FOURTEEN SELECTED MARINE RESOURCE PROBLEMS OF LONG ISLAND, NEW YORK: DESCRIPTIVE EVALUATIONS

Prepared for the
Marine Resources Council
Nassau-Suffolk Regional Planning Board
under
Sea Grant Project GH 63
National Science Foundation

January 1970
7722-377

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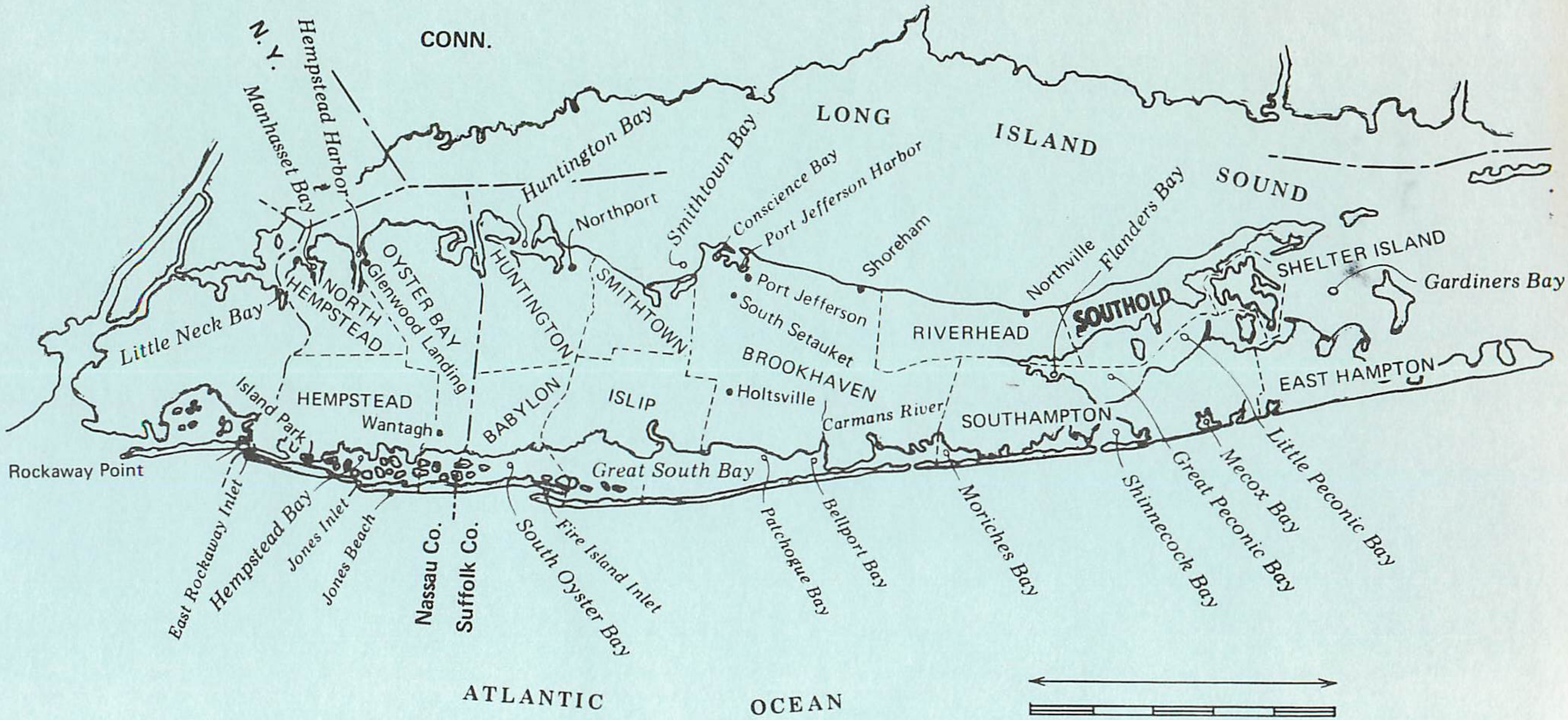

CONN.
N.Y.
LONG ISLAND SOUND
Hempstead Harbor
Manhasset Bay
Huntington Bay
Northport
Smithtown Bay
Conscience Bay
Port Jefferson Harbor
Shoreham
Northville
Flanders Bay
SHELTER ISLAND
Gardiners Bay
Little Neck Bay
NORTH HEMPSTEAD
Glenwood Landing
OYSTER BAY
HUNTINGTON
SMITHTOWN
Port Jefferson
South Setauket
RIVERHEAD
SOUTHOLD
BROOKHAVEN
EAST HAMPTON
Island Park
HEMPSTEAD
Wantagh
BABYLON
ISLIP
Holtsville
Carmans River
SOUTHAMPTON
Rockaway Point
Great South Bay
East Rockaway Inlet
Hempstead Bay
Jones Inlet
Jones Beach
Nassau Co.
Suffolk Co.
South Oyster Bay
Fire Island Inlet
Patchogue Bay
Bellport Bay
Moriches Bay
Shinnecock Bay
Great Peconic Bay
Mecox Bay
Little Peconic Bay
ATLANTIC OCEAN

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PREFACE

Under the auspices of the Marine Resources Council of the Nassau-Suffolk Regional Planning Board, The Travelers Research Corporation has been engaged during the past year in the first stages of a long-term research program relating to the management of the marine resources of Long Island, New York. The program is ultimately designed to provide analytical assistance, methods, and information for the design of a comprehensive planning and management system for dealing with the complexity of interrelated marine resource problems of coastal zone regions.

An initial step in this program has been the identification and systematic description of what are considered to be the outstanding marine resource problems of Long Island in the opinion of Long Island residents and relevant public agency representatives. A thorough, albeit preliminary, understanding of interrelationships between the human activities and natural resource characteristics which together comprise the individual marine resource utilization problems has been considered a necessary prerequisite to a fuller understanding of the broader picture of man's interrelated uses of the coastal zone. In the process of attempting to understand individual problems and possibilities for managing them, an effort is also being made to determine the kinds of knowledge and information that will ultimately be required by planners and policy makers in the formulation of sound public decisions for marine resource allocation. An evaluation of the present state of such knowledge and information should thus contribute significantly to the design of future coastal zone research and data collection programs which at present appear largely fragmented and uncoordinated in relation to the broader needs of management and planning.

This document constitutes a status report on the present state of our research at the individual problem level. It has been produced with three primary purposes in mind. The first of these is to provide anyone interested in marine resource problems, whether on Long Island or elsewhere, with a set of descriptive background case studies of a wide variety of such problems typical of coastal zone regions. The second purpose is to present our research results, as well as our conceptual views on these problems, to those either personally or professionally involved with them in the Long Island community. It is hoped that in so doing we will generate interest and awareness as well as discussion and constructive criticism of our approach to these problems and of our specific findings. We are thus, in fact, making an appeal to private citizens. public agency personnel, and scholars, who feel that they have something to contribute to a more accurate or complete evaluation of these problems, to communicate their criticisms or additional information to us.

Finally, this report serves our own longer term purpose as a "backup" document for a subsequent technical report to the Marine Resources Council dealing explicitly with our formulation of information and knowledge requirements pertaining to the planning and management of marine resources on Long Island.

The overall research program, of which the present report represents an intermediate product is directed by Dr. Robert H. Ellis as Program Manager and Philip B. Cheney as Principal Investigator. The program is sponsored by the Marine Resources Council of the Nassau-Suffolk Regional Planning Board, which provided its initial funding. Continuation funding has been provided through the Marine Resources Council since September 1969 under Sea Grant Project GH 63 of the National Science Foundation.

TABLE OF CONTENTS

INTRODUCTION

Rationale, Purposes, and Objectives

This report consists of a series of fourteen essays, each dealing with a particular marine resource problem previously identified as a cause for concern by residents of Long Island. The identification and evaluation of discretely defined "problems" of the coastal marine environment has constituted a fundamental phase of a longer term research program designed utlimately to provide knowledge, information and methods for more comprehensive management of coastal resources.

Recognizing the inherent complexity of a subject so broadly defined as "coastal marine resource management," our approach thus far has been based essentially on two propositions. The first is that a sound understanding of individual "problems," properly defined, is a necessary prerequisite to comprehending the broader picture in which cause and effect relationships underlying a given problem tend to be interrelated with those of many other problems. In short, one has to begin somewhere, and in order to make the subject manageable, we have thus chosen to begin by examining individual (but overlapping) pieces of the much larger puzzle. The second proposition guiding our approach is a recognition that, while satisfactory comprehension of the complete puzzle is still a long way in the future, individual problems exist today requiring practical policy decisions.

The possibility of acquiring information of direct usefulness to resource management decisions in the short run and, at the same time, working toward an understanding of the more complex coastal resource interrelationships, has thus determined our selection of the "problem" as our basic "unit of analysis."* It has also significantly influenced the way in which we have chosen to define a "marine resource problem." Briefly, in our frame of reference, a problem is considered to exist whenever and to the extent that individuals or organized groups experience dissatisfaction with the

*Alternatively, one might have approached the broader picture by focusing initially on individual "resources" (such as land, air, and water), or on individual management institutions (such as the responsible public agencies), or on individual environmental characteristics and processes (such as energy flows and nutrient cycles), etc.

existing state of the coastal environment at the level of resource utilization or "man-environment interaction."* This can range from dissatisfactions with given natural attributes (such as climate, topography, unfavorable biological changes, etc.), to conflicts arising from competitive use of a given resource or spacial area. Our conception is thus policy-oriented, in the sense that it defines marine resource problems from an explicitly social point of view, rather than from a physical or natural science point of view. However, it is not intended to include social issues of public policy formulation *per se*, within its present scope.

This volume thus presents, under one cover, descriptions of fourteen of the more widely recognized marine resource problems of Long Island as we understand them from our research thus far. The individual discussions vary somewhat in level of detail and depth of sophistication, reflecting both the nature of the problems themselves, and the incomplete status of our project. In no instance does any individual discussion purport to be "the last word" on the subject. Indeed, a primary reason for presenting them at this time is to elicit comment, constructive criticism, and additional information from Long Island residents, public administrators, and academic specialists knowledgeable in particular aspects of particular problems.

Organization and Description of Contents

To facilitate comparisons among problems and ready access to particular kinds of information, each of the fourteen problem discussions is organized according to the following four-part general outline:

- Introduction. Presents a general conceptual view of the technical nature of the problem; technical and working definitions; basic aspects of general cause-effect relationships typically involved; and other background information as considered necessary to later discussion.
- Evaluation of Problem. Relates explicitly to the Nassau-Suffolk bicounty regional context. Presents quantitative and qualitative evidence

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*For a more detailed background discussion, see R. H. Ellis, et al., The Development of a Procedure and Knowledge Requirements for Marine Resource Planning: The Classification of Marine Resource Problems of Nassau and Suffolk Counties, The Travelers Research Corporation Report 7722-3476 prepared for the Marine Resources Council of the Nassau-Suffolk Regional Planning Board, April 1969, pp. 9—12.

thus far obtained from interviews and published sources regarding the present or potential existence of the problem; its local or non-local causes and consequences; locations and geographical extent of occurrence; and general time pattern (trends and seasonal or other fluctuations).

- Public Policy Background. Principally a summary of structure and functions of public agencies at various governmental levels that have regulatory or other roles directly relevant in the problem context. Although not attempting a detailed analysis of policy issues, in some instances brief interpretive comment is offered regarding the scope and function of existing policies or other issues brought to our attention which we have deemed particularly important to an understanding of the problem.

- Indicated Information Needs. Represents a first attempt to identify general types of information that—in our opinion, or in the opinion of various sources referenced—appear fundamental to a fuller understanding of the problem and/or to its effective potential management and control.

A selected list of references consulted, both in the pertinent literature and in interviews and communications, is included at the end of each problem discussion. In addition, for those readers not intimately familiar with Long Island geography, a reference map, printed on the inside front and back covers of this report indicates the general geographical configuration of Long Island and identifies principal coastal features, as well as political jurisdictions and places specifically mentioned in the problem discussions.

The reader familiar with our initial report to the Marine Resource Council* will note that three of the seventeen problems originally identified and reported in that volume are not dealt with here, and a brief word of explanation is in order. The three problems in question are: salt water intrusion, preservation of sites of historic or natural value, and the development of marine-related industry. In each instance, the decision not to include the problem was based partly on a general desire to limit the

*Ibid., pp. 25—56.

total number of problems at this stage of the project and, in part, on a conclusion that these three either tended to be inconsistent with our conceptual framework for problem definition or could be at least partially included as aspects of other problems already dealt with.

Thus, we concluded that salt water intrusion, although a problem of the coastal zone, could properly be regarded as a problem of fresh-water management and that its implications for marine resources did not seem sufficiently strong to warrant our detailed attention at this time. Natural and historical site preservation, on the other hand, can probably be included to a large extent under the wetland destruction problem; while those aspects of historical site preservation not included are essentially policy issues not involving technical man-environment interrelationships. Finally, the development of marine-related industry is both too broad a topic and too closely related conceptually to regional planning itself to be conveniently handled within our present "problem description" framework. Although some aspects of marine industry development are dealt with under the finfish and shellfish problems, adequate treatment of the overall topic requires a much broader analytical approach, and it should probably be treated as a topic worthy of special project status during a later phase of the research program.

SPORT AND COMMERCIAL FINFISH

Introduction

An evaluation of commercial and sport fishing problems and prospects for Long Island requires an initial focus on the status of the fishery population resource base. This is the pivotal concern upon which questions of recreational and commercial success and development depend. Examination of available evidence reveals a decidedly mixed picture with respect to individual finfish populations, so that it is extremely difficult to demonstrate a general decline or depletion of the resource at this point in time.

It is further evident from the widespread diversity in habitat requirements, life-cycle patterns, and intensity of exploitation of the various important species, that individual species must be studied in detail if a satisfactory management program is to be evolved. The reasons for decline or expansion in numbers of a particular species are seldom obvious, and marine fishery science has only recently developed to the point where it can begin to provide tentative answers for only a few of the key species. However, as illustrated below, existing knowledge does show quite conclusively that the problems of management for a substantial proportion of finfish populations necessarily extend well beyond the geographic and legal jurisdictional boundaries of Long Island and New York State waters.

Evaluation of Problem

There exist two major sources of empirical information on the current status of finfish populations in Long Island waters. The first is the records of commercial landings at Long Island fishing ports compiled by the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service [20]. The second general source consists of specialized population surveys conducted primarily by the Bureau of Marine Fisheries of the New York State Department of Conservation. Each has its own inherent strengths and shortcomings, some of which are outlined below in connection with a brief discussion illustrating the types of knowledge and information which they are yielding.

The landings statistics are the most widely referenced source of information on the general status of Long Island fisheries resources. As a data base they possess three outstanding advantages over other sources: (1) they are current, being gathered continuously and published monthly; (2) they have been collected over a long period of time, thus providing a long-term historical record for trend evaluation; (3) they are quite comprehensive, covering over 40 individual finfish species. On the other hand, landing statistics represent only an indirect picture of fishery resource populations, because they necessarily reflect variable degrees both of actual fishing effort and of efficiency of capture over time. Further, they also fail to account for sport fishing results (relatively significant for certain species such as fluke), and can be quite imprecise regarding where the fish were captured (within or outside Long Island waters) or the extent to which catches in the Long Island region may be landed at ports outside the area.* Nor do the published data in and of themselves yield information on size- or year-class distributions or characteristics of individual species landings, other than total weight, which might provide clues to future population changes. Thus, although a most significant source of information, these statistics represent an imperfect measure of the existing state of fishery populations and do not explain the changes that they reflect.

An examination of these landings statistics for the New York Marine District over the past 15 years, presented in Table 1, indicates a decided downward trend in total weight of finfish landed—varying between 86 and 165 million pounds in the 1954—1963 period as contrasted with 24 to 67 million pounds in the 1964—1968 period. It should be noted, however, that menhaden (a species of fairly low unit value) has constituted over 80 percent of the weight of total landings in years of high abundance, and the downward trend for this single species has therefore tended to dominate the aggregate trend for all species. To a large extent, this explains not only the markedly less steep decline but also the significantly greater stability of the total value of finfish landings over the period.

*The offshore fisheries of the Georges Bank are of course exploited by the fishing fleets of numerous foreign nations as well as those of many other North Atlantic Coastal States of the U.S.

TABLE 1
FINFISH LANDINGS IN NEW YORK MARINE DISTRICT,
1954—1968

Yr	Total finfish*		Selected commercially important species (million pounds)										
	Weight (1,000 lbs)	Value ($1,000)	Bluefish	Cod	Fluke	Menhaden	Scup	Sea bass	Striped bass	Whiting	Yellowtail flounder	Butterfish	Blackback flounder
1968	38.7	2,880	.6	.4	1.2	17.8	2.8	.1	1.5	3.3	5.6	1.0	1.8
1967	24.3	2,811	.6	.5	2.0	.6	3.3	.1	1.6	3.9	5.5	1.1	2.9
1966	26.4	2,789	.9	.2	2.5	4.9	4.1	.2	1.1	2.0	3.5	.6	3.2
1965	55.4	3,011	1.0	.4	2.5	30.1	7.5	.4	.7	3.3	3.7	.8	2.2
1964	67.5	3,015	.7	.5	1.9	42.4	8.3	.5	1.0	3.1	3.6	1.1	1.4
1963	118.1	3,498	.7	.8	1.3	91.7	9.3	.6	.6	2.4	4.7	1.2	1.8
1962	165.5	3,644	.8	1.0	1.6	138.3	10.7	.5	.6	2.7	3.9	1.6	3.9
1961	111.7	3,467	.5	1.2	2.3	84.1	12.1	.3	.8	2.6	2.0	1.7	1.7
1960	113.0	3,373	.4	1.0	2.5	84.2	13.0	.5	.5	3.6	1.1	1.8	1.6
1959	113.6	3,545	.3	2.0	2.8	75.9	13.5	.6	.4	2.1	.6	2.6	1.3
1958	85.6	3,530	.1	2.2	2.3	55.0	14.3	.8	.3	2.0	.5	3.0	2.0
1957	146.3	4,202	.4	1.8	3.5	116.8	11.8	.8	.5	3.7	.2	2.5	1.5
1956	138.9	3,608	.4	1.3	4.3	114.4	10.9	.5	.3	1.5	.2	1.4	.9
1955	118.2	3,337	.5	2.3	2.6	89.6	13.0	.9	.4	3.9	.2	1.5	.5
1954	125.0	3,422	.4	1.2	3.7	98.1	12.8	1.3	.4	2.2	.1	1.5	.5

*This table does not include unclassified fish for bait, for reduction or for animal food, but does include unclassified fish for food.
Source: Compiled from [25].

Table 1 also illustrates the decidedly mixed trends of landings of individual species of which the total landings picture is composed. Although landings of cod, fluke, menhaden, scup and sea bass have been down in recent years, those of bluefish, blackback flounder, yellowtail flounder, and striped bass have been generally increasing, while whiting has remained remarkably constant.

As noted above, these statistics do not in themselves provide definitive answers to questions of fishery resource abundance ; however, they do provide a valuable indicator of changes in individual species that may warrant more detailed evaluation.

All biological species exhibit fluctuations (sometimes quite extreme) under natural conditions. Such fluctuations may be due to a variety of natural factors including temperature effects on reproduction success or migration patterns, dynamic predator-prey interrelationships, and many others. It thus becomes extremely difficult to distinguish the effects of man (both through his harvesting activity and his impact on local habitat conditions) from the naturally operative causal factors. It is also difficult in the short run to distinguish between fluctuations in abundance and changes in longer term trends. Very little is known of the open water stages of most of the pertinent species and, since a majority of species important to Long Island are inherently migratory, problems of scientific understanding and management are made even more difficult.

Species population surveys represent an attempt at direct measurement of current status together, usually, with an effort to analyze and explain findings in greater scientific detail. Being much more time-consuming and expensive, they are done on a sampling basis and depend heavily on the adequacy of sampling techniques and methods of statistical evaluation. Efforts relating to individual species thus also tend to be sporadic in time and quite selective in species covered, thus lacking the advantages of the landings data in terms of time-continuity and comprehensiveness of species coverage.

Within the constraints of limited research resources, however, a significant body of knowledge and data regarding Long Island finfish populations is gradually being accumulated. Principal species studied within the past 12—15 years have included the weakfish [14], fluke [15, 8], winter flounder [16,17], striped bass [20, 21], northern kingfish [23],hake and scup. For the most part, the studies have been directed at ascertaining sources of origin (spawning area), migration patterns, size, area and sex distributions as these relate to an explanation of general abundance of given species in Long Island waters. For example, the drastic decline in weakfish populations in New York waters in the period immediately after W.W. II has been traced in significant part to a reduction in southern-spawned fish in Long Island waters (upon which the Long Island fishery was largely dependent), probably due to over-harvesting by southern Mid-Atlantic-based fleets [14].

The published and interview materials thus far obtained indicate that relatively little scientific attention has been devoted to questions of how local (Long Island) habitat conditions, temperature, salinity, pollutant materials, etc. may be related to observed finfish population changes. This area of knowledge remains largely in a speculative stage. It has been suggested, for example, that recently observed declines in fluke (summer flounder) and scup (porgy) may be explicable by a general cooling trend in coastal waters. However, this has not been rigorously supported as yet. Although considerable concern has been expressed regarding pollution effects, we have not found scientific evidence that local pollution has been a significant factor influencing Long Island finfish populations.

The economic status and development potential of the Long Island commercial fishing industry depends at least as much on technological capability, market demand, and regional and international competition as on the health of regional finfish populations. We have not had the opportunity as yet to investigate these factors in detail. However, a number of general impressions may be noted.

To a significant degree, the Long Island finfishing industry shares the same history of economic problems as other U.S. Atlantic Coast fleets. These include: declines in numbers of vessels and employment; depressed rates of return on invested capital and sub-standard wage scales; and a preponderance of old, largely obsolete capital equipment with a markedly slow rate of technological improvement by modern international standards [2]. United States' market demands for finfish have grown very slowly over time, and an increasingly larger proportion of this demand has been met by foreign imports (about 70 percent by 1967) [26, p. 46]. Although some of these difficulties may have stemmed from decreases in the fisheries resource (perhaps due to over-harvesting of certain species), the major explanations must be found in the economic, legal and other institutional factors determining the organization and competitive ability of the U.S. fishing industry itself.

