be largely influenced by eight factors. One of these factors was the availability and quality of the resource base. The relationship between the quality of the resource and its use will be developed further here in Category VII.

Changes in (1) the physical characteristics considered in Category II-A, (2) the water quality parameters considered in Category II-B, and (3) the biological characteristics considered in Category III can be demonstrated to impact upon all major uses of the Long Island coastal zone. The general question implied in this category is: "If one changes these characteristics, how will the usage pattern change?" Many significant questions can be formulated from this general question in varying degrees of specificity by pairing the array of physical, chemical and biological characteristics developed in Functional Step Two [1c], and considered in earlier categories, with the usage classifications outlined in Category I-B. Examples:

- If we "improve" water quality by this much, what difference will it make to commercial fishermen, or ocean bathers?
- To what degree will a wider, sandier beach benefit ocean bathers?
- How much will the loss (or creation) of wetlands diminish (or improve) sports fishing success or aesthetic satisfaction?

Some work on these relationships was initiated on Long Island [104], developed further in California [105] and along the Gulf Coast [106], and illustrated as a basic part of a suggested coastal zone planning procedure in a recent report [39c]. In general, however, well-developed quantitative answers to key questions like the above are scarce, scattered and of questionable quality for most coastal uses. Furthermore,

[1] See the beginning of Category I-B for an explanation of how coastal uses are classified and how they are addressed in several places throughout this report.

as brought out in Category IV-A, socio-economic factors, quite independent of coastal characteristics, often play the dominant role in influencing the extent of coastal usage. For example, New York State has analyzed beach attendance in terms of several major characteristics of the sites [41b]. The resulting capacity equations proved reasonably adequate in reflecting actual site patronage in most of the state, where attendees presumably had choices. But when applied to Long Island, the equations understated actual attendance by factors ranging from three for Suffolk County beaches to 25 (!) for Queens County beaches [39c]. On Long Island, it is apparent that in this case the demand, much more than beach characteristics, influences participation.

VII-A Impacts on Coastal Uses

With the above important reservation prominently in mind—that the non-coastal socio-economic factors often have a greater impact on coastal usage than the characteristics of the coast itself—we will briefly review each major coastal use in terms of the physical, chemical and biological factors that are most applicable to it. Because of the general absence of documented knowledge in this area, most of the following brief summary reflects our own judgment.

Commercial fishing. The effects of coastal conditions on marine life was considered in the preceding category. The great fluctuations in the total catch and even greater fluctuations by individual species (e.g., the demise of the oyster), are well documented; but the reasons for these fluctuations are generally speculative, including such diverse possible factors [1b, 13e] as (a) problems of the industry itself, (b) overfishing of a common resource, (c) minor water temperature changes, (d) diseases, (e) "natural" biological fluctuations, (f) wetland losses and (g) pollution. Despite some assertions to the contrary, the major body of evidence does not appear to show any clearly-defined, widespread, causal relationship between waste water disposal and fish abundance in the bi-county area [1b].

What is clear, however, is that shellfish harvested from large posted areas can no longer be marketed for raw human consumption unless they are first depurated [13e, 20]. Considering the many criteria, other than coliform contamination, employed by the U.S. Public Health Service in deciding to close an area [13e, 20, 30], little assurance can be given that success in current proposals for improved sewage treatment will make much of a difference in opening shellfish areas [20].

An alternative strategy bears consideration: (1) As a public safeguard—something like the pasturization of milk—require all shellfish to be depurated before marketing, (2) where upgrading seems realistically unattainable, accept Class SB waters (suitable for bathing) instead of the much more difficult to achieve Class SA (suitable for harvest of shellfish for human consumption without depuration), (3) subsidize commercial shellfishmen for the added cost of depuration as an equitable redress for a society-inflicted harm. The total cost of the subsidy might be minor, especially when compared with the added cost of going from SB to SA waters. The cost of the subsidy might also be significantly offset by savings in the cost of monitoring the present system and by the value of the additional public health safeguards.