Public Policy Background

The public agency with primary direct authority and responsibility for finfish resources is the Bureau of Marine Fisheries of the New York State Conservation Department. The Bureau's major functions include, in addition to research activities, the issuance of non-resident commercial licenses and the supervision and enforcement of various regulations regarding permissible methods of fishing, size limits for certain species, and areas where certain types of fishing are prohibited [24]. For the most part, the specific regulations themselves are established item by item by the State legislature under the Fish and Game Laws, and thus tend to be rather inflexible over time and subject to private pressure-group influence. These control measures can apply only to the coastal waters within the jurisdiction of the State of New York—generally, the three-mile limit for areas other than Long Island Sound.

In an effort to provide a more rational approach to the management of migratory species, the Atlantic States Marine Fisheries Compact has been established to provide a mechanism for coordination of management and control policies and the encouragement of research and development efforts of mutual interest to the Atlantic Coast states. The Atlantic State Marine Fisheries Commission established under this Compact has advisory powers only, and does not have direct authority to issue regulations or to decide on matters of conflict among its member states. Its budget has also been quite limited. Up to the present, its impact has been relatively restricted, and it is not generally considered a "strong" agency in terms of its ability to influence interstate management.

At the national level, the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife of the U.S. Fish and Wildlife Service, Department of the Interior, are the primary agencies. In general, these agencies lack control functions relative to fisheries in coastal waters, and serve primarily in research and information gathering capacities insofar as finfish management is concerned.

United States federal government involvement is also to be noted in relation to problems of management in international waters, where greatly increased international competition has caused growing concern over the past 20 years. In this area, regulation is even more difficult than for inshore coastal waters, since it involves all the ramifications of international treaty formulation. The beginnings of an institutional structure for obtaining international cooperation and the resolution of conflict have been created in the International Commission for the Northwest Atlantic Fisheries (ICNAF).

It has already become evident that "management" of the finfishery resources is generally in a quite rudimentary state of development. At present it consists mainly of size limits on a few key species, supplemented by certain regulations on commercial fishing gear. With the exception of construction of a few artificial reefs for sport fishing, habitat improvement and preservation activities have remained largely beyond the control of fishery management authorities. The major dependence of Long Island fisheries on migratory species inherently places the jurisdiction of potential management beyond the scope of state or local authority to a very significant degree.

Indicated Information Needs

The information needs for the management and possible development of Long Island finfish resource potentials would appear to fall into two major categories relating to (1) the status of the fishery resource and its environmental relationships and (2) the nature of the commercial and recreational activities dependent upon the fishery populations.

Regarding the former, 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. Effective management requires more systematic information than now typically exists, in terms of numbers of species covered, statistical reliability of data, and continuity of observations over time.

However, even though we might collect every possible bit of information about each individual species population, the picture would still be incomplete. Work is especially needed on the behavior of populations in the context of the biological community and habitat in which they are found (ambitiously, the ecosystem). Clearly this type of knowledge is elusive, but improved knowledge of optimal habitat conditions and environmental relationships for key species is an indicated requirement if management is to be concerned with positive measures for maintaining and increasing natural rates of productivity. This involves directed research and development efforts toward the ultimate objective of increasing man's basic productivity of highly valued species through habitat improvement and other scientific approaches to aquaculture.

Regarding the human activities dependent on finfish resources, the Long Island commercial finfishing industry has not, to our knowledge, been intensively studied in terms of its organizational structure, legal and other institutional attributes, market demand characteristics, and other factors related to its viability and development potential. Knowledge along these lines would appear vital to an assessment of questions related to industry revitalization. It is also quite relevant to questions regarding the setting of priorities for and evaluating the potential gains from investing in fisheries research and management programs, because the regional payoff from such programs depends on the ability of the private fishing sector to exploit the results in an efficient and profitable manner. More knowledge and information relating to sport fishing demands and preferences would also be desirable for similar reasons.

Selected References

1. Alperin, Irwin M. and Richard H. Shaefer, 1965: Marine fishes new or uncommon to Long Island, New York. New York Fish and Game Journal, 12:1, January, pp. 1—16.

2. Bell, Frederick W., 1966: The economics of the New England fishing industry: The role of technological change and government aid. Research Report to the Federal Reserve Bank of Boston, No. 31, Boston, Mass.

3. Briggs, Philip T., (no date): Comparison of the fish fauna over sand-filled and natural bottoms of Great South Bay, New York. A Progress Report, New York State Conservation Department, Ronkonkoma, Long Island, New York, p. 4.

4. Briggs, Philip T., 1969: Salt water fishing on Long Island. Mimeograph, New York State Conservation Department, Ronkonkoma, New York.

5. —, 1968: The sport fisheries for scup in the inshore waters of eastern Long Island. New York Fish and Game Journal, 15:2, July, pp. 165—185.

6. —, 1965: The sport fisheries for winter flounder in several bays of Long Island. New York Fish and Game Journal, 12:1, January, pp. 48—70.

7. —, 1965: The sport fishery in the surf on the south shore of Long Island from Jones Inlet to Shinnecock Inlet. New York Fish and Game Journal, 12:1, January, pp. 31—47

8. —, 1962: The sport fisheries of Great South Bay and vicinity. New York Fish and Game Journal, 9:1, January, pp. 1—36.

9. Christy, Francis T., and Anthony Scott, 1965: The common wealth in ocean fisheries. The Johns Hopkins Press for Resources for the Future, Inc., Baltimore, Md.

10. Jenson, Albert C. and John C. Pool, 1968: Fishing with the Russians. The Conservationist (State of New York Conservation Department), Vol. 22, No. 4, pp. 2—6.

11. —, 1969: Fishing again with the Russians. The Conservationist, Vol. 23, No. 5, pp. 10—13 ff.

12. Knickerbocker, Dave, 1968: Decline of fluke can't be explained. News Day, Long Island, New York, November 13.

13. The Marine Fisheries of New York, 1963. Long Island Commercial Review, November 21, pp. 11 & 13.

14. Perlmutter, Alfred, William S. Miller and John C. Poole, 1956: The weakfish (Cynoscion regalis) in New York waters. New York Fish and Game Journal, 3:1, pp. 1—43.

15. Poole, John C., 1966: A review of research concerning summer flounder and needs for further study. New York Fish and Game Journal, 13:2, July, pp. 226—231.

16. —, 1966: The use of salt-water coves as winter flounder nursery grounds, New York Fish and Game Journal, 13:2, July, pp. 221—225.

17. Poole, John C., 1966: Growth and age of winter flounder in four bays of Long Island, New York Fish and Game Journal, 13:2, July, pp. 206—220.

18. —, 1964: Feeding habits of the summer flounder in Great South Bay. New York Fish and Game Journal, 11:1, January, pp. 28—34.

19. —, 1962: The fluke population of Great South Bay in relation to the sport fishery, New York Fish and Game Journal, 9:2, July, pp. 93—117.

20. Rathjen, Warren F. and Lewis C. Miller, 1957: Aspects of the early life history of the striped bass (Roccus saxatilus) in the Hudson River, New York Fish and Game Journal, 4:1, January, pp. 43—60.

21. Shaefer, Richard H., 1968: Size, age composition and migration of striped bass from the surf waters of Long Island, New York Fish and Game Journal, 15:1, pp. 1—51.

22. —, 1967: Species composition, size and seasonal abundance of fish in the surf waters of Long Island, New York Fish and Game Journal, 14:1, January, pp. 1—46.

23. —, 1965: Age and growth of the northern kingfish in New York State waters, New York Fish and Game Journal, 12:2, July, pp. 191—216.

24. State of New York, 1967: Fish and game law in relation to marine fisheries. Albany, N. Y.

25. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries, 1954—68, New York landings, annual summaries.

26.—, 1968: Fisheries of the United States . . . 1967. Washington, D.C., U.S. Department of Interior.

27. Wilkins, Bruce T., 1967: Outdoor recreation and the commercial fishery in the Town of Southold. Department of Conservation, New York State College of Agriculture, Ithaca, N. Y.

SHELLFISH

Introduction

Shellfishing represents one of Long Island's oldest and most important marine-related industries, the dockside value of production outranking that of finfish many times over.* In addition, shellfishing constitutes a valued recreational endeavor and household food source for thousands of Long Island residents. As was true of finfish populations discussed in the previous section, the "shellfish problem" must be evaluated in terms of individual species and specific regional habitats in order to comprehend the diversity of issues and experience relating to this category of natural resources.

The principal species of importance to Long Island presently include the hard and surf clams (Venus mercenaria and Mactra solidissima), the eastern oyster (Crassostrea virginica), the northern lobster (Homarus americanus), and the bay scallop (Pecten irradians). The soft clam (Mya arenaria), and various conch and mussel species are also fished commercially but are of secondary importance. The sea scallop (Pecten magellanicus), though an important species in New York and adjacent waters, is primarily fished by a specialized dredging fleet landing at Fulton Market.

Unlike finfish, shellfish are for the most part non-migratory, and this constitutes both an advantage and disadvantage from the standpoint of population abundance and effective resource exploitation and management. On the one hand, a localized natural habitat facilitates the application of intensive cultivation and management techniques; and it allows for potential management within local political jurisdictions over the entire life cycle of the species. One the other hand, the same characteristic implies that the entire stock of exploitable resource for any given area is crucially dependent on the maintenance of favorable habitat conditions in that same area over its entire cycle of reproduction and growth. This means that

*For the New York Marine District as a whole, shellfish landings in 1968 were over 3-1/2 times the value of all finfish landings ($11.4 million as opposed to $2.9 million) [2].

temporarily adverse local conditions (natural or man-caused) cannot be escaped by temporary out-migration; nor can low resident abundance in any given year be offset by immigration from other regional populations. In general, this tends to enhance the possibility of large-amplitude fluctuations in abundance and also the potential for local extinction of particular species.

Evaluation of Problem

United States Bureau of Commercial Fisheries statistics on commercial landings in the New York Marine District (presented in Table 2 below) reveal a substantially mixed picture for Long Island shellfish production over the past 15 years. On the one hand, lobster and hard clam landings approximately tripled during this period. while oysters continued their precipitous long-term decline, and bay scallops decreased to a 10-year low in 1967 at barely 15 percent of their 1962 peak for the period. Sea scallops, though showing significant year-to-year fluctuations, evidenced no particular trend, while surf clams showed a steady and continuous recovery from a precipitous decrease in the 1956—58 period.

Inferences from total landings data regarding trends in species abundance must be approached with caution.* This is especially true since data were not readily available for assessing levels of fishing effort corresponding to annual production figures. Thus, the landings figures reflect both changes in individual species availabilities as well as changes in effort and efficiency of harvest. Nevertheless, it seems evident, both from these data and from the expert opinion of New York State Bureau of Marine Fisheries personnel, that no sweeping generalizations concerning the status of Long Island "shellfish resources" as a group can be made with accuracy.

The species of most obvious local concern is the oyster. As recently as 20 years ago Long Island oyster production yielded gross revenues to producers of about $10 million from a harvest of some 10 million bushels [14]. By 1967, even at a price more than double the level of the late 1940's, oysters yielded total revenues barely

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*Most of the comments regarding landings statistics as a source of information on species population status that were made previously in the section on finfish also apply in the present discussion. However, for shellfish, these data do present a much better indication as to the general location of capture.

TABLE 2
SHELLFISH LANDINGS:
NEW YORK MARINE DISTRICT,
1954—1968

Year	Individual species landings (millions of pounds*)						Total landings	
	Lobster	Hard clams	Surf clams	Oyster	Sea scallop	Bay scallop	Weight (1,000 lbs)	Value ($1,000)
1968	1.2	7.0	3.0	.2	1.5	.2	14.4	11.4
1967	.9	7.0	2.3	.1	1.4	.2	13.0	9.8
1966	.7	6.6	1.8	.2	2.1	.3	13.4	8.4
1965	.6	5.9	1.5	.2	2.9	.9	13.6	8.9
1964	.5	5.4	1.2	.2	2.0	.7	11.5	6.9
1963	.4	5.3	1.0	.4	1.9	.3	10.4	5.9
1962	.3	4.8	.8	.7	2.7	1.0	12.0	6.2
1961	.5	4.3	.7	.8	3.0	.8	11.5	5.7
1960	.5	3.9	.7	.8	2.8	.8	10.8	5.3
1959	.6	3.4	.5	.9	3.0	.4	9.8	5.3
1958	.4	3.7	.4	1.0	2.0	.6	9.7	4.5
1957	.4	3.6	1.6	1.1	1.8	.6	10.2	4.8
1956	.5	3.6	2.4	1.1	2.7	.2	11.2	5.2
1955	.3	2.7	2.0	1.4	4.5	.2	12.0	5.5
1954	.4	2.5	2.8	1.7	1.9	.1	10.9	4.1

*Weights of edible meants, except for lobsters.
Source: Compiled from reference [12], 1954—1968.

over 2 percent of the early postwar years. This steady long-term decline in production occurred in spite of a substantial research and development effort supported by Federal and state government and private industry interests. The 1968 harvest marked the first year of the past fifteen to show an increase rather than a decrease over the previous year's production.

The oyster industry is unique among Long Island fin and shellfish in that it has never depended on natural reproduction as the basis for its operations [9]. Long Island waters have traditionally been utilized principally as growing and fattening areas, with "seed" largely obtained elsewhere, primarily from Connecticut natural spawning and setting beds. Long Island oyster misfortunes have largely coincided with a widespread general decline in mid-Atlantic and Southern New England production during past decades [15]. Inability to obtain seed oysters from these other areas has constituted a principal bottleneck in maintaining traditional production practices on Long Island. In this respect at least, the industry's decline has not been due solely to purely local environmental conditions.

In response to this situation, four oyster hatcheries have been established on Long Island; however continuing difficulties have been encountered in rearing the larvae through the stage of metamorphosis ("setting") to the point where they are transplantable as young oysters to the growing beds.

According to Loosanoff [7, pp. 14—18], oyster eggs and larvae are relatively hardy and capable of surviving significant changes in temperature, salinity, turbidity, and mechanical disturbances. However, they can be extremely sensitive to certain trace chemical elements naturally present in sea waters, to toxic substances such as DDT and other pesticides, oils, organic solvents, and detergents, and to a variety of viral, bacterial, and other disease producing organisms as well as being subject to a number of parasite and predator species. The precise combination of these and other factors responsible for poor setting in Long Island waters has not been determined, but at least four types of developmental programs are underway in order to improve setting results [9].

The first involves experimentation and research with salt water ponds as nursery areas, under the auspices of the Bureau of Marine Fisheries and private interests. The second, developing the larvae off the bottom on specially constructed stringers (a technique developed in Japan), has been applied, but as yet has not been perfected. Success in obtaining satisfactory sets has been highly variable due to unknown factors; and the higher costs of the vertical technique have also proved a significant constraint. The third relates to an experiment utilizing the discharge basin of the Northport steam electric station as an artificially warmed nursery area [5]. Since temperatures above 60°F are necessary for successful development of eggs and larvae, it is believed that the discharge basin may offer a more nearly optimal habitat than that found in Long Island Sound itself. The fourth is primarily involved with developing improved strains of disease-resistent, faster growing oysters as well as an oyster whose larvae does not require a cultch to metamorphose into a young oyster.

In addition to seed supply problems, unusually high mortality rates on the growing beds has been another major factor in reduced oyster production. For reasons not entirely known, benthic predator populations of starfish and drills appear to have increased substantially, in spite of concerted efforts at control. The technology of vertical culture mentioned above is also relevant here as a possible means of avoiding benthic predators. However, a number of other environmental factors relating to water quality (e.g., pesticide residues and nutrient-induced increases in (Nannochlorus phytoplankton), and disease-producing and parasitic organisms have also been implicated as causes of adult oyster mortality.

While the oyster industry is highly specialized and almost completely commercial in nature, clamming still represents a mixed operation, engaged in by larger-scaled companies with advanced harvesting equipment, the small-scale "baymen" utilizing traditional methods (both full and part-time), and also as a family quasi-recreational pursuit. Some beds are privately owned or leased, others are publically owned and generally open to the local populace. Good natural clam sets have been the rule since the early 1960's, following severe hurricane damage in the 1950's, and commercial productivity has been increased significantly with the introduction of advanced hydraulic dredges.

There is evidence of over-harvesting of hard clams on the north shore (Huntington Bay) public grounds, resulting in diminished stocks and decreased productivity [13]. This is a potential problem of any natural fishery in which the entry of harvestors is unrestricted, and points up the need for public management in situations where resource exploitation exceeds the capacity of a renewable resource to maintain itself. Reductions of productivity were not evidenced in the privately leased areas of Huntington Bay. Nor have they apparently yet occurred in the public shellfish grounds of south shore bay.

Declining production of bay scallops has also been widely noted for Long Island, commercial harvest in 1967 being at a 10-year low for the species, followed by only a small recovery in 1968. It is generally believed by professional fisheries people that the decline is due to natural causes; and although the precise nature of these causes has not been ascertained, the observed decline appears to have occurred universally throughout the geographic range of this species [9]. Since the life span of the bay scallop is extremely short (18—26 months), and since an individual spawns only once during its life, one or two years at random of poor spawning success is all that is necessary to cause an extreme decline in the population. It may be noted from Table 2 that similarly low levels of harvest occurred in the 1954—56 period, but that very rapid recovery had taken place within a very few years. As far as can be determined, management techniques for mitigating the periodic declines of this species have not been developed or applied. This could represent an important area for basic research and experimental management.

A substantial portion of shellfish growing areas (about 10 percent) are presently closed to shellfishing for public health reasons due to bacterial contamination from domestic and duck wastes.* However, it is not known what portion of closed areas

*Reported figures on total areas open and closed to shellfishing are ambiguous since the definitional basis of "shellfish areas" has not been precisely defined in the sources. One unpublished source indicated that 10% of a total of 331 thousand acres of "shellfish waters" is closed (18% for Nassau and 2% for Suffolk County). Unpublished Bureau of Marine Fisheries tabulations indicate 7.3% of Nassau-Suffolk "shellfish area" (out of a total of 671 thousand total acres) is closed all or part of the year.

are in fact currently producing unharvestable shellfish or could. if reopened, constitute potential areas for cultivation and harvest. There is currently operative a limited, largely experimental, program of transplanting clams from closed to open areas where the organisms purge themselves of contaminants. The economics of transplanting constitutes a significant obstacle to its widespread use. since, counting losses of transplants, transplanting has been estimated to add upwards of $2.00 per bushel to the total cost of harvested product [9]. An alternative to transplanting in relation to possibilities for utilizing the product of contaminated areas is the development of "depuration" plants, where biologically contaminated shellfish would be purged of contaminants. Depuration is practiced extensively in Europe [3, p. 2], and to some extent in Maine and Massachusetts [8]. None presently exists on a commercial basis in New York State, although the Bureau of Marine Fisheries has been operating an experimental pilot plant, and considerable research and development effort is being conducted elsewhere in the U.S. However. it is anticipated that at least some portions of presently closed areas may be reopened with the introduction of improved domestic sewage treatment plants and changes in duck waste disposal methods.

There is every reason to believe that Long Island shellfish production is capable of being substantially increased in the future through the applications of more advanced scientific knowledge, technological development and better management of the resource. Most of these species are potentially capable of intense cultivation or "aquaculture" [4]; and except for oysters, where a strong start has been made, the remaining species are still mainly exploited under a traditional "food gathering" approach dependent on natural conditions of reproduction and abundance. However, intensive cultivation requires not only substantial capital investment but also unified management of the human, capital and natural resources involved in order to exploit its potential. This would seem to imply either relatively large-scaled private enterprise with proprietary rights to exclusive use of the natural resource base, or a public-private cooperative endeavor with restricted private entry to the harvesting stage of production. In either case, adequate demand for the product must exist to ensure success.*

Public Policy Background

For the most part the governmental agencies with a developmental and/or regulatory interest in shellfish production are the same as those discussed in the section on finfishing.

The principal agency is the New York State Bureau of Marine Fisheries which, in addition to research and development activities, exercises a wide variety of State regulatory functions under the New York State fish and game laws. Among the latter are included: issuing leases for exclusive shellfish cultivation rights to private enterprises on certain state-owned lands; the licensing of all commercial shellfish harvestors; the licensing of shellfish processors and shippers; the enforcement of regulations regarding fishing seasons and size limits; the determination of areas to be closed for sanitary reasons, and the enforcement of regulations pertaining to harvesting, transplanting and shipping of contaminated products.

In contrast with the finfish situation, the State of New York is thus able to exercise controls over most of the relevant resource base, which in this case is essentially non-migratory and entirely within its political jurisdiction. It is not, however, empowered by law to regulate all aspects of the environmental resource (such as water quality) or to manage all aspects of resource exploitation. In this latter regard, for example, it does not have the ability to restrict commercial entry to public shellfishing grounds or to directly regulate total harvest from these grounds.

Various town governments are also involved in the leasing of town-owned lands to commercial cultivators and the issuance of permits for commercial harvesting in town waters.

Shellfish destined for sale in interstate commerce are regulated in terms of quality under the National Shellfish Sanitation Program of the U.S. Public Health Service, which both determines the water quality standards under which harvesting

*In this connection, it may be noted that the harvest of hard clams was restricted by hydraulic dredging companies in 1968 [12, p. 2], presumably as a measure to maintain price levels in the face of abundant supply.

is permissible and the sanitary quality characteristics of product to be shipped. The Bureau of Commercial Fisheries of the U.S. Department of Interior, Fish and Wildlife Service, is the primary federal agency involved with shellfish research and development programs as well as the principal source of industry landings and other statistics.

Indicated Information Needs

As with finfish, information needs for dealing with various aspects of shellfish production can be grouped under two general categories: one relating to technical aspects of the resource itself (shellfish species and habitat relationships), and the other relating to economic, legal and other institutional aspects of shellfish production and marketing.

The first requirement is for systematic basic scientific knowledge on the life cycle processes and ecological factors influencing population numbers and growth rates for each important species of shellfish. A considerable body of such knowledge already exists and major on-going research efforts continue under both public and private support. Nevertheless, the knowledge thus far attained and (perhaps more importantly) the ability to integrate the wide variety of physical, physiological, chemical and other areas of knowledge into a comprehensive whole is apparently insufficient to the needs of accurate prediction and precise explanation of population changes in the real-world marine habitat. This seems especially true, for example, in the areas of "setting conditions," chemical toxicities, and pathology.