If a strategy of lowering groundwater levels is adopted, stream flow into the south shore bays will diminish rapidly. The degree to which recreation and aesthetic values would be affected needs more study.

Extraction of non-living resources. Water depths, currents, wave action and distance from shore influence the extraction of sand. However, the major limiting factors are the availability of more economical, alternative sources inland.

Waste disposal. The disposal of wastes into coastal and offshore waters is importantly influenced by a wide variety of environmental characteristics and processes considered earlier. Careful consideration of physical characteristics in the disposal area is required. Water depths, bottom composition and configuration, and currents influence the dispersion of effluents and the location and stability of ocean outfalls. Biological characteristics of the receiving waters influence the location and degree of treatment of effluents. The site-capacity of typical residential plots to accommodate a series of cesspool relocations over the years needs to be expressed in terms suitable for planning purposes.

Recreation and aesthetics. The U.S. Bureau of Outdoor Recreation has published outdoor recreation space standards [107]. Future recreational facilities and open space have been studied on Long Island [108, 109]. Outside of the New York State study [41b], not much has been done on Long Island in relating beach characteristics to perceived quality and patronage.

The principal environmental characteristics which impact on beach recreation and bathing, generally in our estimated order of decreasing importance, are:

- Seasonality. It limits these uses to about 90 days annually.
- Weather. Within the summer season, beach uses vary greatly with daily and even hourly changes in precipitation and ambient temperature.
- Beach composition. There is a very marked preference for clean sand beaches. Pebbly beaches are used much less, and rocky, silty and clay shorelines are little used for beach recreation and bathing.
- Coliform. Public health considerations sometimes force the closing of beaches to bathing particularly along the inland shore of the bays and harbors. As indicated in Category IV-B, there is some question as to the adequacy of coliform standards used for making closure decisions.
- Aesthetic characteristics. Particularly for beach recreation, aesthetic factors such as visual appeal and cool sea breezes have a significant impact on uses. On hot summer weekends this is often the most important factor influencing use.
- Surf action. This is one of the major reasons why the south shore ocean coast is preferred.
- Areal extent. The length and depth of a beach limit its capacity. Congestion limits use.
- Water temperature. Near the beginning and end of the bathing season, water temperature sometimes influences use. Even during the summer, some decide between the bay and the ocean based upon their water temperature differences.
- Unusual conditions such as excess turbidity. Oil and floating and settleable solids, if present, will become limiting factors.

The above environmental conditions are generally beyond the practical control of management except for beach composition, coliform, aesthetic characteristics, and areal extent. Besides public acquistition, most effort in increasing recreational use of beaches therefore lies in creating, preserving and enhancing beaches with sand; maintaining adequate water quality; providing good approaches, access, and on-site facilities and preserving aesthetic appeal.

Boating is also greatly affected by seasonality. Weather, particularly winds and visibility, has more of an impact on boating than it does on beach recreation and bathing.

Other important environmental characteristics include water depth, surface area, current, wave action, the quantity and quality of sports fishing in the vicinity, and the shoreline insofar as it provides adequate launching and docking opportunities and aesthetic appeal. In extreme cases of nuisance conditions, water quality can also have a major impact. Of the above environmental conditions, the ones most likely to be improved or mitigated by management are (1) weather, through warning systems, (2) channel marking and improvement, (3) the sports fishery, and (4) shoreline sites and facilities for launching and docking. The shallow, protected south shore bays are ideal for small craft requiring ample public launching facilities. On the north shore, the need is for marinas which can accommodate the larger craft suited to the Sound.

Marine transportation. Of all of the major coastal uses, the relationship between coastal conditions and usage is probably the most clearly known for this use. The principal conditions which impact most on commercial marine transportation are water depth and wave action in harbors and channels. Also important is the topography of the adjacent land insofar as shorefront facilities are required. All of these factors within economical limits are controllable by management.

Land use. The environmental characteristics which impact most heavily upon the employment of coastal areas for residential use are principally aesthetic. The choicest sites emphasize the varied topography of the coastline. Coves, promentories and overlooks add special appeal. In some locations, drainage and exposure can be limiting. For industrial and commercial uses, the main environmental characteristics are adjacency to water adequate for transportation and waste disposal needs.