In addition to knowledge of how and why shellfish populations prosper or decline, knowledge is also needed regarding the controlling factors themselves in terms of possible ways to manipulate them to better advantage. The history of agricultural science and technology illustrates and suggests the dual possibilities both of altering species characteristics and of controlling environmental conditions to enhance productivity of desired species.*

It is evident that knowledge of local environmental conditions in Long Island shellfish waters is still far from satisfactory. The shellfish resource itself (including

*Laboratory knowledge is already available for inducing oysters to spawn any time during the year [7], and development of "cultchless" oyster setting techniques is imminent. The growing of oysters in heated water of electric power stations is another example of environmental manipulation with great promise.

both benthic habitat conditions and shellfish population densities) has never been systematically surveyed in terms of its existing status and development potential [9]. Such an inventory of present resources, especially if combined with current scientific knowledge and local knowledge of historically high producing areas, would go a long way toward providing a basis for future development.

Ability to apply known and prospective scientific and technological knowledge to preserve and expand production levels must ultimately depend upon economic and institutional factors relating to shellfish resource management and exploitation. At present, systematically developed knowledge and information concerning these factors is almost totally lacking for the Long Island region. Some of the areas and issues requiring the exploration and analysis of the various social and behaviorial sciences would include the following:

- The present legal status relating to private and public proprietary rights over shellfishing resources in Long Island waters for the whole of Long Island. Is the present leasing system consistent with the objective of private development? How much legally leasible acreage is presently unleased? What would be required politically to increase leasible acreage?

- The economic structure, organization and performance of the existing private shellfishing industry. Has the industry been expanding or contracting in terms of numbers of firms and total employment? Are individual firms large enough to provide sufficient capital and managerial ability to exploit the resource efficiently? Where and to what extent is competition excessive, both in terms of excessive harvesting in relation to conservation needs and in terms of substandard profit levels? Would the restriction of entry to certain public fishing grounds enhance total production and could this be accomplished in a politically feasible manner? Is development capital available to the industry? Are future demand potentials high enough to accommodate significantly increased production levels at profitable prices? For which particular species?

- The role and function of public agencies in regulating and managing the resource. What functions of public resource management are necessary to maintain and improve shellfish production? Is the New York State Bureau of Marine Fisheries properly structured, in terms both of organization and legal authority, to serve as an agency for comprehensive management and development of shellfish resources? If considered desirable, in what respects might it be strengthened in this regard?

Selected References

1. Bennett, Clinton, Marine Fisheries Sanitarian, New York State Conservation Department. Personal interview, May 13, 1969.

2. Cooperative Shellfisheries, 1963: R & D Huntington's key to progress. Long Island Commercial Review, November, p. 11.

3. Furfari, Santo A., 1966: Depuration plant design. National Shellfish Sanitation Program, Public Health Service. U.S. Government Printing Office, Washington, D.C.

4. Gaucher, T. A., 1968: Potential for aquiculture, Chapter 4 of Study of Means to Revitalize the Connecticut Fisheries Industry. Report to the Connecticut Research Commission by the Electric Boat Division of General Dynamics Corp., January.

5. LILCO to Aid the Oyster Industry, 1967: News Bulletin, Long Island Lighting Company, July, p. 1—3.

6. Long Island's Underwater Farming Industry Gaining R & D Revival. Long Island Commercial Review, November, p. 10.

7. Loosanoff, Victor L., 1965: The American or eastern oyster. U.S. Fish and Wildlife Service, Circular 205. U.S. Department of the Interior, Washington, D.C.

8. MacMillan, Bruce, Assistant Sanitary Engineer, New York State Conservation Department. Personal interview, May 13, 1969.

9. Miller, William, Supervising Aquatic Biologist, Fisheries Management and Development Unit, New York State Conservation Department. Personal interview, May 13, 1969.

10. New York State Fish and Game Law: Part IX, Marine Fishereies, Albany, New York, 1967.

11. U.S. Department of Health, Education and Welfare, 1965: National shellfish sanitation program manual of operations. Public Health Service Publication, No. 33, Parts I and II, 1965 revision.

12. U. S. Department of the Interior, Bureau of Commercial Fisheries. 1954—1968: New York Landings: Annual Summaries.

13. Wallace, David H., Director of Marine Fisheries, New York State Conservation Department. Personal interview, May 8, 1969.

14. —, 1963: The marine fisheries of New York. Long Island Commercial Review, November, p. 11.

15. Wallace, Elizabeth M. and G. R. Lunz, 1968: The oyster—a shellfish delicacy. Atlantic States Marine Fisheries Commission, Leaflet No. 11 on Marine Resources of the Atlantic Coast, October, Tallahassee, Florida.

EELGRASS

Introduction

Zostera marina (eelgrass) is one of thirty species of flowering plants known to grow naturally in the sea. This species of plant is found over a wide geographic range from Southern Greenland to the Carolinas in the western Atlantic as well as along the European coast. The abundance of eelgrass throughout its range has historically been periodically affected by a serious wasting disease of unknown etiology. In the Eastern United States, the last serious epidemic occurred in the early 1930's. It was not until the mid-1940's that signs of a widespread recovery were noted; and now, 25 years later, the recovery has progressed to the point where eelgrass is regarded by many as a major marine resource problem for Long Island.

The rationale for this designation is based on the difficulties encountered by boating enthusiasts and swimmers utilizing stretches of water where eelgrass flourishes, such as South Oyster, Great South, and Moriches Bays and adjacent waters, as well as by people living near the shore line who are exposed to the obnoxious odors of decaying eelgrass. In addition, standing growth can interfere with shellfish harvesting and sport fishing activities. On the other hand, the ecological value of this species as basic habitat and source of primary nutrients for a wide variety of marine life forms is widely heralded by biologists and conservationists.

Considerable scientific investigation has been devoted within recent decades to studying the life cycle of eelgrass and identifying the environmental factors that influence its growth.* Comparative studies of the seasonal growth and reproduction of Zostera marina were made as early as 1929 by Setchell [2], who identified four growth and reproduction stages.

These stages are described by Burkholder and Doheny [1, pp. 7—9] as follows:

- The first stage of growth may be regarded as extending from germination of the seed to production of the first turion (bud) at the tip of the rudimentary stem.

*For an extensive bibliography, see [1, pp 89—120].

- The second stage extends from the beginning of the growth of the first bud through the development of a rhizome (subterraneous plant stem capable of producing both roots and shoots) and formation of the second turion and lateral buds. These stages take place during the first season of growth beginning in the spring and ending in the late fall and winter.

- The third stage takes place in the second season and consists of the following: (a) the second turion develops into the erect flowering shoot, then through pollen formation, to fruiting, death, and detachment for floating: (b) the axillary buds develop into lateral rhizome segments. each with a terminal turion and lateral buds; (c) the main axis of the rhizone dies away, leaving lateral rhizone segments free.

- the fourth stage and succeeding stages are essentially like the processes (a), (b), and (c) of the third stage for each of the rhizome segments separated and left alive at the close of the previous growing season.

Under favorable environmental conditions, this process, together with seed dispersal by water currents, provides the potential for rapidly increasing density and geographic distribution.

A number of environmental conditions influence the growth and areal distribution of eelgrass, including water temperature, light intensity, depth, salinity, characteristics of benthic materials, and others.

The Wegman report [4] cites studies showing that vegetative growth is carried on primarily in the range of 10°C to 15°C while reproduction occurs solely in the interval of 15°C to 20°C. Water depth has also been extensively investigated, the Wegman report [4] concluding that in South Oyster Bay growth is heaviest in water depth from one to four feet and no significant amount was below the nine-foot depth. A later study by Burkholder and Doheny for the Town of Hempstead [1] also indicated a distinct inverse relation between eelgrass health (as indicated by length of leaves and general vigor of plants) and the depth of the water. The species studied in the South Oyster Bay area demonstrated its best health in depths of water ranging from nine feet to three feet with light intensities down to 19—30% of its incident value at the surface. It was concluded that eelgrass does not and can not grow in the turbid waters of the Bay region below a depth of about 6—8 feet [1, p. 59].

Older reports have indicated the importance of bottom materials in the growth of Zostera, since this marine plant takes its sustenance from the inorganic, nutrient-rich sediments of the bay bottoms rather than from the water in which it is immersed. This has also been substantiated by Burkholder and Doheny who measured heaviest growth in rich mud areas, with short leaves and small shoots evident in sandy gravel areas [1, p. 62—63]. More detailed study of these and other factors has continued since the publication of results in 1968.

Evaluation of Problem

Since its recovery from the wasting disease of the mid-1930's, eelgrass has been spreading westward from Great South Bay (where limited stands of apparantly disease-resistent strains survived) into the bays of southern Nassau County as far west as Great Island Channel in the Town of Hempstead by 1968 [1, p. 47]. It has also become substantially re-established eastward in other bay waters of Suffolk County. Of the approximately 5,000 acres of water surface in South Oyster Bay, some 60% harbored eelgrass in concentrations from 1 to 5.6 tons per acre, dry weight, by 1966, with extremely dense stands yielding up to 14 tons [4]. Wilson and Brenowitz measured stands in Great South Bay up to 8 tons per acre in 1965; and in July of 1968 the standing crop in South Oyster Bay was estimated to vary between 1.1 and 9.2 tons per acre [1, p. 85].* As noted previously, considerable variation in density occurs, depending on depth of water, bottom type, turbidity, period of growing season, and length of time following recovery (or reintroduction) from the earlier period of scarcity.

With the recent reestablishment of large, dense growths of eelgrass, vociferous indictments of eelgrass have come from boating enthusiasts and landowners along the Long Island bays. The former group complains that the long slender leaves of the grass foul propellers and water intakes and impede the passage of small boats. These

*These yields can be compared to average wheat acreage yields for the U.S. of about one ton per acre, dry weight.

difficulties are created both by the attached plants in the shallower waters and by the floating masses of severed leaves. These floating masses are also propelled by winds and tidal currents until they sink to the bottom or move into the creeks and canals and onto the beaches where accumulation and decomposition lead to the unsightly and obnoxious nuisance which is the source of complaint of the landowners. The Wegman report [4] also noted that in some cases, where large amounts of these weeds accumulated on the bottom of quiet bay waters, microbial decomposition became so rapid that the oxygen was depleted and anaerobic fermentation took place, resulting in foul odors and destruction of aerobic life on the bottom. Interference with shellfishing operations, swimming, and rod and reel sport fishing during summer and fall growing periods has also been noted.

While the opponents of eelgrass have presented dramatic evidence of the adverse effects of the species on a number of man's activities, the proponents have been less successful in dramatizing their case. Since no major practical economic use has been developed for the species, it has remained for scientific testimony to proclaim the ecological importance of Zostera. This testimony is based on evidence, as noted in the Town of Hempstead report, that eelgrass growth provides a favorable marine habitat and primary food production to attract and foster the growth of small life forms. These communities provide valuable feeding grounds for species such as oysters, scallops and bait shrimp as well as many other marine forms living on or near the eelgrass beds. Small animals that live in the vicinity of the eelgrass community lead into the food chains of various important fish and waterfowl. Despite the expert testimony of the significance of eelgrass to other marine species, popular opinion is in favor of the control of its growth where it conflicts with other shore line uses.

Control of the grass is generally aimed at the collection of floating masses of broken-off leaves or the removal of the accumulated plants washed up on the beaches and shore lines. Amphibious scavengers equipped with mechanically operated booms and rakes are available for the effective removal of floating grass from the water and beaches of the bay. Barges of other collection units are used to transport the collected grass to disposal areas. This is a relatively expensive method; however, detailed cost data were not available.

In the vicinity of marina harbors or boat channels it may be desirable to control the growth of living plants in the water. Mechanical cutting and uprooting of eelgrass are common eradication methods which are, at best, only temporary solutions in that they increase the chances of scattering root segments and do not prevent the regrowth of the plants. Chemical control (Benclor 3) of eelgrass and macro-algae has been experimented with and has been found effective, but is considered hazardous to fish, wildlife and humans. Consequently, at present these chemicals are not considered a feasible control method for the bays except under strictly controlled applications.

Although its direct economic importance is negligible at present, historically, eelgrass has been put to a wide variety of productive household, agricultural and manufacturing uses [1, pp. 33—34]. At various times and places in Europe and North America, its ashes have been used as fertilizer, and dried fibers have been used for fuel, insulating material, animal bedding, mattress stuffing, quilting, upholstering, packing, basket weaving, and mulching. During World War II it was employed as a substitute for gun cotton in Germany, and patents have been issued for its use as a paper pulping material. As a primary organic material, it posses a number of interesting characteristics in addition to its high rate of natural production, including strength, durability, and resistance to insects and vermin.

If a profitable modern economic use for Zostera were to be developed in the future, it could have widespread implications for the Long Island marine resource picture, especially given its presently important ecological functions. In the meantime, conflicting interests and values abound concerning the extent to which eelgrass constitutes a problem or a blessing; and these must somehow be reconciled in the formulation of management and control policies. If, as is the concensus of expert expert opinion [1, p. 85], eelgrass does continue to spread and increase in density in the bay waters of Long Island, management policy will become an increasingly important issue in years to come.

Public Policy Background

Aside from conducting and sponsoring research relating to its biological and ecological characteristics, public agencies are not actively involved in eelgrass management and control to any significant extent. Some public control is undoubtedly carried on as an incidental aspect of channel and other dredging operations; and the protection of eelgrass habitat does constitute an aspect of the New York State Bureau of Marine Fisheries and U.S. Fish and Wildlife Service responsibilities for biological resource management.*

It is evident that pressures have been mounting at the town and county level for the introduction of control programs to benefit small boat navigation and shore line property owners. With the continued spreading and possible increase in growth densities in certain regions, local governments may well become increasingly involved.

Indicated Information Needs

It would appear that the information needs for developing a rational eelgrass management policy fall under three general categories: (1) biological and ecological characteristics of eelgrass and eelgrass-dominated ecosystems; (2) human activities affected by eelgrass; and (3) technologies for control and their environmental effects.

Of the three, the first area of information seems the most highly developed. This involves not only knowledge of environmental factors influencing the quantity and locational distribution of eelgrass, but also the quantitative relationships between eelgrass and other aquatic organisms.

The second area has not, to our knowledge, been seriously explored. Thus, for example, we do not have well-developed information regarding numbers of people who consider themselves adversely or beneficially affected by eelgrass or the intensity of their dissatisfactions as a basis for determining future control policies.

Regarding control technologies, there would appear to be a real need for research and development relating to alternative mechanical, chemical, or other means of collection, removal, and localized inhibition of growth. This is necessary to ensure both effective and economical control where considered necessary while at the same time avoiding undesired and unintended side effects of particular methods.

*During its earlier period of decimation, these agencies were involved in active programs of attempted restoration of this species.

Selected References

1. Burkholder, Paul R. and Thomas E. Doheny, 1968: The biology of eelgrass. Contribution No. 3 from the Department of Conservation and Waterways, Town of Hempstead, Long Island. Contribution No. 1227 from the Lamont Geological Observatory, Palisade, New York. Department of Conservation and Waterways, Hempstead, Long Island, New York.

2. Setchell, W. A., 1929: Morphological and phenological notes on *Zostera marina*. Univ. of Calif. Pub. Bot., 14, pp. 389—452.

3. Udell, H. J., J. Zarudsky, T. E. Doheny and P. R. Burkholder, 1969: Productivity and nutrient values of plants growing in the salt marshes of the Town of Hempstead, Long Island. Bulletin of the Torrey Botanical Club, 96:1, pp. 42—51.

4. Wegman, Leonard S. & Company, 1967: Channel and eelgrass study. Report to the Nassau County (N.Y.) Commissioner of Public Works, June 23. Mineola, Long Island, New York, Department of Public Works.

5. Wilson, Ronald S. and H. Harry Brenowitz, 1966: A report on the ecology of Great South Bay and adjacent waters. Oakdale, Long Island, New York, Institute of Marine Science, Adelphi Univ., July.

WETLAND DESTRUCTION

Introduction

There is considerable room for differences in definition associated with the term "wetlands," concerning the types and extent of land and water areas included. The U.S. Fish and Wildlife Service, for example, considers the wetland complex to include not only salt marsh and salt meadows, but mudflats, open saline and brackish water seaward from mean low tide, and open fresh coastal waters [12, pp. 6—7]. The Department of Conservation and Waterways of the Town of Hempstead defines wetlands for its purposes as tidal shorelines, estuaries, waterways in general, salt and brackish marshes including areas drained by fresh water streams which flow into salt water, tiny islands (hassocks) in bays and all salt water bottoms that support plants and other biota [2, p. 1].

The present discussion focuses primarily on the intertidal portion of the wetland complex comprising the salt marshes and meadows to the limit of spring and storm tide. It is this zone lying between dry uplands and open water that is most subjected to the pressures of urbanization and alternative land use development on Long Island; and it is these ecologically important marsh and meadow lands that constitute a permanent concern of conservation interests. Most of the remaining portions of the broader wetlands complex omitted from this discussion are considered elsewhere in this report under various aspects of Wastewater Disposal, Dredging, Shellfishing, Eelgrass, Coast Stabilization, and Shoreline Recreation problems.

Depending on elevation and frequency of flooding, coastal meadows and marshes are characterized by various dominant plant groups. For example, the natural meadows that are washed only occasionally by brackish waters during unusually high tides consist primarily of spike grass (Distichlis spicata) and salt meadow grass (Spartina patens). Near the normal high water line a dwarf form of Spartina patens occurs; and from the normal high water level to about half way down the intertidal slope, the salt marsh grass (Spartina alternifolia) becomes the predominant species [6, p. 51].

In their natural state, these vegetated wetlands perform a number of important ecological and physical functions in the coastal environment. They are generally recognized as the most productive of all natural primary food producing environments. They provide food and habitat directly to a host of invertebrate and vertebrate life forms, and serve as the principal source of primary organic nutrients to adjacent estuary, bay, and offshore waters [6, 8, 11]. As such, they are thus of far greater biological importance than their relative surface area alone would imply since, to a significant degree, they constitute the primary base of the food chains upon which all higher marine organisms depend.

In addition, these marshes serve as a natural buffer to dissipate the energy of storm waves, thus protecting higher land areas and structures from flooding and erosion. Marshlands also accelerate the settling of suspended particulates, thus contributing to improved water quality.

Wetland areas may be destroyed directly, either by excavation to create harbors, marinas and navigable channels, or by filling and bulkheading to create "new land" for housing, highway construction and other development purposes. Short of destruction by excavation or filling, the values of wetlands as stable and productive ecological areas may be significantly altered by a variety of other unnatural causes. The process of siltation which normally occurs in estuarine wetlands may be accelerated by excessively turbid conditions resulting from dredging and spoil disposal and by sand and gravel washing operations. This in turn can result in replacement of Spartina alterniflora by less productive plant species [12, p. 7]. Various forms of pollution, such as oils, persistent pesticides, and other chemicals can either directly damage the primary vegetation or otherwise seriously interfere with biological production. The drainage of standing water pools as a mosquito control measure can have mixed effects, not all of which are necessarily detrimental. The improved flushing action through wetlands as a result of the drainage ditches can, in some circumstances, make more food and habitat for fish and waterfowl [7, p. 1].

Evaluation of Problem

Although quite incomplete, evidence on the extent of wetland destruction on Long Island has been documented in a series of surveys conducted by the U.S. Fish and Wildlife Service in cooperation with the New York State Conservation Department over the period 1953—1964. The surveys covered fresh and saline coastal marshlands of 40 acres or larger, and were not designed to reveal destruction or damage other than physical loss [12, pp. 3—4].* Table 3 summarizes the survey findings on total marshland acreage lost.

In the 10-year period up to 1964, the Nassau-Suffolk bicounty region lost over 8,200 acres of marshland by physical destruction, or 24 percent of the total acreage existing in 1953. Total losses were somewhat greater for Nassau County (4,635) than for Suffolk (3,582); and, in relative terms, Nassau County's proportionate losses were even greater (33 percent as compared with 17 percent for Suffolk County). It is also of interest to note that total losses in both Counties were greater, in both relative and absolute acreage terms, in the 1959—64 period than in the preceding 1954—59 period.

TABLE 3
COASTAL MARSHLAND ACREAGE AND
ACRES OF COASTAL MARSHLANDS LOST IN
LONG ISLAND REGION, 1954—1964*

	Nassau County	Suffolk County	Total bi-county region	Total Long Island†
1954 acreage	14,130	20,590	34,720	43,215
1959 acreage	11,911	19,208	31,119	37,504
1964 acreage	9,495	17,008	26,503	30,508
Acres lost 1954—64	4,635	3,582	8,217	12,635
Percentage lost 1954—64	33	17	23	29
Acres lost 1954—59	2,219	1,382	3,601	5,711
Percentage lost 1954—59	16	7	10	13
Acres lost 1959—64	2,416	2,200	4,616	6,924
Percentage lost 1959—64	20	12	15	19

*See text for definition of marshlands covered.
†Includes Bronx, Kings and Queen Counties in addition to Nassau and Suffolk.
Source: Adapted from [12, p. 6].

*The original survey was designed to include only marshlands considered to be of moderate to high value as waterfowl habitat. (38,214 acres in 1954) but subsequent revisions were made in later surveys to include an additional 5,001 acres of low to negligible waterfowl value.

There is no way of knowing preci he extent to which wetlands were reduced in the years prior to 1954, since developmental pressures have been taking a gradual toll for over 200 years, especially in the Metropolitan Counties of eastern Long Island and, to a lesser extent, in Nassau County. It was stated in the 1964 survey report, however, that most of the historic losses in Suffolk County had occurred during the previous decade, indicating that the eastward-spreading pressures of urban development have only recently begun to exert a substantial effect on Suffolk County marshlands [12, p. 8].*

Comparative information on causes of destruction (type of development) was also developed in the Fish and Wildlife Service surveys and this is summarized for Nassau and Suffolk Counties in Table 4.

Housing, recreation (parks, golf courses, etc.), industry, and marinas, docks and channel developments are all of major importance in the lists of purposes for marshland destruction in both counties. The "miscellaneous fill" category, second in importance in both counties, was indicated to be largely spoil disposal from hydraulic dredging for the immediate purposes of channel and harbor maintenance or improvement and dock and marina construction. The greater part of this filled marshland will undoubtedly be built upon eventually. To the extent that marshland losses from miscellaneous filling constituted an "unintentional" side-effect of dredging operations (rather than purposeful filling for future unspecified land development), it may indicate a simple failure on the part of local county and town authorities during this earlier period to appreciate the values being destroyed. On the other hand, filled waterfront land, however created, can represent an opportunity for substantial private gain; and the joint technological relationship between dredging and land filling can thus easily tend to obscure the relative importance of underlying purposes. In any event, one is struck by the large magnitude of "miscellaneous filling," accounting

*It is interesting to note that Bronx County, which had less than 1900 acres remaining in 1953, lost 97 percent of these marshlands over the next 10 years. Queens County had lost 31 percent of its 1953 acreage by 1964.

TABLE 4
CAUSES OF COASTAL MARSH LOSSES IN NASSAU AND
SUFFOLK COUNTIES, 1954—1964

	Nassau County		Suffolk County	
	Acres	% of losses	Acres	% of losses
Housing	1,885	41	1,226	34
Miscellaneous fill	984	21	905	25
Recreation	487	10	336	9
Industry	729	16	316	9
Marinas, docks, channels	330	7	402	11
Airports	0	—	4	—
Bridges, roads, parking	85	2	209	6
Waste disposal	60	1	16	1
Schools	75	2	33	1
Agriculture	0	—	96	3
Drainage	0	—	39	1
Total	4,635	100	3,582	100

Source: [12, p. 9].

for 21 and 25 percent, respectively, of marshland losses in Nassau and Suffolk Counties during the 10-year period.

Although it is known that significant additional marshland losses have occurred since 1964, systematic enumeration will not be available until the publication of results from the 1969 resurvey by the U.S. Fish and Wildlife Service for the national wetlands inventory, currently in preparation [10].

Nor is it possible to present systematic evidence on other types of wetlands or on damages resulting from deterioration in quality of marshlands as biological habitat and primary nutrient producers. Deteorioration due to accelerated siltation from dredging and spoil disposal activities, as well as from pesticides and other pollution sources is known to be of significance in the bicounty region. For example, highly productive Spartina alterniflora marshland areas in Great South Bay have been altered by hydraulically deposited spoil to the extent that they have become largely inhabited by almost valueless stands of reeds(Phragmites) [10]. This type of ecological change can occur in as short a period as a single growing season [12, p. 7]. Residues of DDT and other pesticides occur presently in a large number, if not all. of the marshland areas of Long Island (see essay on pesticides below). Further, extensive ditching of marshes for mosquito control purposes has been a long standing practice in both counties, especially in south shore bay regions. Although the precise effects of ditching are debatable, they are considered generally unfavorable by many wildlife biologists [7, 10].

The question of vulnerability of marsh and other wetlands to future destruction and deterioriation is of obvious crucial importance. According to an assessment by the New York State Conservation Department, Division of Fish and Game, in 1964, only about 3,500 acres (12 percent) of Nassau and Suffolk County marshlands were at that time judged "safe from destruction," due to their ownership [12, p. 10] by public and private conservation agencies and conservation minded individuals. Of this amount, less than one-third was owned by the New York Division of Fish and Game, the Nature Conservancy, the U.S. Fish and Wildlife Service, or "other similar agencies as could reasonably assure preservation"; and about half was privately owned by "wealthy sportsmen, gun clubs, or conservation-oriented individuals" [12, p. 11]. Regarding the latter, it was further noted that:

> Such holdings are (becoming) increasingly unstable. Taxes and active land acquisition programs by public agencies using condemnation proceedings when owners are reluctant to sell are factors in this trend. Wetland preservation unfortunately has not been a primary objective of these acquisition programs.

Although the public ownership status of Long Island wetlands has improved somewhat in this regard since 1964 under the Long Island's Wetlands Act (see below) and federal acquisitions on Fire Island, a complete enumeration of the current wetlands ownership pattern is not available. A current inventory of wetlands conducted by the New York State Department of Conservation for the Office of Planning Coordination has determined the ownership of marshlands in Nassau County and the Town of

Huntington, but encountered extreme difficulties in obtaining accurate and complete records of ownership in other Suffolk County towns.*

There is every indication that pressures for coastal land development will continue to increase and spread eastward on Long Island. To a significant degree these pressures quantitatively are reflected in increased market values for filled shoreline land, estimated in the mid-1960's at from $5,000 to $15,000 per acre [5, p. 3.37]. As these values increase, so will the pressures on current private owners to convert potentially developable natural wetlands into housing and other uses.

Public Policy Background

Public agencies exercise authority or influence over the disposition of wetlands on Long Island in a number of ways, including: the issuance of permits for dredging, gaming regulations, property tax policies and condemnation proceedings, drainage ditching for mosquito control, wildlife management and protection programs, and outright ownership.

Permits to dredge in the navigable waters offshore of the high water line in Nassau and Suffolk Counties of New York State are issued by the U.S. Army Corps of Engineers. Whenever wetland areas might be affected by dredging operations, the Corps is directed to take into advisement the recommendations of state and federal conservation agencies; however, final authority rests with the Corps of Engineers whose decision must depend primarily on matters relating to navigation.†

Town zoning ordinances can potentially influence wetlands in a variety of ways which may either hasten or retard their destruction. For example, a zoning regulation in Easthampton requires that wetland tracts must be filled to an elevation of seven feet above mean high water before qualifying as building sites]3]. However, whether this or other similar ordinances will stand under a court test is debatable at this time.

*Completed portions of this report are presently in preparation for publication by the Office of Planning Coordination. However, lack of funds and manpower has hampered completion of the more difficult surveys of Suffolk County Town Records[9].

†In all other counties of New York State the New York State Water Resources Commission is the issuing agent, and the Commission is specifically empowered to deny permits not only with regard to navigation but also when unreasonable, uncontrolled or unnecessary disruption of natural resources might occur [5, p. 3.40].

Property tax policies and condemnation powers of public agencies can also influence the preservation of wetlands, as well as their ownership [12, p. 11]. These factors, along with zoning issues, require further study regarding specific local details.

The mosquito control commissions of Nassau and Suffolk Counties have ditched marshlands extensively for the purpose of reducing mosquito larvae in standing water bodies [7. p. 1]. The effects of the drainage ditches have been mixed, or at least not altogether adverse. As with the Corps of Engineers, these commissions represent single-mission-oriented agencies with a considerable degree of autonomy in choice of methods and locations of operations. Although subject to the advice of the State Conservation Department, their cooperation in matters relating to wetlands conservation is voluntary rather than obligatory.

The principal conservation agencies relating to wetlands are the New York State Conservation Department and the Bureau of Sport Fisheries and Wildlife of the U.S. Department of Interior. Aside from lands specifically owned by the State or Federal Governments and specifically delegated to these agencies for management purposes, the functions of these agencies appear to be principally advisory or research oriented in nature as far as coastal marshlands preservation is concerned. Both agencies have played a primary role in stimulating public awareness and concern regarding wetlands conservation.

Public agencies exercise firmest control over wetlands through outright ownership. The Long Island Wetlands Act of 1959 was designed to encourage Long Island towns to dedicate to conservation purposes those wetlands already owned by municipalities. The Act allows the state to provide financial and professional assistance of up to fifty percent of the cost of developing and managing the wetlands for conservation. Over 16,000 acres of wetlands on the south shore have been dedicated by three towns—500 acres in the Town of Oyster Bay as a wildlife sanctuary, another 4,500 acres of marsh in Oyster Bay as a wildlife habitat, 550 acres of wildlife habitat have been reclaimed on Captree and Sexton Islands in the Town of Islip, and 10,000 acres of marsh have been dedicated in the Town of Hempstead [4].*

*These acreage figures include a variety of wetland types in addition to the marshlands emphasized in our evaluation of acreage data above.

Indicated Information Needs

Although the general ecological importance of coastal marshes as local habitat and as primary food producing areas for wider coastal regions is well documented in qualitative terms, basic quantitative information on these subjects is in an early stage of development (for example, see reference [10]). Objective and quantitative demonstration of the biological importance of Long Island marshlands to the broader coastal region would be invaluable in the development of general policy as well as in arriving at decisions for specific regional cases involving development conflicts.

At a more applied engineering level, it appears that possibilities for creation of new marshlands (in conjunction with dredging spoil disposal operations),* as well as the rehabilitation or upgrading of presently degraded or low-productivity marshlands, have received relatively little consideration in wetlands management discussions. As marshlands become increasingly scarce, the marginal values of upgraded and newly created marshes will be increased. Technical requirements and specific methods as well as information relating to the economic practicality of creative management approaches along these lines remain to be developed.

Better information relating to the institutional structure and processes governing the disposition and management of wetlands is also indicated. Information on the present ownership status of Long Island wetlands is only partially complete; and further work along these lines—especially for Suffolk County—should be given high priority. In addition to basic information on ownership categories (private individuals and different varieties of public agencies), an authoritative evaluation of the legal details of ownership status, relating to special categories of property rights under current zoning ordinances and other modifying arrangements (such as scenic easements), would be desirable. Such information is essential to a thorough evaluation of current wetlands "vulnerability."

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*Practical possibilities for this have been demonstrated, by accident rather than by intention, in Great South Bay where "stored" volumes of dredging spoil in bay waters have sometimes become populated by Spartina vegetation, thus "creating" local marshland habitat [9].

In a similar respect, better understanding of the complex institutional pattern of agencies and decision-making processes determing decisions on the issuance and operational details of dredging permits—including especially spoil disposal considerations and issues relating to enforcement of permit provisions—would also be useful.

Selected References

1. Belt, C. B. Letter to Milton S. Heath, Jr., July 9, 1968.

2. Town of Hempstead Department of Conservation and Waterways, Hempstead Town Conservationist, 1966: Wetlands: Their full meaning. Hempstead, Long Island, N. Y.

3. Lamb, Donald, 1969: Comments made at Workshop for Conservation Council, March 29, Riverhead, Long Island, N. Y.

4. Knoch, H. W. and A. S. Taormina, 1969: The Long Island Wetlands Act (mimeograph). New York State Conservation Department, Ronkonkoma, Long Island, N. Y.

5. Nassau-Suffolk Regional Planning Board, Oceanographic Committee, 1966: The status and potential of the marine environment. Nassau-Suffolk Regional Planning Board, Hauppaugue, Long Island, N. Y.

6. Redfield, Alfred C., 1965: Onotogeny of salt marsh estuary. Science, Vol. 147(3653), pp. 50—54.

7. Taormina, Anthony S., 1966: Mosquito problems in fish and wildlife management in New York (mimeograph). New York State Conservation Department, Ronkonkoma, Long Island, N. Y.

8. —, 1967: The natural values of marine wetlands. The New York State Conservationist, June—July.

9. —, Regional Supervisor, Division of Fish and Game, New York State Conservation Department. Personal interview.

10. Taylor, Maurice, Supervisor, Long Island Area Office, Division of River Basin Studies, U.S. Fish and Wildlife Service. Personal interview and communications.

11. Udell, H. F., J. Zarundsky, T. E. Doheny and P. R. Burkholder, 1969: Productivity and nutrient values of plants growing inthe salt marshes of the Town of Hempstead, Long Island. Bull. of the Torrey Botonical Club, 96:1, January—February, pp. 42—51.

12. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, 1965: Supplementary report on the coastal wetlands inventory of Long Island, New York. U.S. Fish and Wildlife Service, Division of River Basin Studies, Boston, Mass.

13. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, 1967: Waterfowl resources—Halsey Neck to Hook Pond, Long Island, New York. U.S. Fish and Wildlife Service, Boston, Mass.

DOMESTIC AND INDUSTRIAL WASTEWATER DISPOSAL

Introduction

Domestic wastewater includes the liquid wastes originating in the sanitary conveniences of dwellings, business buildings, factories and institutions; i.e., the "spent water supply of the community" [5, p. 56]. By comparison, industrial wastewater consists of the liquids discharged from commercial and industrial establishments including water used for processes, boiler feed, manufacturing, or cooling purposes. Domestic wastewater is sometimes treated on an individual basis by means of septic tanks or cess pools, and then discharged to the ground. Alternatively, domestic wastewater can be collected in sewers and transported to a central treatment plant; following treatment the wastewater (or effluent) is discharged to the ground and/or a water course.* When a central treatment facility is employed, the waste is typically referred to as "municipal wastewater" and usually consists of a combination of domestic and industrial waste.

Domestic wastewater consists of complex organic matter which is subject to attack by micro-organisms that transform it to a stable form. Domestic wastes are heavily laden with disease-producing bacteria and viruses excreted by persons suffering from or "carrying" infectious diseases. When domestic waste is treated using septic tanks or cess pools, it is subsequently discharged to a ground water table, and, consequently, such wastes may eventually reach a surface water body. Since the transmission of wastes to surface water via the ground water table is circuitous, it is difficult to forecast quantitatively the ultimate effects on surface water quality.

In contrast, the impairment of surface water quality resulting from direct wastewater discharges is more evident. The impact of such a discharge depends on the characteristics of the waste stream before treatment, the type of treatment, and the location of the discharge. Available treatment methods can accomplish everything from the simple removal of large solid materials to the production of water of highest quality suitable for human consumption. Typically, however, treated municipal waste discharges affect the following surface water characteristics: pH, turbidity, suspended

*It is also obviously possible to discharge domestic wastes from a sewage collection system "raw" (i.e., without treatment), but this practice is becoming less common.

solids, bottom deposits, concentrations of bacteria and viruses, dissolved oxygen. phosphorous compounds, nitrogen compounds, and the concentration of oxygen consuming organic matter. Industrial wastes (and municipal wastes with significant industrial waste components) may also influence a number of additional water quality characteristics, such as concentrations of metallic ions and other chemical elements, depending on the composition of the industrial waste sources. (Electroplating wastes, for example, commonly contain chromates and cyanide. Changes in these water quality characteristics in turn can significantly affect the types and quantities of biological organisms inhabiting the affected environment.

Changes in the levels of environmental characteristics noted above can influence a large number of water-related activities which, in the case of waters adjacent to Nassau and Suffolk Counties, include swimming, boating, water-skiing, and commercial and sport fishing. The specific groups of people affected quite naturally include all those associated with these activities as direct participants, and may even affect many individuals who do not make direct use of the coastline, insofar as they feel "less good" when the environment is degraded. Willeke [22] has documented this intuitively plausible statement using survey research methods in the San Francisco Bay region. This category of use, while often classified under the elusive rubric of "aesthetics," may nevertheless represent an extremely significant class of affected "uses."

Evaluation of Problems

The issues discussed above in general terms are now described in the context of Nassau and Suffolk counties. As of 1967, more than 56% of the population of Nassau county employed individual waste disposal systems [6, p. 5]; in Suffolk County the percentage was even higher [7, p. 62]. The impact of wastes discharged from septic tanks and cess pools on ground water quality in Long Island has long been recognized. Numerous studies attest to the deleterious effects these discharges have had on drinking water supplies [8; 6, p. 6]. Concerning the coastal waters, there are indications that ground waters contaminated by wastes from septic tanks and cess pools have resulted in the closing of several small beaches in Suffolk County [7, p. 25]. Such wastes have also been cited as one cause for the deterioration of water quality in Great South Bay [6, p. 7; 19, p. 91].

A significant portion of the wastewater originating in Nassau County is collected, treated, and discharged to coastal waters. Progress is being made for the provision of public sewerage throughout the county [6]. In 1968 Suffolk County had a total of 30 wastewater treatment plants receiving approximately 15 percent of the total sewage flow in the county [17, p. 62]. Engineering studies for the construction of regional treatment facilities have been undertaken for Suffolk County [17, p. 62].

In the above general discussion of impacts of municipal waste treatment plant effluents, a number of water quality indicators were mentioned. In the Long Island area, however, the environmental factors of current major concern relate to the concentration of disease producing micro-organisms (as indicated by coliform concentration), the concentration of dissolved oxygen, and the extent of fertilization of coastal waters as indicated by concentrations of compounds of phosphorous and nitrogen. A recent (1968) study [11, pp. 38—46] of Hempstead Bay indicated that wastewater treatment plant effluents were contributing to the violation of bacterial quality standards for shellfishing and that dissolved oxygen in Hempstead Bay was below acceptable levels. Another study [9, p. 28] indicated that the fertilization of Hempstead Bay has caused periodic blooms of phytoplankton.

A current issue of considerable significance relates to whether wastewater treatment plant effluent discharges should be permitted in the bays along the south shore. The Nassau County Department of Health has recommended that studies be undertaken to determine the feasibility of relocating existing outfalls in Hempstead Bay out of the Bay area [10, p. 113]. In a separate study [9, p. 31], the Town of Hempstead recommended that sewage effluents from the proposed "Nassau County District No. 3 Water Pollution Control Plant" at Wantagh be discharged into the Atlantic Ocean "at a suitable distance ... south of ... Jones Beach." Cosulich, in a study related to sewerage in the five western towns of Suffolk County [3, pp. 2—8], concluded that ocean disposal would be necessary to avoid "aggrevating the algae problem" in Great South Bay.

We turn from problems relating to discharges from individual disposal systems and municipal treatment works to those associated with industrial wastewater. Especially significant industrial wastewater problems are also treated in the separate sections on Thermal Pollution, Oil Pollution, and Wastewater from Duck Farms.

Bowe, Albertson and Walsh [2, p. 9] have observed that Suffolk County has no "large wet industries." They asserted that industrial wastewater in Suffolk County is relatively low in volume; the predominant wastes are from plating solutions which contain varying concentrations of hexavalent chromium, cyanide, acids, and heavy metals. Further, "all industries with any appreciable concentration of these wastes are providing treatment prior to sub-surface disposal as a protection to the ground water supply" [2, p. 9]. Note that the Suffolk County Health Department has an inspection program to determine the adequacy of such treatment methods [17, p. 66]. In 1967 the Nassau County Health Department reported that industrial wastewater discharges in the county were "essentially under control," although occasional breakdown in treatment devices were such that industrial wastes were an "intermittent source of pollution."

One issue, not mentioned above, concerns the waste load contributed to coastal waters by storm runoff. Although detailed descriptions of the contribution of such wastes to the coastal waters off Long Island are not available, studies in other parts of the U. S. have indicated that storm runoff is "akin to sanitary sewage in its pollutional characteristics..." [1, p. 20].* The Nassau County Health Department has reported that storm runoff has contributed to the formation of "mud banks"; also, storm runoff contains nutrients and organic material which contribute to problems relating to excessive aquatic plant growth and depressed dissolved oxygen, respectively [6, p. 6]. Problems relating to storm runoff in Nassau and Suffolk counties are obviated to some extent by the use of "recharge basins" which divert storm runoff to the ground water table.

Public Policy Background

The various public agencies having a direct interest in wastewater disposal are mentioned below. On the Federal level, the agency having primary responsibilities is the Federal Water Pollution Control Administration (FWPCA). This

*An important difference between sanitary wastewater and storm-water runoff is that the latter occurs in a discontinuous random fashion.

agency has held "enforcement conferences" with state and local officials to discuss publicly the pollution occurring in the Great South Bay—Moriches Bay region [19, 20]. The FWPCA also plays a significant role in the establishment of "classifications and standards" of water quality (discussed below). Grants to help defray the costs of municipal wastewater treatment facilities are also available through FWPCA. On the interstate level, the Interstate Sanitation Commission enforces a tri-state compact among New York, New Jersey, and Connecticut regulating tidal water quality [6, p. 3]. The jurisdiction of the Commission extends to Fire Island Inlet on the south shore, and Port Jefferson Harbor on the north shore [7, p. 50].

The primary state agency concerned with wastewater disposal is the New York State Department of Health. A grant program which provides for 30 percent of the cost of construction of municipal wastewater treatment facilities was established by the state under the Pure Waters Act of 1965 [19, p. 93]. At the county level, the health departments of both Nassau and Suffolk Counties participate in evaluating the effectiveness of wastewater treatment works [6, p. 4; 17, p. 66]. In addition to the agencies mentioned above, it should be noted that villages, cities, towns and special districts have played a role in the provision of sewer service to population centers [6, p. 3].

An institutional issue warranting special emphasis relates to the "classifications and standards" of water quality prepared by the New York State Department of Health. These classifications, which have been adopted for the coastal waters off Nassau and Suffolk Counties, serve to establish the "best usage" of the waters and the associated standards of water quality to protect these uses [12—16]. These classifications and standards have long been used to control the character of wastes discharged in coastal waters. However, the implications of Federal legislation adopted in the mid-1960's lend increased significance to the standards. Under provision of the Federal Water Pollution Control Act, as amended, the FWPCA has the ability to use the violation of water quality standards as a partial basis for initiating "enforcement measures"; this gives the FWPCA increased strength in carrying out its pollution control mission [18].

Indicated Information Needs

In concluding this discussion, we make note of some of the issues involved in obtaining information that can be useful in making recommendations and decisions relative to domestic and industrial wastewater disposal. A basic item of information concerns the impact of wastewater disposal on the physical, chemical and biological state of coastal waters; in other words, the "causal activity-environmental condition" relationships. Figure 2 which summarizes much of the preceding discussion, serves to indicate typical interactions involved in tracing the impacts of wastewater disposal. Information describing these interactions can be obtained by various combinations of field sampling (data collection), physical modeling, and mathematical modeling. The extent to which the interactions shown in the figure can be described quantitatively will be discussed in a subsequent report.

A second item of information that is useful in the formulation of policies governing wastewater disposal relates to the manner in which water-based activities (see Fig. 2) are influenced by environmental characteristics; this is well documented for some aspects of selected activities. In some instances, water quality standards dictate whether or not an activity can even be pursued. For example, high bacterial concentrations may prohibit shellfishing and water contact sports in a region. In other instances, environmental characteristics may influence the "quality" of the activity. For example, high levels of turbidity may not rule out swimming as an activity, but the quality of the experience might be diminished for some swimmers. There is much literature describing the levels of environmental characteristics that influence water-related activities (e.g., see the Report of the Committee on Water Quality Criteria [21]).