In coastal stabilization and protection, the effort is to preserve and enhance those characteristics which significantly impact on the coastal uses being considered here. Distinctions are necessary for this purpose between the backbay and ocean shorelines.

In the backbays, every physical, chemical and biological characteristic—and, through them, every significant coastal use—can be affected by physical changes around inlets, whether the changes are produced by nature or by man [1h].

Along the oceanfront, the forces of nature are much more severe than in the bays, but conditions have, to a greater extent, accommodated to this intensity. Shoreline erosion along the oceanfront, for example, cannot drastically alter general water quality, water surface elevations, and marine biology to the extent that it can in the backbays.

Along the oceanfront, impacts are largely physical and reveal themselves in changes in the location and character of the land form. Coastal uses most impacted by such changes are beach recreation and structures (primarily residential) located close to the shoreline. These impacts can be very severe. For example, the damages predicted from a recurrence of the tidal flood of record along the south shore of Long Island have been estimated at about $170 million [13e]. Engineering and management techniques for controlling, or accommodating to, these losses have been summarized [39b, 39c] and described in a local context [39a and 1h].

Physical, chemical and biological characteristics play a dominant causal role in the birth, growth, stabilization and biological productivity of wetlands. Wetlands, in turn, impact upon many coastal uses in ways that are still poorly understood—(1) indirectly through their effects on natural hydrologic, sedimination, food production, habitat, thermal exchange and other functions, and (2) directly through increasing fish abundance, recreation, aesthetic appreciation and other human values.

VII-B Recapitulation of Research Needs

(1) General usage impacts. Improve existing knowledge of the relationships between selected coastal uses and the coastal characteristics controllable by man.

(2) Fish diversity and density. Determine the causes of major annual fluctuations in the populations of selected coastal species.

(3) Feasibility of opening shellfish areas. Evaluate the likelihood of opening areas currently closed to shellfish harvesting, if anticipated waste water treatment and boat pollution programs are completely implemented.

(4) Feasibility of requiring depuration. Evaluate the proposition that all shellfish from Long Island wasters should be depurated and that commercial fishermen should receive a public subsidy for the increased cost.

(5) Impacts of groundwater level changes. Evaluate the probable impacts on biological, recreational and aesthetic uses, of a decline in groundwater levels sufficient to dry up existing lakes and

streams, except after storms. Also evaluate the probable impacts on these users, and the users of basements and other underground structures, of a rise in groundwater levels.

(6) Limit to cesspool sites. Estimate the limit on the number of successive cesspool or septic tank locations that representative plots of residential property can accommodate.

(7) Extent of beach closures. Assemble and evaluate information on the number, location and duration of beach closures in the bi-county area, the criteria and data employed in making the decisions, and the impacts upon recreational use. Also collect and document examples of illness ascribed to bathing in contaminated sea water anywhere on Long Island (including Kings and Queens Counties) and estimate the total annual health impact ascribed to this cause.

(8) Understanding wetland values. Develop a comprehensive list of beneficial uses of wetlands and quantitatively estimate how specific Long Island wetland complexes provide these benefits.

CATEGORY VIII - OBJECTIVE METHODS AND PROCEDURES

VIII-A Predicting Physical, Chemical and Biological States Resulting from Changes in Selected Causal Factors

The state of the art regarding methods for predicting physical and chemical changes in coastal waters was covered at length in a previous report [1e]. Because of the complexity of interactions, some form of model is required for predictions of the physical and chemical results of changes in boundary conditions; thermal loads; and concentrations of suspended and dissolved materials such as sediment, salt, oxygen and other chemicals. Numerical and physical models each have their particular advantages and limitations [88]. Widely used quantitative prediction techniques exist for coliform bacteria, dissolved oxygen, biochemical oxygen demand and temperature. For water quality variables that display a high degree of interaction among themselves and with other aquatic variables, prediction techniques are not highly developed [1e]. These variables include compounds of nigrogen and phosphorous, pesticides and oil. Also not highly developed, at least in numerical models, are methods for predicting the transport of sediments, as, for example, in shoaling [88].