Another set of information needs relates to the costs of wastewater disposal policies and the benefits or disbenefits of these policies. It is often important to determine the incidence, as well as the magnitude, of costs and benefits. Cost estimates for different types of waste treatment and effluent discharge configurations can generally be obtained using standard engineering procedures. However, information regarding benefits is far more elusive, since many of the affected activities do not have associated market prices to indicate the extent to which the activity is valued by participants. The quantitative evaluation of benefits from improved water quality is

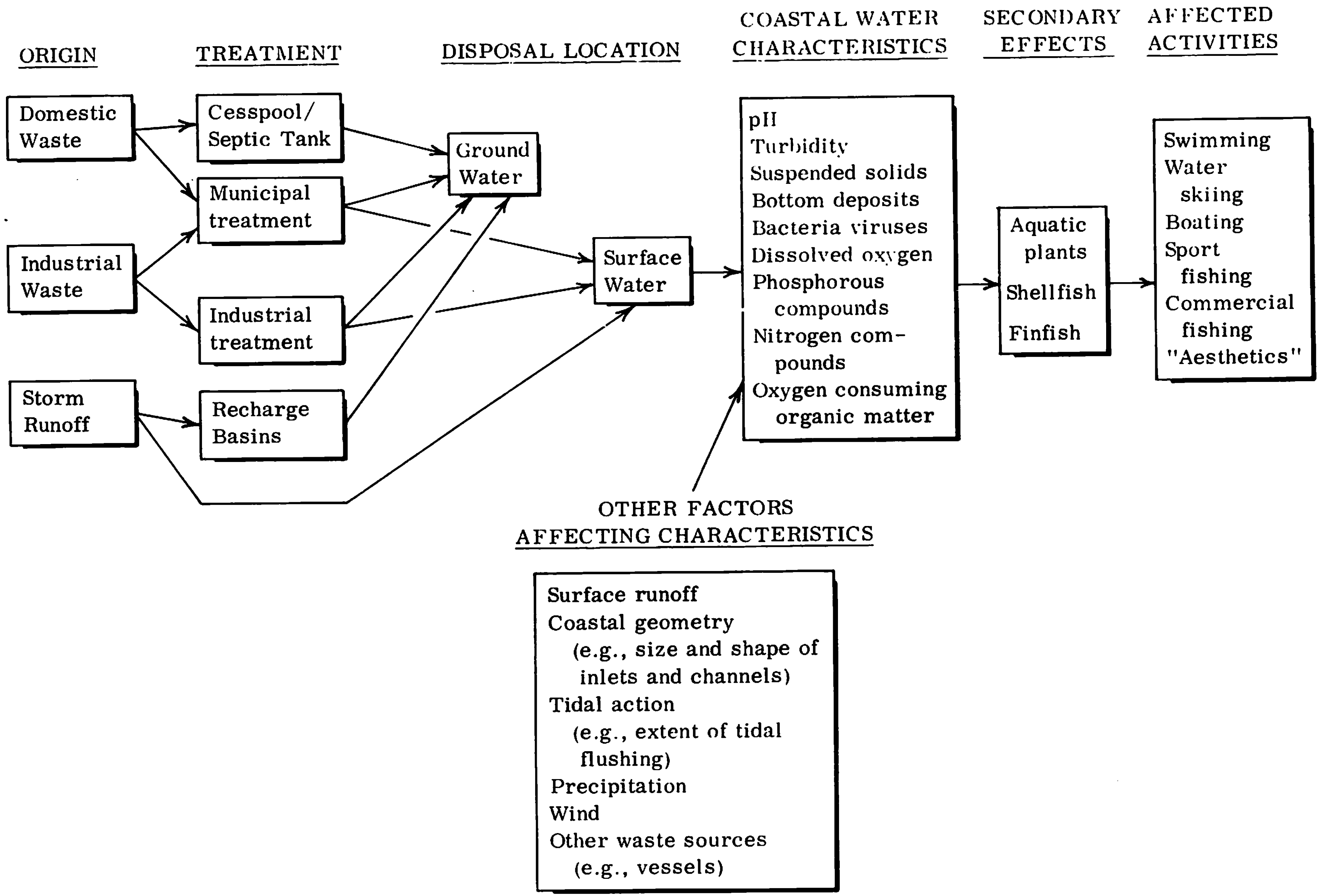

Fig. 2. Impacts of domestic and industrial wastewater disposal.

a topic that is receiving the attention of a number of social scientists (e.g., see Davidson, et al. [4]).

A complete understanding of the nature of the wastewater disposal problem also requires an appreciation of the jurisdictions and objectives of the various Federal, state and local agencies involved. Clearly, any recommendations regarding future wastewater disposal policies must take cognizance of the interests and authority of such agencies. Also, there may exist effective water quality management policies that cannot currently be implemented because of the absence of an institution with appropriate authority. Such policies might involve such nontypical activities as the use of artificial aeration as a partial substitute for "advanced" wastewater treatment.

Selected References

1. American Public Works Association—Research Foundation, 1969: Water Pollution Aspects of Urban Runoff, U. S. Dept. of Interior, FWPCA Pub. No. WP-20-15.

2. Bowe, Albertson and Walsh, 1965: Report, comprehensive sewerage studies, five western towns, Suffolk County, New York, Appendix D, N. Y., N. Y.

3. Cosulich, W. F., Appendix G in Bowe Albertson and Walsh, ibid.

4. Davidson, P., et al., 1966: The social value of water recreation facilities resulting from an improvement in water quality in the Delaware estuary, in Kneese, AV., and S. C. Smith (eds.), Water Research. Baltimore, John Hopkins, pp. 175—211.

5. Fair, G. M. and J. C. Geyer, 1954: Water supply and waste-water disposal. Wiley.

6. Flood, F. J., 1968: Water pollution control program, Nassau County, Dept. of Health, Mineola, N. Y., mimeo.

7. Flynn, J. M., and C. G. Lind, 1962: Report on need and feasibility for public sewage disposal facilities in Western Suffolk, Office of the Suffolk County Executive, Suffolk County, N. Y.

8. —, et al., 1963: Long Island ground water pollution study, Report for the temporary New York State Water Resources Planning Commission, mimeo.

9. Hempstead Department of Conservation and Waterways, 1968: Water Quality Study, Hempstead Bay Estuary—1968, Point Lookout, N. Y.

10. Nassau County Department of Health, 1968: Nassau County, South Shore Bay Study—1968, Mineola, N. Y.

11. New York State Conservation Department, 1968: Hempstead Bay Shellfish Growing Area I, Water Quality Survey Report, Division of Fish and Game, Ronkonkoma, L. I., N. Y.

12. New York State Department of Health, 1968: Classifications and standards of quality and purity for waters of New York State, Albany, N. Y.

13. New York State Department of Health, 1951: Classifications and standards of quality and purity for fresh surface waters and tidal salt waters within the Moriches Bay Drainage Basin in Suffolk County, N. Y., Albany, N. Y., mimeo.

14. New York State Department of Health, 1953: Classifications and standards of quality and purity for fresh surface waters and tidal salt waters within the Peconic River—Flanders Bay Drainage Basin in Suffolk County, N. Y., Albany, N. Y., mimeo.

15. New York State Department of Health, 1965: Surface waters of Western Suffolk County, Official Classifications, Albany, N. Y.

16. New York State Department of Health, 1965: Surface waters of Nassau County, Official Classifications, Albany, N. Y.

17. Suffolk County Department of Health, 1968: Annual Report—1968, Suffolk County, N. Y.

18. U. S. Dept. of Interior, FWPCA, Federal water pollution control act, Oil pollution control act, Washington, D. C., undated.

19. U. S. Dept. of Interior, FWPCA,1966: Proceedings, conferences in the matter of pollution of the navigable waters of Moriches Bay and the Eastern Section of Great South Bay and their tributaries, September.

20. U.S. Dept. of Interior, FWPCA, 1967: Proceedings, conferences in the matter of pollution of the navigable waters of Moriches Bay and the Eastern Section of Great South Bay and their tributaries, Second Session, June.

21. U. S. Dept. of Interior, FWPCA, 1968: Report of the Committee on Water Quality Criteria, Washington, D. C.

22. Willeke, G. E., 1968: Effects of water pollution in San Francisco Bay, Report EEP-29, Project on Engineering-Economic Planning, Stanford Univ., Stanford, Calif., October.

WASTEWATER FROM VESSELS

Introduction

Commercial and pleasure boating in coastal waters can give rise to at least three types of waste disposal problems, including oil and gas pollution, general littering from overboard trash disposal, and sanitary wastewater discharges. Of the three, oil and gas wastes are discussed below in the essay on Oil Pollution, while sanitary wastewater disposal from vessels constitutes the principal topic for present discussion.

Sanitary wastes originating on vessels generally receive low volumes of flushing water and, as a consequence, the effluent concentration of coliform bacteria and other water quality indicators may be very high compared to sanitary wastes originating in households. However, the magnitude of the waste load originating in a single vessel is usually negligibly small when considered in isolation and in comparison to the volume of receiving waters. The extent to which wastewater from vessels noticeably affects water quality depends on the quantity of waste originating from all vessels over a particular time period in a particular area, the ability of the watercourse to assimilate wastes, and the policies governing disposal (including the extent of treatment and location of discharge).

Affected environmental characteristics of special significance are similar to those of domestic wastewaters, including the concentration of disease-causing microorganisms (as measured by coliform bacteria*), dissolved oxygen and nutrients. The activities potentially affected by changes in these characteristics include the complete gamut of water-based activities mentioned above in the section on Domestic and Industrial Wastewater Disposal. Activities of special importance, however, include shellfishing and water contact sports; both these classes of activities are sensitive to changes in the level of coliform concentration. (Note that shellfish, or "filter feeders," concentrate "microorganisms and microparticles of organic detritus from large volumes of water" [7]. Those affected by waste discharges from vessels naturally include individuals engaging in water contact sports and shellfishing. Also, insofar as

*Coliform bacteria concentrations are commonly employed as a surrogate for other enteric, disease-causing microorganisms.

the deterioration of water quality is aesthetically unappealing, the users of boats may themselves be affected.

Evaluation of Problem

The number of pleasure boats in the waters off Nassau and Suffolk Counties (including inboard and outboard motor boats and sail boats) was estimated as 175,000 in 1965 [4, p. 3-34]. The number of boats used for commercial shellfishing is probably a very small fraction of the number of pleasure boats [7, p. 3]. Foehrenbach [1] has reported that in Great South Bay water quality is degraded by waste originating on pleasure boats. Udell [7] conducted studies to determine the effects of wastewaters discharged from small boats off Long Island. His study involved water quality sampling in Huntington Harbor on the north shore, and in several creeks and bays on the south shore. The water quality parameter of primary interest was coliform bacteria since, as noted above, this parameter is of special significance with respect to water contact sports and shellfishing. The study yielded evidence of increased coliform concentrations caused by discharges from pleasure boats. However, the increases were not sufficient to cause violations of water quality standards for bathing and shellfishing water [7, p. 2]. Depressed dissolved oxygen levels caused by boat wastes were not observed. The study concluded that "pollution levels, as determined by bacterial densities, vary directly with the levels of boating activity and boat populations." Also, the importance of factors such as tidal flushing and precipitation in influencing the impact of wastewater discharge on the environment was stressed.

Public Policy Background

Problems relating to boat wastes have received attention at both the state and federal level. Recently (1969) the New York State Conservation Commission issued an order establishing standards for acceptable marine toilet facilities [5]. The types of marine toilets acceptable under this order are: sewage retention assemblies, sewage recirculating assemblies, and sewage incinerating assemblies. Detailed standards prescribed for each of the three systems are given in reports of the Yacht Safety Bureau, Inc. [8, 9, 10]. One requirement common to all systems is that "there shall be no provisions for direct or indirect overboard discharge of sewage" [9, p. 9].

Sewage from incineration units would be burned to a dry ash with a low volume relative to the original waste. Sewage from systems using holding tanks would be pumped out at a dockside facility and eventually transported to a wastewater treatment plant. Groups of boat owners have questioned the willingness of marine operators to provide dockside pump-out facilities [6]. They have also been concerned over the omission of macerator/chlorinator from the list of acceptable treatment systems [6]. The New York State Departments of Conservation and Health plan to cooperate in enforcing the regulations governing marine sewage disposal to be effective March 1, 1970. These state agencies plan an extensive public information program to alert boat owners of the recently adopted regulations [3]. It should also be noted that the Federal government has considered issuing legislation controlling boat wastes, since variations in regulations for different states would hamper interstate boat movement [2].

Indicated Information Needs

Regulations prohibiting the direct or indirect discharge of sewage from vessels are a matter of record. The substantive information requirements at this point relate to the extent to which these regulations can and will be enforced. Strictly for completeness, we observe that the sorts of information that would be useful in establishing policies for dealing with boat wastes are similar to the information needs discussed above (pp. 52—54), in the section on Domestic and Industrial Wastewater.

Selected References

1. Foehrenbach, J., 1969: Pollution and eutrophication problems of Great South Bay, Long Island, New York. J. Water Pollution Polution Control Fed., Vol. 41, No. 8, Part 1, August, pp. 1456—1464.

2. League of Women Voters of the U.S., 1969: Water resources current review, No. 5, Washington, D.C., February.

3. O'Brien, J. J., Director, Division of Motor Boats, State Conservation Department, Albany, N. Y. Personal communication, September 1969.

4. Oceanographic Committee of the Nassau-Suffolk Regional Planning Board, 1966: The status and potential of the marine environment, December.

5. State of New York, Conservation Department, 1969: Order establishing rules and regulations of the Conservation Department, relating to standards of safety for marine toilets, Albany, N. Y.

6. Suydam, J., President, National Party Boat Owners Alliance, Inc. Personal communication, December 1968.

7. Udell, H. F. (undated): Pollution effect on marine waters from wastes discharged by small boats. New York State Department of Health.

8. Yacht Safety Bureau, Inc., 1969: Requirements for marine retention assemblies for sewage. YSB Standard E-45 (Tentative), Westwood, New Jersey, April.

9. —, 1969: Requirements for marine recirculating assemblies for human waste. YSB Standard E-49 (Tentative), Westwood, New Jersey, April.

10. —, 1968: Requirements for marine sewage incinerating devices. YSB Standard E-52, Westwood, New Jersey, June.

WASTEWATER FROM DUCK FARMS

Introduction

Duck farming, as traditionally practiced on Long Island, involves the use of holding pens that provide ducks access to both land and water. The quantity of water used varies between 14 and 120 gallons per day (gpd) for each duck [6, p. 28], but there are indications that quantities as low as 10 gpd per duck are satisfactory [6, p. 395]. Duck wastes can enter surface water directly or they can be washed into surface water by rainfall. Untreated (raw) wastewater from duck farms generally contains substantial quantities of suspended solids, BOD,* coliform organisms, and compounds of phorphorous and nitrogen. The extent to which duck wastes influence the quality of marine waters depends on the size of individual farms, the characteristics of the raw waste, the extent of wastewater treatment, the location of waste discharges, and the characteristics of the receiving waters.

In considering the size of individual farms, it should be observed that the number of ducks present at any given time will be much lower than the total number of ducks processed in a year. This follows because the average duck life is only two months [3 p. 3—33] while the season for duck farming on Long Island is about 9 months [6, p. 29]. Available treatment techniques for duck wastes include the use of aerated lagoons for removing suspended solids and BOD, chemical precipitation for removing phosphates, and chlorination for reducing coliform concentrations [6, p. 393]. The effects of the locations of discharges and the characteristics of receiving waters are similar to effects for domestic and industrial wastes (discussed above).

Duck wastes can interfere directly with shellfishing and water contact sports by raising the coliform concentrations of marine waters above acceptable levels. Duck wastes also have an indirect influence in that increases in the levels of phosphorous and nitrogen compounds in marine waters can lead to increased growth of aquatic plants.

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*Coliform bacteria concentrations are commonly employed as a surrogate measure for disease-causing microorganisms. BOD, or biochemical oxygen demand, is a measure of the quantity of free oxygen required to biologically oxidize (decompose) the organic material in a unit volume of wastewater.

The latter can interfere with the complete gamut of water based activities, including shellfishing, boating, and water contact sports. In addition, excessive growths of aquatic plants is considered aesthetically unappealing.

When duck wastes are discharged without treatment to remove suspended solids, the resulting influence on the marine environment can be quite striking. Turbidity levels are raised at the point of discharge and organic solids ultimately settle out to form sludge blankets which can alter drastically the composition of the bottom. In extreme cases, the oxygen levels at the bottom of the receiving water can be depleted in the process of stabilizing the organic material in the sludge blanket. Further stablization in the absence of oxygen often yields hydrogen sulfide gas with its offensive odor [6, p. 45]. Sludge blankets can be removed by dredging.

Evaluation of Problem

Lands adjacent to Bellport, Moriches and Patchogue Bays in Suffolk County are major areas for duck production. In 1965 the annual production in this region was on the order of 6 million ducks (6, p. 29]. The effects of duck farm waste has been a significant issue since 1949 when state legislation to abate pollution from duck farms was passed. Of the total of thirty-two farms in Suffolk County at the end of 1968, twenty-seven had installed and operated aerated lagoon-chlorination facilities, four were using "dry operations," and one had installed a spray irrigation system [5, p. 63]. Waste treatment methods for phosphate removal are being studied by the duck industry. It is noteworthy that eleven duck farms went out of business during 1968 [5, p. 63].

During the last two decades, duck wastes have been cited as the cause of significant alterations in the coastal waters off Suffolk County. Two Federal enforcement conferences dealing with pollution in Great South Bay and Moriches Bay have emphasized the deleterious influence of duck wastes through suspended solids, BOD, coliforms, nutrients, and sludge deposits. These changes have resulted in interference with shellfishing and bathing [6, p. 7]. The effects of extensive fertilization of Great South Bay from duck manure, combined with low flushing rates, have been cited by Odum [4, pp. 96, 97] as the cause of the elimination of the "blue point" oyster industry from the area. Foehrenback [1] has indicated that poor operations of treatment facilities for duck wastes justifies skepticism regarding the rate at which duck wastes will cease to be a problem in Great South Bay.

Issues of special importance concern the influence of sludge blankets, formed by incompletely treated duck wastes, and the impact of programs to remove these sludge blankets. Hennigan (7, pp. 48—52] reported that duck sludge in the Moriches Bay—Great South Bay area has caused interference with shellfishing and bathing, and also represents a significant source of nutrient addition. Dredging programs to remove duck sludge have been carried out; in one instance, however, the resulting spoil was disposed of on Fire Island Wetlands causing the disposal area to become "unuseable for an indefinite time in the future" [7, p. 50]. It should be noted that the second Federal enforcement conference for the Moriches Bay—Great South Bay region recommended that no dredged duck wastes be disposed of on wetlands or in adjacent waters. Also, except under special circumstances, such spoil is to be disposed of in the Atlantic at a point at least 1-1/2 miles from Moriches Inlet [7, p. 133].

Public Policy Background

There are several public agencies and private groups involved in the effort to control waste discharges from duck farms. The Federal Water Pollution Control Administration has held two enforcement conferences dealing with pollution in the Great South Bay—Moriches Bay area; these conferences have focused considerable attention on the influence of duck wastes on alternative uses of the coastal waters. The New York State Department of Health has issued formal orders to all duck farmers requiring that they "cease and abate . . . all discharges of duck wastes . . ." [6, p. 179]. The Suffolk County Health Department is responsible for the inspection of waste treatment facilities on duck farms [6, p. 104]. Individual duck farmers, organized as the Long Island Duck Farmers Cooperative, Inc., have sponsored a number of research studies to determine effective methods for treating duck wastes. In this connection, note that Suffolk County, the State Health Department [6, p. 179], and Cornell University [2] have, on different occasions, participated in programs to develop effective techniques for dealing with duck wastes.

Indicated Information Needs

The information needed for devising policies to deal with duck wastes are essentially similar to those items noted earlier in the section on Domestic and Industrial Wastewater Disposal. The key issues relate to the way the constituents of the wastewater are distributed in the receiving water, and the way other human activities are influenced by these changes in the receiving water. In connection with the duck waste problem, two items deserving special consideration include the effectiveness of duck waste treatment processes, and the removal of sludge blankets formed in the vicinity of duck waste discharges. Both these issues have been dealt with to some degree by participants in the Federal enforcement conferences cited earlier. However, more definitive information concerning both issues would be helpful in establishing policies in the future.

Selected References

1. Foehrenbach, J., 1969: Pollution and eutrophication problems of Great South Bay. Long Island, New York. J. of Water Pollution Control Fed.. Vol. 41. No. 8, Part 1, August, pp. 1456—1464.

2. Long Island Duck Farmers Cooperative, Inc., 1965: A study of the pollution control efforts in Suffolk County, New York, as it pertains to the Long Island duck industry, Eastport. Long Island, N. Y.

3. Oceanographic Committee of the Nassau-Suffolk Regional Planning Board. 1966: The status and potential of the marine environment, December.

4. Odum, E. P., 1967: Fundamentals of ecology, second edition. W. B. Saunders and Co., Philadelphia, Pa.

5. Suffolk County Department of Health, 1968: Annual report—1968. Suffolk County, N. Y.

6. U.S. Department of Interior, Federal Water Pollution Control Administration, 1966: Proceedings, Conference in the matter of pollution of the navigable waters of Moriches Bay and the Eastern Section of Great South Bay and their Tributaries. Patchogue, N. Y., September.

7. —, 1967: Proceedings, Conference in the Matter of Pollution of the Navigable Waters of Moriches Bay and the Eastern Section of Great South Bay and their Tributaries, Second Session. Patchogue, N. Y., June.

SOLID WASTE DISPOSAL

Introduction

As used herein, the term solid waste refers to all the solid material discarded (and considered no longer useable) by individual households, commercial, industrial and governmental units. Such materials include garbage (food waste), rubbish, street refuse, demolition debris, construction refuse, abandoned automobile hulks, certain industrial wastes, and sewage treatment residue (sludge). Note that dredging spoil, which is a solid waste in the literal sense of the term, is discussed separately in the section on Dredging and Dredging-Spoil Disposal.

On Long Island, the disposal of solid waste is accomplished using incinerators and sanitary landfills. In a landfill, wastes are covered regularly with a layer of soil for reasons of public health, safety and aesthetics. Incinerators are used to reduce the volume of wastes by seventy to eighty percent; the residual waste (incinerator ash) is buried in landfill. Since sanitary landfills occupy large land areas, the extent to which incineration is used to reduce the need for landfills is greatly influenced by land costs.

The commonly used methods of solid waste disposal on Long Island have only indirect effects on the marine environment. One effect is the deterioration of ground (or surface) water quality caused by the leachate from landfills. Another effect is the water quality deterioration caused by the discharge of quench water and wet-scrubber effluents from incinerators. The influence of solid waste disposal on the marine environment is direct under circumstances (not widespread on Long Island now) where wetlands are used as sites for landfills, or where wastes such as incinerator ash and construction rubble are disposed of directly at sea.

Evaluation of Problem

The following discussion emphasizes those aspects of disposal that influence the coastal region. Nassau County has a total of 11 landfills involving 197 acres of remaining land; Suffolk County has 23 landfills with 437 acres of remaining land [7, p. 40]. The primary water-related problem associated with these landfills relates to the leaching of material from the disposal sites to surface and ground water.

While no specific data relating to the Nassau-Suffolk region are available, studies of pollution from runoff [1, p. 61] imply that leachates from sanitary landfills may have substantial concentrations of BOD, COD* and coliform organisms. Baffa [3, p. 19], in a study of solid waste problems in Suffolk County, has reported that leachate from incinerator residue fill can contain phenols and water-soluble organic compounds. Baffa has also observed that under Long Island conditions "proper drainage and sealing of landfill surfaces can prevent or minimize leachate" [3, p. 19]. Since the extent of contamination by leaching is not known, it is impossible to indicate the extent to which this factor is influencing activities in the coastal zone.

There are 29 incinerators in the bicounty region; Nassau County has an incinerator capacity of 3,680 tons per day, and Suffolk County has a capacity of 1,800 tons per day [7, p. 38]. The single most significant environmental problem associated with incinerators is the deterioration of air quality resulting from incinerator stack-gas emissions. Concerning the coastal zone, the key issues relate to leachates from incinerator residue fill (noted above), and the disposal of waterwaste effluents resulting from quenching and stack-gas scrubbing operations. In Suffolk County the discharge of such effluents into the ground constitutes a potential problem with respect to phenols which can result in taste and odor in water supplies [3, p. 18]. The extent to which these effluents are interfering with activities in the coastal zone is not known.

In addition to the impacts of incinerators and upland landfills, the coastal zone may be affected by the utilization of wetlands for landfill sites. Up to now, wetlands have been destroyed primarily for real estate developments and dredging spoil disposal [10, p. 9]. However, there is some concern that wetlands will be considered increasingly for solid waste disposal sites as upland landfills become saturated. The consequences of wetland destruction have been discussed in the section on Wetlands.

Another activity having direct influence on the marine environment is the direct discharge of solid wastes to the ocean. In a preliminary report, Gross [5, p. 5]

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*COD, or chemical oxygen demand, is a measure of the oxygen consumed in the chemical oxidation of organic materials in a unit volume of wastewater.

has indicated that the Corps of Engineers has designated 13 waste disposal sites in Long Island Sound for dumping dredging spoil and for disposing of wastes from New York City during bad weather. Solid wastes disposed of in this manner typically include ash from coal-burning steam-generating plants, construction rubble, and industrial wastes or defective products [5, p. 3]; however, Gross has observed that there is little information available on the specific physical and chemical composition of waste solids dumped in the ocean [5, p. 4].

Because of the expected decreases in available landfill areas, both Nassau and Suffolk Counties will have to make changes in their solid waste disposal practices. It has been estimated that by 1985 most of the existing landfills will be saturated in Nassau County and western Suffolk County [7, p. 40]. Future requirements for landfill areas can be decreased by increasing the extent of waste volume reduction. In addition to factors like changes in population growth and packaging practices, land area requirements can be influenced significantly by [3, 26]:

Crushing or shredding bulky material,
Compaction (or super-compaction) in landfills,
High-pressure baling, and
Incineration with subsequent compaction of ash.

In addition to the items listed above, the following approaches have been mentioned as possible for the Long Island area:

- The use of sand and gravel pits for landfill sites. After landfilling, the land can be used for such purposes as community parks, golf courses and ski slopes [3, p. 21].*
- Long distance rail transportation of wastes to abandoned strip mines [6, p. 6].
- The use of compaction facilities in conjunction with the building of offshore land masses for public and private purposes [7, p. 42].

*Difficulties can be encountered from materials that remain soft for many years; and there may also be a need for rodent control [3, p. 20].

- Disposal of compacted refuse or incinerator residue in the Atlantic Ocean [7, p. 6].
- Use of an incinerator ship in which solid wastes are burned on the way out to sea; residue is discharged to the ocean [6, p. 6].

Clearly, the last three items might significantly affect the state of the coastal environment. Determining the impacts of such disposal methods on the coastal environment appears a fruitful area of continued investigation. It may be noted that a joint research project involving Harvard's School of Public Health and the University of Rhode Island's Graduate School of Oceanography has studied the environmental impacts associated with the last item. There are indications that the report from this research project, which has been in progress for the past five years, will provide ample information to evaluate the benefits and disbenefits associated with the use of incinerator ships [8].

An additional aspect of the solid waste disposal issue relates to the recycling of solids for productive uses. In a study for Suffolk County, Baffa [3, p. 12] has suggested that current possibilities for reuse include metal salvage at landfills and the use of heat from refuse incinerators for power generation. Future possibilities exist in the manufacture of fertilizer, charcoal briquets, hardboard and building blocks. As mentioned above, solid wastes can be used effectively in programs for land reclamation. One practical illustration is the construction of artificial reefs off the south shore of Long Island to increase fishing opportunities; the reefs were constructed using discarded automobile bodies and tires, construction rubble, and concrete [4].

Public Policy Background

The primary Federal activity in solid waste disposal is defined by Public Law 89-272, the Solid Waste Disposal Act of 1965. This Act is administered by the Bureau of Solid Waste Management, a part of the recently created Consumer Protection and Environmental Health Service [2]. A substantial portion of the budget of the Bureau of Solid Waste Management goes for demonstration grants to develop improved methods for collection, reuse, and disposal of solid wastes. Another Federal agency involved in solid wastes disposal is the Department of Housing and Urban Development (HUD); under the 701 Grants program, HUD awards grants to communities for planning solid waste disposal systems.

The New York State Public Health Law vests authority in the State Commissioner of Health to make Grants in Aid for financial studies relating to refuse collection and disposal. The Public Health Law also prohibits open dumps and open burning at disposal sites. The Nassau and Suffolk County Health Departments administer state regulations regarding refuse disposal as they relate to air and water pollution control. County health department personnel inspect refuse disposal facilities to determine compliance with the State Sanitary Code [6, p. 3; 9, p. 67]. In both Nassau and Suffolk Counties the operation of both landfills and incinerators is carried out under the auspices of individual towns, cities, and incorporated villages.

Indicated Information Needs

Needs may be summarized in the form of the following questions:

- What are the quantities and qualities of leachates from landfills? Do any leachates ultimately influence the quality of coastal waters?
- What are the quantities, qualities and ultimate disposal sites for stack-gas scrubber effluents and quench water? What environmental conditions and marine activities are influenced by these effluents? (Note that Baffa [3, p. 29] has suggested the need for monitoring these effluents and investigating the means for their reduction and treatment before discharge.)
- What special difficulties are associated with the use of wetlands as landfill sites?
- What are the physical, chemical, and biological impacts associated with the disposal of different forms of solid waste at sea (e.g., incinerator ash, construction rubble, etc.)?
- How would coastal activities be influenced by the use of incinerator ships?
- What additional possibilities exist for the reuse of solid wastes?
- What are the costs and benefits associated with the alternative solid waste management schemes noted above?

Selected References

1. American Public Works Association, Research Foundation, 1969: Water pollution aspects of urban runoff. FWPCA Publication No. WP-20-15, U.S. Department of the Interior, Washington, D.C.

2. Anonymous, 1969: Bureau attacks nation's solid waste. Env. Sci. and Tech., 3:8, pp. 705—707.

3. Baffa, J. J., et al., 1969(?): An action plan for solid waste disposal in Suffolk County, New York, Vol. I. John J. Baffa, Consulting Engineers, New York, N. Y.

4. Department of Conservation, 1969: Artificial reef sites.

5. Gross, M. G., 1969: New York City—A major source of marine sediment. Tech. Rpt. No. 1 (preliminary draft). Marine Sciences Research Center, State University of New York, Stony Brook, N. Y., June.

6. Mafrici, D., 1967: Solid waste disposal. Programs in Environmental Health, Nassau County Department of Health, Long Island, N. Y.

7. Nassau-Suffolk Regional Planning Board, 1969: Utilities: Inventory and analysis. Hauppauge, Long Island, N. Y.

8. New England Marine Resources Information Program, 1969: New England marine resources information 2. Pell Marine Science Library, Narragansett, R. I., June—July.

9. Suffolk County Department of Health, 1969: Annual Report 1968. Long Island, N. Y.

10. U.S. Department of Interior, Fish and Wildlife Services, 1965: A supplementary report on the coastal wetlands inventory of Long Island, New York. Boston, Mass.

THERMAL POLLUTION

Introduction

The discharge of heated industrial wastewaters into natural waterbodies can produce a wide variety of environmental effects of potential significance for a diversity of water related activities. The fact that the terms "thermal pollution" and "thermal enrichment" have both been applied to the general phenomenon of aquatic temperature additions indicates that the social implications are not clear-cut, and that they may involve both adverse and beneficial aspects.

Heated effluents may originate in any number of industrial processing and cooling water applications. However, because they produce the largest concentrated volumes of heated discharges, steam-electric generating stations easily constitute the most significant source of potential thermal effects on Long Island as elsewhere. This is essentially due to three basic characteristics of the steam-electric plant: the low "thermal efficiency" of basic steam-cycle technology*; the large size of modern generating stations; and reliance on water as the condenser cooling medium. Of the existing and potential alternative technologies for electricity generation, none is presently competitive with steam as a source of base-load power supply, and none appears likely to supplant steam in the foreseeable future [2, pp. 32—35].

The volume and temperature of the effluent, together with its outfall location, are the basic causal variables that initially determine its environmental impact. Depending on locational factors affecting generating costs, contemporary condensers may be designed for a temperature rise in the cooling water of anywhere from 10° to 30° Fahrenheit. Thus, depending on condenser design, a plant of given size and given total waste heat load could discharge a relatively large volume of water heated to a low temperature or a much smaller volume heated to a higher temperature.+

* "Thermal efficiency" relates to the proportion of total fuel energy actually transformed into electric energy. The most efficient fossil-fueled (gas, oil, coal) plants currently approach 40% thermal efficiency, which means that 60% or more of the fuel energy results in residual (waste) heat energy, most of which is "disposed of" in the condenser water effluent. At the present state of technology, nuclear fueled units average about 50% greater condenser heat discharge per kilowatt than fossil-fueled plants.

For a technical discussion of the basic physics, technology, and economics of steam-electric power generation, see reference [3].

+ Rough estimates of heated water discharged from a plant operating at 38% thermal efficiency are: 56,000 gallons per hour per megawatt at a 10° rise or 18,000 gallons per hour at a 30° rise in temperature.

For purposes of discussion, possible environmental effects of thermal discharges may be grouped into four broad categories:

- Temperature changes in the receiving water body,
- Other physical and chemical changes in the receiving water, such as dissolved oxygen levels and changes in chemical reaction rates,
- Increases in atmospheric moisture and temperature resulting from evaporative heat exchange at the water surface, and
- Biological responses to changes in the aquatic habitat, including temperature and other physical and chemical changes.

It should be emphasized that the social implications of any particular environmental change should be evaluated in terms of both the local intensity and the geographical extent of the change in question.

The pattern of aquatic temperature increase is both the basic determinant of other environmental effects and the source of potential social effects on temperature-sensitive activities (such as water-contact sports and cooling water uses). The temperature change will obviously be greatest at the point of effluent discharge, where the environmental temperature essentially becomes that of the effluent (10° to 30° F. warmer). Beyond this point, the assimilative and dissipative capacity of the water body both moderates the temperature differentials and limits their maximum areal extent through a complete combination of physical mixing, surface stratification, and atmospheric heat transfer processes.*

Since many of these factors are subject to significant seasonal, diurnal and other periodic and random variations, the configuration of the effluent "plume" will typically be subject to continual shifting. This is especially true of sea coast and estuarine locations where tidal variations are a dominant factor. In general, it may be observed that the aquatic heat dispersion and atmospheric transfer capacities of

*The relative strengths of these interrelated physical processes depend on a large number of local environmental characteristics, among the most important being: the volume, depth, turbulence, and pattern of currents of the water body, and the temperature, wind velocity and humidity of the surface atmosphere. For further discussion and references to the literature on these processes, see [2, pp. 39-69].

coastal waters are substantial, with the result that significant observed temperature differentials seldom extend more than a few hundred or a few thousand feet from the discharge point at observed sites where measured.

The indirect atmospheric effects (humidity and fogging) and the aquatic chemistry effects of thermal discharges are, for the most part, not well documented. However, one aspect of widespread concern, on which recent field studies have shed considerable light, is the reduction of dissolved oxygen in heated waters. Empirical evidence from West Coast studies indicates no measurable reductions in dissolved oxygen, either in effluent discharge canals or in the immediate outfall vicinity [1]. A study recently undertaken by the Atmospheric Sciences Research Center of the State University of New York will examine the incidence of fog and icing conditions in relation to thermal additions in the New York City Metropolitan region [14].

The principal concern for thermal effects in Long Island waters relates to the possibility of adverse biological responses of importance to commercial and recreational fisheries. Basic biological functions of respiration, growth, survival, and reproduction are all subject to thermal influences; directly, indirectly, and in combination with other life-influencing environmental conditions. Evolution has adapted the life-cycle stages of virtually all aquatic species in any given habitat to a relatively narrow range of seasonal and shorter-term temperature variations. However, in any given habitat, certain species may be existing at the lower margin of this range while others are closer to the upper limit of tolerance during one or more life cycle stages. Thus, certain species may benefit while others may be seriously or fatally affected by even modest increases in temperatures.

Biological responses for any regional or sub-regional location will depend so much on specific local conditions that any general predictions are hazardous, especially because we are dealing, for the most part, with relatively small temperature differentials that are seldom beyond the natural variations experienced by a species over its normal habitat range. Thus many effects are likely to be relatively subtle and of a long-term nature, rather than immediate and dramatic.

Social and economic activities affected by biological changes can include potentially the whole range of coastal commercial and sport fisheries, in addition to the general conservation and aesthetic implications of biological change. Water contact sports might also be influenced by possible changes in nuisance or harmful species. As indicated above, an extremely large variety of complex biological changes are possible, ranging from minor seasonal or average annual shifts in population balances to the creation of entirely different local ecological communities. Predictive evaluation of social effects is further complicated by the fact that different interests may be affected in opposite ways—certain species of commercial or recreational importance may be increased while others are simultaneously decreased—and as a result there may well be conflicting interests among potential gainers and losers from thermal impacts. This can have important policy implications regarding whether and to what extent to control thermal waste disposal.

Evaluation of Problem

There are four major steam-electric stations presently operating within the Nassau-Suffolk region. All are fossil-fueled and all are operated by the Long Island Lighting Co. They vary in size from roughly 375 to 760 megawatt capacities and would be classed in the small-to-medium category by modern standards of comparison.* Of these, the three largest are located on the north shore (Glenwood Landing, Northport and Port Jefferson) and one is located at Island Park on the south shore (the E. F. Barrett Station) [4, 11].

We have found no concrete evidence to indicate significant thermal effects for any of these plants up to the present. In interviews, professional fisheries' biologists have expressed the opinion that ecological effects have been either indeterminable or negligible. However, experience at the Northport Station (the largest, at 760 mw) has been extremely brief: the first unit has been operating only since 1967 and the second unit for an even shorter time. The discharge water at this plant is relatively warm—about 24° warmer than the L. I. Sound receiving waters. The New York State Bureau of Marine Fisheries has just begun a field study of water temperature effects in the vicinity of the Northport plant, and the Long Island Lighting Co. has also retained

*In 1966, there were 15 fossil-fueled stations in the U. S. with capacities in excess of 1200 megawatts, ranging up to 2000 megawatts [5, p. xxi].

a consulting biologist to evaluate possible ecological changes in this region. At the time of this writing, however, findings are not available.*

Regarding the near future, much discussion has centered on the announced construction of Long Island's first nuclear-fueled generating facility at Shoreham, presently scheduled for startup about 1975 [8, 9]. Designed as an 820-megawatt facility, this would probably carry an approximately 60 percent greater condenser heat rejection load than the 760-megawatt Shoreham fossil-fueled station.†

Although this would represent a substantial increase in total heat discharge in comparison with existing Long Island experience, there are several much larger stations currently operating elsewhere in the U. S. Further, even by Long Island regional experience, this would not necessarily imply a significantly different intensity of thermal effects, or even significant differences in the kinds of effects produced. Although the total heat load is larger, the precise effluent temperature differential is not known at this time, but it could easily be less than the 24°F, reported for the Northport facility. Total effluent volume, however, would necessarily be larger, and this would tend to extend the area of whatever effects are produced.

For the more distant future, it seems apparent that thermal effects issues will become increasingly important. National projections of both the Federal Power Commission and private utility groups foresee a continual growth in electricity generation and capacity expansion on the order of a 100 percent increase each decade for the remainder of the century. Assuming Long Island capacity expansion were no greater than these national average projections, this would mean an eightfold expansion by the year 2000. Combined with the trend toward larger plant sizes, these projections imply a significantly larger number of larger sized generating stations.

Should control of thermal discharges become necessary, there exist a wide variety of technically feasible alternatives for management consideration. Among

*The experimental work relating to seed oyster production in the effluent discharge channel (not a part of the natural coastal waters) of the Northport Station has been discussed in the section on shellfish. If successful, this pilot project may be taken as prima facie evidence that at least some species may be benefiting from the warmer water in the vicinity of the plant discharge.

† This is an engineering calculation based on a general knowledge of current design practice and the reported plant capacities.

these are the following:

- Planned location and size of new generating units,
- Alterations in condenser designs to manipulate effluent temperature,
- The piping of effluent to alternative discharge points (single or multiple) where effects will be less severe, and
- Recycling part or all of the condenser effluent through cooling towers or cooling ponds, prior either to reuse or discharge.

Any of these alternatives can involve substantial additions to the cost of power generation that could be expected to be passed on to electricity users in the form of higher prices. Evaporative type cooling towers, for example, would add from 3 to 12 percent to the cost of generation.* For a large generating station, this would amount to many hundreds of thousands of dollars in additional annual costs. Before costs of this magnitude are imposed arbitrarily, it is essential that decision-makers have the soundest possible basis for evaluating the environmental and social values to be preserved by such decisions.

Public Policy Background

In general, the public regulation of thermal discharges into Long Island waters is subject at state and Federal levels to the same statutory authority and administrative agencies as other aspects of pollution control discussed previously in the section on domestic and industrial wastewater disposal. Basic responsibility resides in the Bureau of Water Quality Management of the New York State Department of Health, and basic policy has been established under the system of "best usage" regional water classification. Specific water temperature criteria were recently announced, under which future decisions on allowable temperature changes will presumably be based. These criteria have been summarized as follows:

* For a more detailed discussion of control technologies and the derivation of these cost estimates, see [2, pp. 116—123, and p. 135]. To our knowledge cooling towers have not yet been constructed for salt water operating conditions. This could pose technological development requirements and would almost certainly increase capital and maintenance costs.

Coastal Waters—no increase of more than 4° in surface temperatures over monthly high average during October-June, nor more than 1.5° during July-September beyond radius of 300 feet or equivalent area.

Estuaries—no increase beyond 90° surface temperature at any single point; in addition, at least 50% of volume of estuary flow, including at least one-third surface water, may not be raised more than 4° or to maximum of 83°, whichever is less; during July-September, if surface temperatures exceed 83°, increase of not more than 1.5° will be permitted at any given point. Because Long Island Sound and its bays can be considered either coastal or estuarine waters, criteria for discharges into them will be established on basis of site and "best usage" classification already assigned to them [12].

Regarding coastal waters—presumably including primarily southshore Long Island waters—the criteria appear quite conservative and could well be sufficient in themselves, if rigidly adhered to, to prohibit effectively the construction of larger steam electric plants with conventional heat disposal systems. Deep water disposal at a considerable distance off-shore might, however, constitute a feasible alternative. Regarding Long Island Sound waters (the major portions of which are presently classified in the "higher" water use classes), it appears that decisions will be made on a case-by-case basis. The determining factor in these waters will apparently be the potential effects on shellfish and other marine organisms. It is not clear at this time, however, precisely who will be responsible for providing the information or what specific criteria will be used in arriving at judgments regarding adverse effects on marine life, but presumably the N. Y. State Conservation Department will have an important role in this regard.

It may be noted that the State Health Commissioner retains certain discretionary powers to apply more severe limitations or to authorize conditional exceptions to temperature standards where "best usage" is not adversely affected. This provides a necessary flexibility to the authorities in dealing with particular cases.

Indicated Information Needs

It should be evident from our discussion that there are a number of poorly understood issues related to the aquatic disposal of heated effluents. Among the most obvious are those relating to environmental effects, both physical and biological.

One fundamental area requiring clarification is systematic empirical data on the three-dimensional temperature profile of the Northport discharge region (under various seasonal, atmospheric and tidal conditions) in order to establish precisely the boundaries and intensities of the direct physical temperature effects. This would not only shed some light on what to expect at Shoreham, but it is also basic to any ecological analysis at Northport itself.

As generating stations become larger and more numerous, there will be an increased need to be able to predict in advance both the physical and ecological effects. In this regard, much basic scientific work remains to be done in the design and testing of predictive models. Mathematical modeling of physical temperature effects appears both inherently simpler and much further advanced than predictive techniques relating responses of biological systems. However, there is considerable room, even here, for advance in basic science and in applications to explicitly defined Long Island conditions.

Systematic inquiry also is warranted into the specific kinds of biological responses of Long Island species, including representatives of all plant and animal phyla at various life-cycle stages. This should involve not only a comprehensive literature search but also laboratory and field studies relating to local species. Especially relevant here is field work in the Northport environs to determine what, if any, biological changes can be attributed to this "experiment." Similarly, it is not too early to begin systematic study of the ecology of the Shoreham area to accumulate background data as a basis for both prediction and future testing of possible effects in that region.

Another area of knowledge relevant to decision making relates to our ability to anticipate and evaluate the effects on various human activities. Among these the most relevant and important would appear to be water-based recreation and commercial and sport fisheries. The former requires knowledge especially of potential reactions of water-contact sports enthusiasts to increased seasonal water temperatures. The latter, of course, depends first on ability to perceive and predict changes in species numbers and compositions. Beyond this, however, it requires knowledge of the preferences and potential reactions of commercial and sporting interests to such known or predicted changes. Without the latter, knowledge of species changes alone is inadequate for either basic policy formulation or specific policy decisions relating to "best usage" of coastal environments.

Selected References

1. Adams, James R., 1969: Thermal power, aquatic life, and kilowatts on the Pacific Coast, paper presented at the American Power Conference Annual Meeting, Chicago, Illinois, April 22—25.

2. Cheney, P. B., F. A. Smith, et al., 1969: A systems analysis of aquatic thermal pollution and its implications. (The Travelers Research Corporation Report 7743-341b, prepared for the National Coal Policy Conference, Inc.), Hartford. The Travelers Research Corp., January.

3. Cootner, Paul H., and G. O. G. Löf, 1966: Water demand for steam electric generation: An economic projection model. Baltimore, The John Hopkins Press for Resources for the Future, Inc.

4. Federal Power Commission, 1966: Principal electric facilities, Northeastern Region.

5. —, 1967: Steam electric plant construction cost and annual production expenses—1966. Washington, D. C., Federal Power Commission.

6. Gaucher, Thomas A., Thermal enrichment and marine agriculture, Paper presented at the Conference on Marine Agriculture, Oregon State University, Marine Science Center, Newport, Oregon, May 23 and 24, 1968.