Even when relevant processes can be modeled with precision and confidence, practical considerations may override. The requirements for detailed initial data inputs or computer capacity, for example, may be overwhelming. Before any major models are developed, a preliminary study is required. The study should describe very specifically what the model is expected to cost in dollars and time and what the expected end product will be. The value of this expected end product in influencing major decisions should be evaluated before the decision is made to develop a major model.

Major shore protection and dredging projects have a potential for significantly affecting the physical, chemical and biological states of coastal areas. It is necessary to predict the location and intensity of these effects. The processes are so complex that some form of model will be required.

For such purposes, several physical ("hydraulic") models have been developed at the U.S. Army Engineer Waterways Experiment Station at Vicksburg, Mississipi, for analyzing coastal stabilization and protection problems on Long Island:

- Jamaica Bay. This model was developed to determine the effects of a proposed hurricane barrier across Rockaway Inlet on the tides, currents, salinities and dye dispersion patterns throughout Jamaica Bay for normal tidal conditions [110]. The model is permanent. It has been molded into a larger model of New York Harbor.
- Fire Island Inlet. This model was developed to evaluate alternative designs for stabilizing the inlet and adjacent updrift, downdrift, bayside and oceanward conditions. The model was temporary and has been destroyed, but the study has been summarized in a report [111].
- Moriches Inlet. This model was developed for purposes similar to the Fire Island Inlet model. It too has been destroyed, but a report summarizing the study is being prepared.

Mathematical simulation models relevant to Long Island waters include:

- Jamaica Bay. A model was developed for New York City by the Rand Corporation to evaluate water quality. Another simpler model was developed for the U.S. Army Corps of Engineers by Tibbets, Abbot, McCarthy and Stratton to evaluate hydrologic conditions near the inlet.
- Hempstead Bay. A one-dimensional model was developed by Hydrosciences, Inc. to evaluate the inpact of various levels of treatment of liquid wastes on water quality in the bay [1e, 112].

A mathematical simulation model of the Great South Bay has been proposed by several groups. Both physical and mathematical simulation models are being considered for the U.S. Army Corps of Engineers' study of Great South Bay and adjacent waters authorized by Section 209 of the Flood Control Act of 1966 (Public Law 89-789).

Five models were recommended in our previous report on water supply and waste water disposal [1g]. The models would store and manipulate basic existing and projected data and assist in evaluating trends and management alternatives. The models, which will be briefly described in subcategory VIII-D, were: (1) a surface hydrological accretion model, (2) a subsurface hydrological model, (3) groundwater quality models, (4) bay water quality models, and (5) ocean water quality models. A sixth family of model, closely related to (4) above, is predictive inlet models, recommended in the previous report on coast stabilization and protection [1h].

VIII-B Methods for Formulating and Evaluating Alternative Courses of Action

Most decisions are, and should be, intuitive. They are based upon "experience" or "professional judgment." If this were not so, if the great number of decisions involved in every process had to undergo sophisticated analysis, all progress would stop in a maze of complexity. The planning process and management procedures, however, should identify the decisions with major strategic impact for more sophisticated analysis. This concept is illustrated in the permit screening process suggested in the earlier report on dredging [1i] —to distinguish which of the numerous permit applications warrant the most careful evaluation.

For the remainder of this subcategory, therefore, we consider only major strategic decisions, these justifying significant effort to identify and compare all reasonable alternatives.

Alternatives are formulated through the use of systems techniques, research, expert opinion, public hearings and much imagination. The aim at this stage is to guard against unintentionally overlooking options. After a period of incubation, the weeding out process begins with the emphasis on constraints. The mix of numerous alternatives can often be reduced to a manageable few this way. Frequently, one alternative or several alternatives may be seen, without detailed study, to dominate all the others with respect to all important criteria.