7. Long Island Lighting Company, 1967: Annual Report.

8. —, 1965: Atomic power for Long Island.

9. —, 1967: LILCO to aid the oyster industry, LILCO News Bulletin, July 12.

10. —, 1966: The Shoreham Project, April.

11. Nassau-Suffolk Regional Planning Board, 1969: Utilities inventory and Analysis. (Comprehensive Plan Series). Hauppauge, Long Island, N. Y.

12. New York sets up thermal pollution standards based on 'Best Usage' Classification, 1969: Air/Water Pollution Report, p. 263.

13. Raney, Edward C., and Bruce W. Menzel, 1969: Heated effluents and effects on aquatic life with emphasis on fishes: A Bibliography. Washington, D. C.: U. S. Department of the Interior, Office of Water Resources Research, April.

14. Weyl, Peter K., 1968: Text of remarks on thermal pollution, (News release by Office of University Relations, State University of New York, Stony Brook, New York), November 26.

OIL SPILL POLLUTION

Introduction

Oil spill pollution is here defined as the effect of accidental or deliberate release of oil or related products into the natural marine environment. In this context, "oil" means a floating or suspended petroleum product including but not limited to a fuel oil, oil sludge and refuse, and oil mixed with other matter.

While little information is readily available on the sources, risks, and measures available to cope with oil pollution on Long Island, much can be learned from general experience in other locations. Oil may enter the environment from either accidental or deliberate releases. Most accidental releases result from shipping accidents, malfunction of unloading or loading equipment, storage facility leaks or human failure. The danger of oil pollution from these sources is increasing as the number of storage and transfer facilities increases and as ocean transport of oil increases. In the mid-1960's, forty percent of oceangoing traffic was made up of oil tankers, and both the number and average size of these vessels has been increasing [10]. Not a present factor in the Long Island region, but of increasing significance in Gulf and West Coast waters, offshore oil drilling and pumping operations represent another major source of accidental spills and leaks of obviously increasing concern.

A second major category of oil pollution sources is the deliberate release of oil by bilge pumping (i.e., pumping out waste oil and water that collects in the holds of ships), oil and gas emitted from engine exhausts of recreational and commercial boats, fuel jettisioned from airplanes, and industrial waste disposal (e.g., refinery and metal-working wastes). These are generally far less dramatic than the major accidental spills; but, at the same time, they tend to be more continuous, frequent, and widespread in occurrance.

The release of oil into the marine environment can have both dramatic short-term as well as long-term deleterious effects on the ecology of the receiving waters. In the Santa Barbara (California) disaster, reports described a thick black layer of oil that gummed birds, and coated seals, whales, and dolphins[6]. This thick layer also blotted out sun to organisms beneath it. Another effect that was equally injurious and perhaps even longer lasting was the thin, almost transparent oil film that resulted from the oil release. This film can refract light and thereby deprive phytoplankton of the essential sunlight needed to produce energy. Neither the extent nor the longevity of this thin oil film is known. In most oil disasters, the thin film covers an area many times greater than the clearly visible blanket and can seriously disrupt the chain of life [10].

In the case of Torrey Canyon, oil pollution had its worst effect on the rocky breeding grounds of many shellfish as well as on many thousands of seabirds. Finfish outside of the shallowest areas did not appear to be affected by the oil itself, but some were apparently killed by the detergent-treated oil sinking to the bottom, covering their area [8, 10].

Closer to Long Island, in 1967 an oil slick drifted onto a 30-mile stretch of coastline, including recreational beaches, on Cape Cod, Massachusetts. Snails, clams and other marine life were killed and washed ashore; waterfowl and ducks were covered with oil, many drowning due to loss of buoyancy; and, in the wetlands, salt grass turned yellow where it came in contact with the oily surface and then the whole stock died and collected on the water surface [8]. Where the oil came into contact with swimmers, the substance adhered to their skin and hair and was difficult to remove. The air was permeated by a strong odor of petroleum.

Many remedial measures, such as detergents, chemical dispersants and absorbants, used to assist in spill cleanup have themselves produced deleterious effects, contaminating and poisoning shellfish and other species [10].

Effective control of oil pollution can involve a wide variety of management measures and technological methods, relating both to the prevention of spills and other discharges as well as to the minimization of damages once a spill has occurred. In general, prevention requires a systematic appraisal of all relevant factors—production procedures, technological design, environmental influences—on a source by source basis, in order to develop means for reducing the frequency and volumes of potential oil released. For example, reducing the risk of oil pollution from tanker accidents in a particular coastal region could involve any of the following: improved construction and design of tankers; redesign of sea routes and traffic patterns; improved navigational guidance and weather warning systems; imposition of speed or other coastal traffic restrictions, including more rigid standards for officer and crew training; and many others. Similar lists of possibilities could be enumerated for coastal transfer and storage operations, offshore drilling, and other potential sources of accidental or intentional discharges.

Remedial actions for minimizing damages once a spill has occurred include a variety of possibilities relating to "early alert" procedures and contingency plans for containment of the spill, recovery and/or other methods of reducing environmental impacts, and eventual cleanup or repair of damaged property and coastal resources. Both management procedures and technological methods in these areas are in a very early (and largely experimental) stage of development at present. However, it is apparent that much more could be done than at present with the available technology. For example, various types of floating booms are available for containing and accumulating large spills so that they can be recovered by mechanical skimming devices or suction hoses [1]. A considerable amount of research and development effort is being devoted to the formulation of chemical dispersants and oil-cleaning methods [8, 9].

Evaluation of Problem

There is an apparent paucity of readily available information pertinent to current or potential oil pollution problems in the Long Island region, relating either to small-scale, local discharge of petroleum wastes or to possibilities for large-volume spills.

Visual inspection of water surfaces in the vicinity of marinas, docks and harbors typically reveals evidence of surface films of petroleum wastes from engine exhausts and/or bilge-pumping from commercial and pleasure boat traffic. To our knowledge, the significance of this pollution form has not been seriously studied in any detail, although Foehrenbach [3] has alluded to its locally adverse ecological effects in qualitative terms for Great South Bay waters.

Long Island itself, as well as adjacent New York City and Connecticut coastal areas, is a major importer of fuel oil and other petroleum products for home heating, electric power generation, chemical industry processing, and transportation uses. As a result, Nassau and Suffolk Counties not only contain numerous petroleum unloading and storage facilities, but they are also located adjacent to major coastal shipping lanes utilized by large volumes of barge and tanker traffic enroute to other New York and Connecticut destinations.

Complete data on spills from vessels and coastal installations is not readily available to ascertain long-term trends. However, the following summary of known incidents occurred during the brief period of November 1, 1968 to February 22, 1969 [11, pp. 920, 1010, 1011]:

- Bridgeport, Connecticut: 30,000 gallons of No. 4 fuel oil lost during transfer from barge to tank farm; 90 percent of Bridgeport Harbor covered by oil film.
- Albany, New York: 100,000 gallons of slop oil lost from storage tank to Hudson River.
- Providence, Rhode Island: 1,000 gallons of No. 5 fuel oil overflowed from storage tank at U.S. Navy Reserve Training Center, creating slick in Yacht Harbor.
- Block Island, Rhode Island: oil barge accident contaminated beaches from Watch Hill Point to Point Judith.
- Rockaway Point, New York: 4,000 barrels of No. 4 fuel lost from grounding of an oil tanker during heavy storm; largely dispersed by heavy seas.
- Long Island Sound: oil barge grounded on reef; Thames Science Center in New London reported 1,000 birds killed or injured.

None of these represent major spills by comparison with the Torrey Canyon, Ocean Eagle, Cape Cod, or Santa Barbara experiences; however, the list is suggestive of the relative frequency and potential seriousness of the more typical types of oil spill events.

Although a detailed survey of coastal oil handling and storage facilities has not been made, major facilities are known to exist in connection with all five of the principal steam electric generating stations in the immediate Nassau-Suffolk region (Island Park, Far Rockaway, Glenwood Landing, Northport, and Port Jefferson). The Northport facility is unique in that it involves an offshore fuel-unloading platform and underwater pipeline permitting unloading from tankers two miles offshore [4, p.9]. Another public utility, the Northville Dock Corporation, also operates an offshore unloading platform and pipeline (1,000 feet) at Northville, in addition to a major underground transportation pipeline (the first of its kind in the region) from South Setauket to Holtsville [5, p. 47]. Offshore unloading, in both instances, eliminates a significant volume of barge traffic close to shore; and the underground pipeline is said to significantly reduce barge and tanker-truck traffic in the Port Jefferson area. Offshore unloading has also reduced the need for dredging of natural shorelines for docking facilities.

Other areas where possible unloading spills, storage and transfer leaks, or industrial processing losses could affect the Long Island coastline would be the heavily industrialized East River estuary end of Long Island Sound and, possibly, the Lower Hudson River area.

It can be speculated that, at present, the greatest threat of major potential spills lies not on Long Island itself but in the increasingly heavy oil barge and tanker traffic in adjacent coastal shipping routes. This is particularly true in Long Island Sound; but it also applies to the south shore region, especially the western portions close to the lower Hudson and New Jersey Coast traffic routes. Heavy traffic in general cargo enhances possibilities for collison, in addition to possibilities for oil tankers and barges running aground during periods of bad weather.

Although not presently a consideration in this region, the question of offshore oil drilling cannot be completely ruled out as a future possibility. "Project Sea Map," a 1968 East Coast survey conducted jointly by a number of major petroleum companies, has generated considerable interest and encouraged further exploratory effort [7]. Primary attention has apparently focused on Georges Bank, although possibilities for other continental shelf regions have not been excluded.

Public Policy Background

In instances where marine oil pollution originates from land based sources such as processing, storage and transfer facilities, it may be regarded for purposes of public regulation and control as one particular type within the general category of industrial wastes. As such, it is subject essentially to the same Federal and State Legislation, public regulatory agencies, and administrative control procedures as other forms of industrial wastes discussed in the previous section on Domestic and Industrial Wastewater Disposal.

The U.S. Coast Guard has traditionally had a primary role in matters relating to coastal transportation in general as well as to specific aspects of marine oil pollution. As summarized recently by Rear Admiral Robert W. Goehring, Chief of Coast Guard's Office of Operations [11, pp. 926—928], major Coast Guard responsibilities relate to:

> The entire spectrum of involvement in the marine safety field including ship and equipment design and construction; the licensing, competence, and performance of shipboard personnel; requirements for safe operational practices and adequate navigational equipment; the maintenance of an aids-to-navigation system; the enforcement of the maritime rules of the road; the establishment of sealanes for traffic separation and general safety requirements for various classes of vessels....
>
> In addition, three specific programs are directly involved in pollution prevention. The Tank Vessel Act (46 U.S.C. 391a) and the Dangerous Cargo Act (46 U.S.C. 170), together with the regulations issued thereunder, specifically involve requirements for the handling and stowage of inflammable or conbustible liquid cargo in bulk and for the handling and movement of dangerous cargoes in package form. Regulations involving tanker design, vessel equipment, manning and operation, looking to pollution prevention, have been issued under both these acts.
>
> On the shoreside, the Magnuson Act (50 U.S.C. 191), involving port security and port safety authority, serves as a vehicle for operational regulations, addressed to pollution prevention from waterfront facilities.
>
> The Coast Guard is presently involved in the enforcement of the Oil Pollution Act of 1924, as amended, and the so-called Refuse Act of 1899... [involving] surveillance and the investigation of oil spills, [and is presently] strengthening that enforcement by expanding our patrol procedures and by expanding our research and development program, looking to improved surveillance and detection techniques as well as more efficient materials and equipment for cleanup.

Under the basic authority of the Rivers and Harbors Act, the U.S. Army Corps of Engineers in concerned with design, construction and maintenance of harbors, canals and other navigable waterways as well as being a premit-granting agency for the construction of offshore facilities such as drilling platforms and unloading docks.

Substantial efforts have been underway recently at the federal level to strengthen interagency coordination and improve contingency planning for the prevention, control and subsequent cleanup of oil spills. Under the direction of a National Interagency Committee, composed of representatives of the Departments of Interior, Defense, Transportation and Health, Education and Welfare, and the Office of Emergency Preparedness, policies and procedures are being established for the National Multi-agency Oil and Hazardous Materials Contingency Plan [11, pp. 932–933, 1019–1021]. Thus, for the first time, regional contingency plans are in the process of being prepared in each of the nine FWPCA regional offices, involving both the survey of potential oil spill sources and existing safeguards, as well as the formulation of multiagency measures for prevention and emergency response procedures relating to containment and cleanup actions.

Indicated Information Needs

A considerable amount of local area information is required to answer the types of questions implied by the formulation of the regional contingency plans discussed above. Some of these questions include [6, p. 4]:

- What are the potential sources and types of spills within local area operations?
- What safeguards would routinely be observed to prevent spills?
- What water uses and related resources might be damaged by any of the potential spill situations?
- What equipment, materials and supplies may be needed on an emergency basis to control and clean up a spill?
- Where are such items available in the quantities needed?
- Can mutual aid agreements be developed between public and private agencies at all levels for emergency control purposes?

Sufficiently detailed answers to these questions would provide a comprehensive review of the present oil spill risk for the Long Island region as well as an assessment of the area's preparedness to cope with spills.

Selected References

1. Boyd, William A., 1968: Report of a feasibility study of an oil spill control facility for the Connecticut River, prepared for Connecticut Research Commission.

2. Conservationists forecast: Deadly shadow at sea. Water Newsletter, Vol. 11, No. 12, June 18, 1969.

3. Foehrenbach, Jack, 1969: Pollution and eutrophication problems of Great South Bay, Long Island, New York. J. Water Pollution Control Federation, 41, 8. pp. 1456—1465.

4. Long Island Lighting Company, 1968: LILCO Annual Report, 1967.

5. Nassau-Suffolk Regional Planning Board, 1969: Utilities inventory and analysis (comprehensive plan series). Hauppauge, Long Island, N. Y. pp. 47—48.

6. Oil Spills, 1969: Environmental technology and economics, Vol. 3, No. 26, August 29.

7. Oil Thought to be Under Georges Bank, 1969: New England marine resources information 1. Pell Marine Science Library, Narragansett, Rhode Island, May, p. 3.

8. Secretary of the Interior and the Secretary of Transportation, 1968: Oil pollution—A report on pollution of the nation's waters by oil and other hazardous substances. Washington, D.C.

9. Two New Oil Slick Chemicals are Announced. Air and Water News, August 4, 1969.

10. U.S. House of Representatives, 1967: Report on international control of oil pollution. Intergovernmental Maritime Consultative Organization (IMCO), Washington, D.C.

11. U.S. Senate, 1969: Water Pollution—1969, Part 4. Hearings Before the Sub-Committee on Air and Water Pollution of the Committee on Public Works, 91st Congress, First Session. Washington, D.C.

CHEMICAL PESTICIDES

Introduction

In our initial report identifying the marine resource problems of Long Island, chemical pesticides and marshland drainage for mosquito control were discussed together under the headings, "Control of Insects and Related Pests." For reasons of emphasis and consistency, we have since chosen to deal with chemical pesticides as a separate problem and to include marshland drainage for mosquito control in the category of Wetland Destruction and Alteration.

The issue of greatest concern centers on the side-effects on wildlife, fish, and shellfish (and, potentially, humans) of persistent, non-specific, chemical insecticides and herbicides applied for the control of pest species. Singled out for particular importance has been synthetic-organic, chlorinated hydrocarbon group which includes DDT, aldrin, endrin, lindane, dieldrin, chlordane, toxaphene, Methoxychlor, heptachlor, and others. These are characterized by relatively high toxicity, persistence in the environment, non-specificity (they are toxic to a wide variety of organisms) and a tendency to be increasingly concentrated in various vital organs and tissues of organisms at higher trophic levels in ecological food chains [18]. Evidence on the deleterious effects of pesticide residues on fish and wildlife has been steadily mounting over the past 20 years, especially with regard to DDT, which has been the most widely used and the most studied [1, 2, 14, 18].

The newer families of pesticides of increasing use are the organic phosphates, including parathion, malathion and tetraethyl pyrophosphate, and the carbamates (of which sevin is a commercial example). Although experience with these and other, newer varieties is much less than with older types, most of these pesticides are felt to be less injurious to non-target species because of their lower persistence and/or greater specificity.

A major difficulty, both for scientific understanding and for public policy, lies in the fact that there are literally tens of thousands of chemical pesticide formulations, and more are being developed continually.* Further, it may take many years for unanticipated side-effects of particular compounds to be discovered and analyzed. Pesticides have only quite recently become a widespread public issue, and regulatory policy is currently in a state of rapid change. Interest centers both on devising new chemical formulations less damaging to environmental values and on developing alternative biological and physical means for pest control, in addition to closer regulation on the use of existing chemical pesticides—to the point of banning the use of the more damaging types entirely.

Evaluation of Problem

In our review of the pesticide problem on Long Island, we have concentrated on five questions as a basis for organizing pertinent information:

(1) What are the major target species of pests?

(2) Who are the major users of pesticides?

(3) What evidence exists on environmental concentrations of persistent pesticides?

(4) What is the evidence on environmental damage?

(5) What social controls are there on pesticide applications?

Recent Long Island experience regarding the first two of these questions is outlined in Table 5.

Of the five groups listed, information on types of pesticides, quantities, and locations sprayed is available (at least in principle) only for the first two. It has been reported that public spraying for Gypsy Moths (confined in recent years to the north shore hardwood stands) has now been discontinued entirely, due to lack of economic justification and in compliance with the wishes of the New York State Conservation Department [12]. Nassau and Suffolk County Mosquito Control Commissions no longer use DDT or other chlorinated hydrocarbons (Suffolk County, only since 1966) [10, 11]. They now use primarily malathion and "Flit" (a non-synthetic mineral oil product) and place a greater reliance on non-chemical control approaches [8, 15].

*It has been estimated that, in the mid-1960's, 8,000 manufacturing firms were mixing about 500 chemical compounds into more than 60,000 formulations registered for use as pesticides [13, p. 2].

TABLE 5
PEST SPECIES AND PESTICIDE USERS IN RECENT LONG ISLAND EXPERIENCE

Major target species of pests	Primary applicators of pesticides
Mosquitos	Nassau and Suffolk County Mosquito Control Commissions
Gypsy Moth	U.S. Department of Agriculture and New York State Department of Agriculture and Markets (Contracts with commercial airplane spraying concerns)
Species affecting commercial agricultural crops	Commercial farmers
Marine shellfish pests ("drills" and other parasites, predators and competitors)	Commercial shellfish producers
General household; building, yard and garden varieties	Private households and commercial contractors

The application of marine pesticides to shellfish beds has not yet been examined, but in the opinion of New York State Conservation officials, this practice is, at present, negligible [5].

The major part of present DDT and other persistent pesticide applications thus seem to result from private use by households and commercial farmers, either directly or by contract with commercial applications. Since large numbers of individual units are involved in both instances, quantitative data on these sources requires a more extensive research effort than was possible in the present program.

From information developed thus far, however, it does appear that overall DDT and other "hard" pesticide usage has decreased significantly on Long Island within the past few years, due to reductions in applications by governmental agencies. This is not to say, however, that there may not be local areas of increased application by the private sector, or that there may not be continuing damages occurring from environmental residuals accumulated from past uses.

Turning next to evidence on pesticide concentrations in the environment, it has been only very recently that information has begun to be developed on any kind of systematic basis. Beginning only in March 1966, as part of the U.S. Bureau of Commercial Fisheries' pesticides monitoring program, the New York State Department of Conservation has undertaken a year-round monthly sampling program at 15 marine locations to test for residual levels of seven chlorinated hydrocarbon pesticides in Long Island shellfish, as indicator organisms for general environmental levels. Although the sampling locations are of necessity widely spaced, they do provide a rough coverage of the entire coastline. Of the pesticides routinely tested for, only DDT (together with its DDD and DDE decay products) and Dieldrin have been found in measurable quantities [2]. For the majority of locations sampled in recent months, shellfish concentrations of DDT and its decay products were found to be less than 0.007 parts per million (ppm) in the shellfish organisms, with combined levels of DDT, DDD and DDE reaching upward to 0.1 ppm in the location of greatest measured concentration [7]. Dieldrin, the only other chlorinated hydrocarbon detected in addition to the DDT group, was found only at the sampling locations on the northwest shore (from Hempstead Harbor to Conscience Bay). Concentrations of Dieldrin generally were less than .03—.04 ppm, with the highest recorded concentration being slightly over .09 ppm in Huntington Harbor in November 1968.

Although the accumulated monthly data have not been subjected to rigorous statistical analysis, casual observation does not reveal obvious trends or seasonal patterns of variation [2]. No systematic effort has yet been made either to analyze the environmental significance of these presently observed shellfish pesticide levels or to trace these measured residuals to the sources of application. Clearly, much remains to be done in this regard.

Declines or disappearances of local populations of a wide variety of Long Island species have been attributed to pesticides. These have included shrimp, summer flounder, blue crab, various amphibia, woodcock, bitterns, herons, and hawks [11, 12, 16]. To the extent that it has occurred, such damage has apparently not been of the sudden and dramatic sort (such as directly observable "fish kills"), but rather of a slower and more subtle nature. Conclusive direct evidence linking species declines to pesticides requires possession of directly analyzable remains of recently deceased organisms. Where direct mortality occurs gradually over time, or where a species decline is due to diminished reproductive success, extensive controlled laboratory experiments and indirect comparative field analyses may be required to substantiate a pesticide effect. In certain instances, a local species may be already decimated to the point where investigation of cause is virtually impossible.

Unfortunately, scientifically documented evidence on the quantitative extent of wildlife losses is not available. Nor does it appear that detailed scientific study has been undertaken for more than a few local areas of the Island. Woodwell, Wurster and Isaacson, for example, have reported [18] on a study of DDT residues (including DDD and DDE) for the Carmans River Marsh Area of Great South Bay conducted in 1966. They found pesticide concentrations in many of the higher organisms approaching or exceeding levels within the known lethal range for the particular species. Combined with observed historical declines of such species for the same area (relatively undisturbed in its physical characteristics), long-term damage from pesticides may be inferred with some confidence.

Public Policy Background

A variety of public agencies at all levels of government are presently involved in one way or another, both in regulation and control and in direct use of pesticides.