The method adopted in a previous report in this series on water supply and waste water disposal [1g], illustrated some elements of this approach, in a way tailored to that specific problem. To achieve a goal (satisfaction of projected needs), a set of essential steps (phases) was identified; alternative ways of achieving each step were described and evaluated; and the pieces were put together in the form of 16 competing systems. Using five stated considerations/1, some of which were clearly subjective, the competing systems were rated and compared. Using the concept of dominance, four of the systems emerged as worthy of major consideration and feasibility research. Insofar as judged practicable, the major value judgments required to make the final decision, were explicitly brought out.

/1 Economic, drinking water quality, groundwater quality, ecosystem, and political.

Methods for identifying and evaluating alternatives were emphasized and illustrated in a recent report on shoreline management procedures [39c].

Two widely advocated techniques for evaluating alternatives are cost effectiveness analysis and benefit-cost analysis. The former is by far the easier. It seeks to determine the best way of meeting a given objective (e.g., how best to meet water quality standards or how best to stop erosion). Benefit-cost analysis is more complex. It seeks not only the best way of meeting the objective, but it also evaluates the objective (e.g., is it worth the cost to achieve water quality standards or stop erosion?) In both methods, as in all modern approaches, costs (and benefits) are both monetary and non-monetary. To identify and evaluate the latter, useful techniques are matrices, decision trees, and public exposure [1n].

Sometimes computers can be very useful. For example, courses of action might be broken down into a number of functionally-interrelated steps with numerous internal sub-decisions. The implications of each sub-decision might be easy to determine, but the right combination of such decisions might be very obscure. Computer optimization is useful in these cases. A common example is the application of discretionary levels of manpower, materials, equipment and capital to segments of a large undertaking to minimize cost, time, capital, manpower or some other variable.

In conclusion, although many methods for evaluating alternative courses of action are available, the basic rule is to reserve sophisticated analysis only for decisions of high strategic importance[/1].

VIII-C Selected Investigations

In a previous report [1g], 14 investigations were recommended to improve knowledge of alternative processes applicable to some of the eight phases of an integrated water supply-waste water disposal system. The investigations, which will be briefly described in the next subcategory, involve: (1) imported water, (2) desalination, (3) iron removal, (4) leakage control, (5) evaporation control, (6) sewer infiltration control, (7) AWT methods, (8) individual package treatment plants, (9) recharge by injection, (10) recharge by spray irrigation, (11) recharge through

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[/1] Observe that this is merely a restatement of the basic, and often-maligned, principle of benefit-cost analysis.

storm basins, (12) stream recharge, (13) direct recycling of treated effluent and (14) value judgments.

A recent joint study [113] by the National Academy of Sciences and the National Academy of Engineering on waste management in the coastal zone provides many recommendations for further research and investigation on municipal and industrial waste loads, treatment plant design and water quality monitoring.

In the previous report on coast stabilization and protection [1h], the need to evaluate land use management techniques was stressed as an alternative or complement to engineering methods. This need, of course, is also pertinent to almost all aspects of coastal zone management, not just shore protection. A previous report on dredging described the need for improved management techniques for screening permit applications [1i],

VIII-D Recapitulation of Research and Investigation Needs

The following models are needed to improve accuracy in predicting environmental changes likely to be caused by man under various options for water supply and waste-water disposal, shore protection, and dredging:

(1) Surface hydrological accretion model. Develop a model that will integrate current and projected data on natural surface processes, such as precipitation, evapotranspiration, and runoff, with data on human changes, such as alternative strategies of surface development and alternative water supply and waste water disposal systems.

(2) Subsurface hydrological model. Improve existing hydrological models of the Long Island aquifers, such as the Hele-Shaw model, the Battelle model, and the USGS family of groundwater models, with a view to evaluating the impact of accretion changes predicted in item (1) above on groundwater levels and salt water infiltration.

(3) Groundwater quality models. Develop models to predict the sub-surface fate of contaminants introduced into the groundwater by natural forces and human activities, especially by the use of cesspools and fertilizers.

(4) Water quality models in bays. Develop models to predict the concentration of contaminants, including salinity, (a) introduced into bay waters through stream inflow, overland runoff, groundwater upwelling, and in-bay waste disposal practices, and (b) modified by potential human and natural changes in the location and size of inlets.

(5) Water quality models in the ocean. Develop models to predict the fate of contaminants introduced into offshore waters under alternative strategies involving ocean outfalls and offshore dumping.

(6) Predictive inlet models. Develop models for predicting the relationship between the characteristics of selected inlets (East Rockaway, Jones Beach, Fire Island, Moriches and Shinnecock) and selected processes and characteristics (tidal elevations, shoaling and scouring, salinity and water quality) in the backbays.

The following investigations are needed to improve knowledge of alternative processes applicable to the eight phases of an integrated water supply-waste water disposal system:

(7) Feasibility of importing water. Evaluate the institutional/political feasibility of importing significant portions of the water supply, especially for Nassau County, from New York City and from Suffolk County.

(8) Feasibility of desalination. Maintain a continuing awareness of advances in desalination technology that may make this process feasible for supplementing the bi-county water supply.

(9) Feasibility of iron removal. Examine the feasibility of reducing the iron content of Long Island's water supply.

(10) Feasibility of leakage control. Investigate the economic feasibility of reducing losses in the transmission, distribution and usage of fresh water.

(11) Feasibility of evaporation control. Investigate the feasibility of reducing evaporation losses during the high-loss summer season by instituting a policy of sprinkling and irrigation at selected times, such as during early morning or late evening hours.

(12) Feasibility of sewer infiltration control. Investigate the feasibility of minimizing the loss of groundwater that infiltrates into sewer systems.

(13) Feasibility of AWT. Investigate the economic and technical feasibility of AWT methods on Long Island with particular attention to physical-chemical processes applicable to raw waste water (as distinct from AWT as an add-on to the primary-biological methods currently employed for secondary treatment).

(14) Feasibility of packaged treatment plants. Maintain a continuing awareness of major advances in this type of treatment and investigate its feasibility, particularly in outlying bi-county areas, if current problems of solid residue disposal and fail-safe design can be resolved.

(15) Feasibility of recharge by injection. Investigate the feasibility of injecting water of suitable quality into the aquifers at locations selected to minimize salt water intrusion near the coast and increase potential pumpage rates inland. Problems of well-clogging merit special attention. The water considered for injection should include not only AWT effluent but also water drawn directly from the potable water supply system.

(16) Feasibility of recharge by spray irrigation. Investigate the economic and technical feasibility of recharging the aquifers by spray irrigation processes at inland sites.

(17) Feasibility of recharge through storm basins. Investigate the economic, technical and social feasibility of recharging AWT effluent into the aquifers at existing inland storm water recharge basins, giving particular attention to the apparently high potential for rapid and deep penetration of water-borne contaminants along the longitudinal axis of the island.

(18) Feasibility of stream recharge. Investigate the economic and technical feasibility of minimizing decreases in stream flow and lake levels by recharging treated, pumped and imported water directly into the streams or lakes, on a year-round or seasonal basis.

(19) Feasibility of direct recycling of AWT effluent. Investigate the economic, technical and public acceptability aspects of recycling highly-treated AWT effluent directly into the water supply system.

(20) Value judgments on water systems. Conduct sociological research to improve understanding of the relative values with which Long Islanders might be expected to assess alternative water supply and waste water disposal systems.

The following investigation is needed to evaluate an often-overlooked non-engineering solution to coastal protection problems.

(21) Feasibility of land use management techniques. Evaluate the current and potential application to coastal stabilization and protection problems of management techniques that influence people in their use of land along the shore; specifically include the relationship of flood plain management techniques to Long Island's coastal areas subject to tidal flooding.

The following management tool needs to be developed to improve the review of applications for dredging permits:

(22) Screening of dredging applications. Develop simplified management tools to facilitate dredging decisions, particularly methods to distinguish readily between the multitude of dredging applications on the basis of most likely levels of environmental significance.

The following recommendation is addressed to improving the management of wetlands:

(23) Wetlands management. Recommend ways that publicly-owned wetlands can be managed to sustain and enhance the benefits they can provide.

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

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