At the local levels, the primary agencies of interest are the Nassau and Suffolk County Mosquito Control Commissions, which operate primarily as applicators. Although subject to policy direction by the County Boards of Supervisors and controlled by County budgetary allocations, these Commissions operate to a large extent as autonomous agencies under the New York State Public Health Laws of 1935. Given their primary statutory function of mosquito and other insect pest control, these agencies are thus responsible for decisions regarding methods, locations and frequencies of control actions, including types and quantities of pesticide applications. At this time there does not appear to be a routine formal mechanism, either statutory or administrative, by which these decisions may be monitored, regulated, or coordinated as part of a broader policy framework for environmental management.

At the state level, at least four public agencies conduct programs directly relevant to pesticide issues. The New York State Conservation Department, the state agency most directly concerned with fish and wildlife damage, does not have powers of control over insecticide applications, except indirectly through its capacity to provide recommendations and advice to other public and private agencies regarding potential fish and wildlife effects. As noted previously, the Shellfish Sanitation and Engineering Services Unit of this Department is presently the only agency conducting systematic monitoring of pesticide residuals in the Long Island coastal environment.

The New York State Health Department, as the State agency responsible for establishing and enforcing water quality standards for inland and coastal waters, is the agency with the greatest statutory authority for potentially exercising direct control of pesticide levels in Nassau-Suffolk waters. However, it has not, to our knowledge, established specific water quality standards for pesticide residuals for New York State waters; nor do we know of specific instances in which the Health Department has instituted regulatory action against individual applicators. It is worth noting in this regard that traditional pollution abatement procedures are, in principle, extremely difficult to apply in the case of pesticides. One reason is that pesticides users are extremely numerous, and their intermittent uses of pesticides do not, for the most part, represent continuous "point sources" of direct discharge to aquatic environments. Another reason is that the environmental transport mechanisms by which pesticides reach water bodies are frequently extremely complex; therefore, tracing observed residual levels back to their individual or multiple sources is extremely difficult.

At present, the state agency with greatest authority over the supply of pesticides distributed within New York State is the Division of Plant Industry of the Department of Agriculture and Markets [7]. Article II of the Agriculture and Markets Law requires registration of all formulations transported, distributed, or sold within the state. The basic requirement for registration is that the pesticide already be registered by the U.S. Department of Agriculture; however, the state agency has the authority to impose more stringent criteria, and could thereby restrict sales of particular pesticides for use within the state [6, p. 5]. In 1968, the New York State Legislature passed Article II-A which requires registration of all commercial enterprises applying pesticides for hire ("custom applicators") as well as evidence of their knowledge of the hazards and safety constraints of use. Together, these laws provide some basic control on types of pesticides and the qualifications of at least one category of appliers. They do not, however, directly control conditions of applications or quantities used.

The Pesticide Control Board was established in 1964 under Article 16 of the Public Health Law to provide an agency for developing "overall policy in the State's programs for regulating the use, transportation, storage and disposal of pesticides" [7, p. 1]. Housed within the State Health Department, the Board is composed of the Commissioners of the Departments of Conservation, Agriculture and Markets, Commerce, Education, Health, Labor, and Transportation, as voting members, with ten advisory members representing state colleges of agriculture, forestry and medicine as well as organized conservationists, pesticide manufacturers and appliers, and "ecologists." Although an advisory body only, the Board represents the only state-level agency with explicitly designated responsibility for surveillance of the whole range of pesticide issues on a continuing basis. Because of its status and membership composition, the Board is in a pivotal position to develop and implement pesticide policies at the state level. The Board presently has under consideration a resolution recommending that many of the chlorinated hydrocarbon pesticides be restricted to use only by custom appliers and commercial farmers, and only under a special permit system. If implemented, this would effectively eliminate general household uses and would provide additional controls and limits on commercial uses.

At present, the primary regulation of pesticides at the national level (regarding general environmental effects) resides with the Pesticides Regulation Division of the U.S. Department of Agriculture under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) passed in 1947. This Act relates essentially to <u>registration</u> and <u>labeling</u> of pesticide products sold in interstate commerce, and does not directly regulate subsequent uses or users. The Department of Health, Education and

Welfare (Consumer Protection and Environmental Health Service) and the Department of the Interior advise on, but cannot block approval of USDA's decisions on applications for registration. The Food and Drug Administration also has direct regulatory powers over those pesticides that relate to food products and to interstate shipment of food products containing pesticide residues.

The role of the Interior Department in monitoring environmental residues and in research has been mentioned previously. In addition, many agencies of the federal government are themselves direct users of pesticides, including the Forest Service, the National Parks Service and the Department of Defense. A number of these agencies have recently announced temporary bans on the use of DDT and other persistent pesticides on federal lands within their jurisdictions.

In this regard, it is worth noting that at least two states (Arizona and Michigan), as well as many local communities, have banned to varying degrees the use of DDT within their jurisdictions. Sweden has banned all uses of DDT for a period of two years; and bills have recently been introduced in both Houses of the U.S. Congress to prohibit the interstate sale and shipment of DDT [2, p. 25]. A similar movement is underway in New York relating to persistent pesticides in general.

Indicated Information Needs

There is already a voluminous and rapidly expanding body of technical literature on the biological effects of many of the most important pesticides; especially the older ones, such as DDT. While we are not in a position to comment on the "completeness" or adequacy of existing scientific knowledge in this area, there are at least three kinds of basic information specific to Long Island that would be particularly useful in understanding and potentially managing pesticides-related marine resource problems.

The first of these is the monitoring of accumulations of pesticide residuals in the Long Island coastal environment. As noted previously, a beginning has been made by the New York Bureau of Marine Fisheries; however, only shellfish (principally hard clams) are presently covered, and these at only 15 locations around the entire coastline. Even if all further pesticide applications were arbitrarily curtailed or stopped in the near future, the existence of present quantities of persistent residuals "stored" in the physical and biological environment could be of significance for many years to come.

The second kind of information pertains to the biological significance of existing residual levels. To our knowledge, no one has yet attempted to analyze in detail the specific biological implications for Long Island even for the present data on monitored pesticide residuals. Lacking information of this type, very little can be said regarding the magnitude of ecological effects or their social significance.

Third, assuming pesticide applications will not be completely stopped in the immediate future, detailed information is required on specific locations, types and quantities of applications. Such information seems essential as a basis for controlling local uses as well as explaining and predicting levels of environmental concentration.

Selected References

1. Carson, Rachel, 1962: Silent spring. Houghton Mifflin Co., Boston, Mass.

2. The Conservation Foundation, 1969: Pollution by pesticides (reprint of April 25 and May 5, 1969 issues of C. F. Letter). The Conservation Foundation, Washington, D.C.

3. Foehrenback, Jack, Senior Chemist, Shellfish Sanitation and Engineering Services Unit, Bureau of Marine Fisheries, New York State Conservation Department. Personal interview.

4. Headley, J. C. and J. N. Lewis, 1967: The pesticide problem: An economic approach to public policy. Johns Hopkins Press for Resources for the Future, Inc., Baltimore, Maryland.

5. Miller, William, Supervising Aquatic Biologist, Fisheries Management and Development Unit, Bureau of Marine Fisheries, New York State Conservation Department. Personal interview, May 13, 1969.

6. New York State Department of Conservation, Bureau of Marine Fisheries, Shellfish Sanitation and Engineering Services Unit. Unpublished data for Pesticide Analysis Report to U.S. Bureau of Commercial Fisheries Pesticide Monitoring Program.

7. New York State Department of Health, Pesticide Control Board, 1969: The use and control of pesticides within New York State. Draft II of Pesticide Information Leaflet, Albany, N. Y.

8. Sanzone, Joseph, Entomologist, Suffolk County Mosquito Control Commission. Personal interview, May 9, 1969.

9. Report of Committee on Persistent Pesticides, 1969. Division of Biology and Agriculture, National Research Council to U.S. Department of Agriculture, Washington, D.C., May.

10. Suffolk County Mosquito Control Commission, 1965—1967: Annual Reports. Yaphank, N. Y.

11. Taormina, Anthony, S., 1966: Mosquito problems in fish and wildlife management in New York. Mimeograph. New York State Conservation Department, Ronkonkoma, Long Island, N. Y.

12. —, Regional Supervisor, Division of Fish and Game, New York State Conservation Department. Personal interview. May 12, 1968.

13. U.S. Department of the Interior, Fish and Wildlife Service, 1966: Fish wildlife, and pesticides. U.S. Government Printing Office, Washington, D.C.

14. —, 1965: The effects of pesticides on fish and wildlife. Fish and Wildlife Service Circular 226, U.S. Government Printing Office, Washington, D.C.

15. Williamson, C. T., Director, Suffolk County Mosquito Control Commission. Personal interview, May 9, 1969.

16. Woodwell, George M., 1967: Toxic substances and ecological cycles. Sci. Am. 216:3, March, pp. 24—31.

17. —, Biology Department, Brookhaven National Laboratory. Personal interview, May 13, 1969.

18. —, C. F. Wurster and P. A. Isaacson, 1967: DDT residues in an east coast estuary: A case of biological concentration of a persistent pesticide. Science, Vol. 156, May.

DREDGING AND DREDGING-SPOIL DISPOSAL

Introduction

As an activity producing direct physical changes and indirect side effects on environmental conditions, dredging must be considered one of the most important activities in the coastal region. Dredging operations are inherently conducted in two phases, the first involving the removal of bottom material by suction or scooping and the second relating to disposal of the removed material. These two phases may occur at one location or at locations remote from each other, as in the case of dumping spoil at sea.

Depending on specific purposes, methods used, and locations involved, the environmental effects of dredging and spoil disposal encompass a wide range of physical, chemical and biological changes. In any specific instance, the environmental conditions changed because of removal may differ significantly from those affected by disposal. Thus, the two operations must be evaluated individually.

Dredging of solid material from underwater surfaces may be conducted for a number of reasons. The material itself may be desired, as sand and gravel for the construction industry, to replenish the eroding seaward slopes of barrier beaches, or to provide landfill to raise wetlands above tidal levels, creating new land surfaces. Alternatively, the desired purpose may be the removal of bottom materials, such as duck waste sludge, to improve water quality or to restore bottom surface conditions; or removal may be done to create and improve navigational waterways, harbors and mooring areas, and to improve water circulation and tidal flushing action. Some of these purposes may be accomplished singly or jointly. For example, the material dredged to widen a channel may concurrently be used to build nearby beaches or to fill wetlands for housing development.

The environmental effects of dredging, *per se*, include not only the alteration of bottom topography and material composition, but also modification of the habitat of benthic marine forms, such as shellfish. In addition, water quality in the vicinity of the dredging operation may be significantly altered. To some degree, effects will depend on the type of equipment and procedures used. For example, hydraulic dredges typically have less effect on water quality in the vicinity of the removal area since all of the solid material disturbed is removed through a suction pipe. However, the slumping of side slopes along hydraulically dredged cuts may cause local turbidity and resuspension [8, p. 59]. By contrast, dipper and clamshell dredges, in scouring the bottoms and lifting buckets through the water, may generate turbid conditions at the removal site and may release to the water column whatever toxic, nutritive or chemically unstable materials are present in the bottom material. Regardless of the type of dredge used, benthic communities are disturbed or destroyed, and water circulation in the dredged area may be altered [10, p. 76].

The social activities affected by dredging typically include both those which the dredging is intended to benefit (via navigational improvements, for example), as well as those affected by unintended or unavoided changes in water quality and biological habitat conditions (such as water-contact sports, fishing, or shellfish cultivation).

The environmental effects resulting from disposal of dredged materials also depend significantly on purposes, location, and type of equipment utilized, as well as on the type of material involved. For example, because it involves direct pumping of large volumes of water under pressure along with the dredged material, hydraulic pumping can create greater turbidity at disposal areas than other forms of transport [8]. Sand and gravel materials, because they are typically transported by barges and because they are destined principally for inland construction uses, seldom result in adverse affects on coastal environments insofar as disposal is concerned, aside from washing operations at preparation sites.

Environmental effects associated with the disposal of dredging spoil in open waters are discussed by Flemer, et al. [5, p. 684]. They observed that sediments suspended as a result of dredging "can reduce light, change nutrients concentrations and entrain plankton organisms, clog egg membranes and gills, and smother benthic populations." Biggs [1], in a study of the effects of overboard disposal of dredged spoil in upper Chesapeake Bay, reported that spoil material settled over an area at least five times the predefined disposal site.

Dredged material destined for use in the replenishment of eroded beach areas may also (again depending on material type and method of transport) produce adverse effects on water quality from surface runoff or local nuisance effects from biological decay processes. Another principal use of dredged material is for filling of coastal wetlands, either for expressed land development purposes or because these areas may simply provide a convenient disposal site. In either case, the physical and ecological changes involved rank among the most important of the environmental impacts of spoil disposal. These have been treated separately in the section on Wetland Destruction.

Evaluation of Problem

Several adverse effects of dredging in Long Island waters have been observed. The dumping and resettlement of dredged spoil over biologically productive marshlands has caused valued *Spartina* cordgrass to be replaced by valueless common reeds [11, p. 7]. Oyster beds covered with dredged silt have been destroyed as shellfishing areas or repopulated by hard clams instead of oysters [9, 3.24]. Algae blooms and fish kills have occurred when duck sludge has been dredged during the warm summer months [12, p. 11]. Large borrow pits and holes dredged in harbors and bays during sand and gravel operations are now common to many parts of Long Island. The environmental effects of these pits, other than the generation of obnoxious gases from accumulated decomposing organic detritus, have not been thoroughly documented [9, p. 3.8].

The environmental effects of spoil disposal for Long Island and adjacent waters are being investigated by Gross [6]. The effects of dredged spoil discharge on the Continental Shelf are not known, although, in contrast to river-borne sediments, spoil dumping is usually more localized in space and time [6, p. 15]. Gross has observed that because of the relatively small area of spoil disposal sites in Long Island Sound, "short" dumping, outside the designated areas, is likely to occur as a result of navigational errors and the exigencies of adverse weather.

The total acreage of wetlands physically destroyed by dredging is not known, although surveys of Long Island wetlands indicated that at least 23% of the marshlands lost during the decade from 1954 to 1964, amounting to approximately 1,900 acres, were attributed largely to dumping of hydraulic spoil [11, pp. 8—10]. Additional acreage of wetlands used for housing, recreation and other specific uses were also prepared originally by depositing dredged spoil.

Information on the current intensity of dredging activity in the bicounty region, in terms of the number of dredges in operation and volumes of material removed, locations of removal and deposition, is not readily available in summarized form.*

Public Policy Background

Dredging operations in Nassau and Suffolk Counties are administered by the U.S. Army Corps of Engineers. Elsewhere in New York, the State Water Resources Commission exercises jurisdiction over navigable waters in the state, having the power to issue or deny permits on the basis of ecological effects and public health as well as navigation. In the bicounty region, the Corps issues permits for dredging offshore of the high water line, on the basis of effects on navigation. However, under the Federal Coordination Act, the Corps must take into consideration the advice of the Fish and Wildlife Service in the Department of the Interior regarding possible effects on natural resources. The Corps also receives advisory comments on dredging permit applications from the New York State Conservation Department and, occasionally, from the state Departments of Health and Commerce. All State agency comments are officially transmitted to the Corps through the State Water Resources Commission [9, pp. 3,39—41].

The Corps of Engineers also has authority over the dumping of dredging spoil at sea. The Supervisor of New York Harbor, who also serves in the capacity of District Engineer of the New York District, U.S. Army Corps of Engineers, designates and supervises spoil disposal in 19 designated sites in Long Island Sound [6, p. 5].

Several towns in the bicounty region regulate dredging operations. The Town of Hempstead prohibits all dredging on public lands except for public works construction, and designates two areas at Jones Inlet as the only sites where material may be dredged as landfill [7, p. 4]. The Town of Babylon passed a dredging ordinance in 1957 establishing stringent regulations concerning the removal of material from town-owned wetlands [9, p. 3.41].

*The location and volume of material removed by county-owned dredges in Suffolk County over the period 1956—1962 was reported by Bishop in Civil Engineering [2, pp. 40, 41].

Indicated Information Needs

To appraise better the intensity of dredging operations, it would be helpful to obtain data on the volumes of material dredged and disposed of, the location of each activity, and the agency or firm conducting the operation. Quantitative data concerning the immediate environmental effects would indicate the severity of the problem and help to establish clearly the other human activities adversely or beneficially affected. Changes in the physical parameters, such as turbidity, sedimentation rates, particle size and water circulation, as well as chemical and biological changes in the waters surrounding dredging operations, would depend upon the type of material dredged and the equipment used.

To understand better how dredging is accomplished, additional information regarding institutional restraints and procedures is needed, such as the processing and enforcement of dredging permits, local dredging ordinances, and the extent of jurisdication of the regulating agencies.

Selected References

1. Biggs, R. B., 1968: Environmental effects of overboard spoil disposal. Journal of the Sanitary Engineering Division, Vol. 94, No. SA3, Proc. Paper 5979, June, pp. 477—487.

2. Bishop, H. F., 1962: Suffolk County dredges make new land and water areas. Civil Engineering, September, pp. 40—41.

3. Brown, D. L. and R. Clark, 1968: Observations on dredging and dissolved oxygen in a tidal waterway. Water Resources Research, 4(6):1381—1384.

4. Caldwell, J. M., 1969: Corps of Engineers programs in coastal waters. Proceedings of the 1969 annual meeting of National Security Industrial Association, Ocean Science and Technology Advisory Committee. Washington, D.C., April 23—24, pp. III-42—46.

5. Flemer, D. A.,W. L. Dovel, H. T. Phitzenmyer and D. E. Ritchie, Jr., 1968: Biological effects of spoil disposal in Chesapeake Bay. Journal of the Sanitary Engineering Division, ASCE Vol. (SA4), pp. 683—706.

6. Gross, M. G., 1969: New York City—a major source of marine sediment. Tech. Rpt. No. 1 (preliminary draft 20 June 1969). Marine Sciences Research Center, SUNY, Stony Brook, N. Y.

7. Hempstead Town Conservationist. 1966: Vol. 1. No. 1 (winter 1966), p. 4. Department of Conservation and Waterways. Town of Hempstead. Long Island, N. Y.

8. Huston, John, 1967: Dredging fundamentals. Journal of the Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers. pp. 45—69.

9. Nassau-Suffolk Regional Planning Board. 1966: Status and potential of the marine environment. Report of the Oceanographic Committee to the Regional Planning Board. Hauppauge, L. I., N. Y.

10. U.S. Department of the Interior. 1968: Water quality criteria. Federal Water Pollution Control Administration. U.S. Government Printing Office, Washington, D.C.

11. U.S. Department of the Interior. 1965: Supplementary report on the coastal wetlands inventory of Long Island, New York. Fish and Wild life Service. U.S. Fish and Wildlife Service, Region V, Boston. Mass.

12. Wallace, D., 1969: Marine Resources Council of the Nassau-Suffolk Regional Planning Board. Minutes of the Meeting of May 26, Hauppauge, Long Island, New York.

13. Yahn W. B. Ellicott Machine Corporation. Personal correspondence, October 14, 1969.

SHORELINE RECREATION

Introduction

Shoreline recreation is of unquestioned importance to Long Island, both for its amenity values to residents and as the basis of a substantial amount of regional commerce and industry. " Shoreline recreation" actually subsumes a diversity of specific consumer-level activities, including swimming, surfing, skin diving, water skiing, pleasure boating, sport fishing, waterfowl hunting, birdwatching, camping, picnicking, hiking, and other leisure-time pursuits. Individually, most of these activities depend upon different combinations of natural environmental characteristics, and some also require (or are enhanced by) various man-made facilities and services. All, however, depend upon personal access to areas in which the desired natural shoreline features are located.

In general, a shoreline recreational problem can be defined as any situation in which the quantity or quality of opportunities for a particular type of recreational experience are judged inadequate to satisfy reasonable demands on the part of resident or non-resident populations. More specifically, some of the more obvious "demand and supply" problems relating to shoreline recreation are the following:

- Quantity of a particular type of natural resource is limited in natural occurrence relative to demand. This is increasingly typical of natural coastal recreation resources, as population growth, together with increased leisure time and family incomes, cause demands to increase with respect to relatively fixed supplies. The problem is compounded when original resource bases are decreased by their development for non-recreational uses. Examples: sandy coastal beaches are becoming increasingly scarce relative to the numbers of people desiring to use them; the decrease in coastal marshlands has significantly reduced opportunities for waterfowl hunting and bird-watching.

• Quality of natural resources is either originally of low value for a particular activity or becomes deteriorated over time. Examples: rocky or muddy beaches are of low value to sunbathers and swimmers; pollution-caused turbidity, etc., reduces water quality for personal contact sports; for many users, crowding reduces the quality of the recreation experience.

• Access to existing natural resources is precluded to many potential users, either by absence of public rights of way, exclusive private ownership, the restriction of particular areas for non-recreational public purposes, or by local public restrictions against non-residents.

• Ancillary facilities in short supply restrict (or reduce the quality of) recreational opportunities otherwise available. Examples: inadequate boat launching, storage, and service facilities may restrict the number of boats in a particular area or cause long delays at facility sites; absence of bathhouse, toilet, or other public beach facilities may be a source of inconvenience and annoyance.

Certain additional issues bearing on shoreline recreation problems are worthy of note. First, recreation demands on coastal resources are typically subject to extreme seasonal and daily variations in intensity. For most activities in the New York region, peak demands obviously occur during the summer*, especially on week-ends and holidays. Thus, many resource areas and facilities are typically under-utilized (or not used at all) during much of the year, and the major problems of "shortage" for most activities occur only during a very few peak-use days during the activity season.

A second issue, and one with serious policy implications, is that of potential conflict between resident and non-resident uses of a region's natural resources.

*This is not true of waterfowl hunting (legally restricted for conservation reasons to the fall and early winter months) or for certain specialized sport-fishing enthusiasts whose peak demands are timed to coincide with the maximum availability of favored migratory species such as striped bass, mackerel or billfish.

The extent to which recreational resources are considered adequate by resident participants will depend significantly on the extent of their use by non-residents. Local resident participants may well prefer to exclude "outsiders," even while local commercial interests are seeking to attract them, and state-level development and planning agencies are attempting to extend these recreational opportunities to all state residents and out-of-state tourists.

In addition to obvious conflicts between non-recreational and recreation uses, and between resident and non-resident recreationists, there may also be conflicts among different kinds of recreational use for the same resource base, for example: waterfowl hunters vs. birdwatchers and other naturalists, or surfcasters vs. swimmers vs. waterskiers.

Finally, it may be noted that problems and issues of all of these types are inevitable to a certain extent, as both recreational and other demands on the same limited resources continue to expand. Some of the problems can be mitigated in various ways, such as by investing in resource improvement or facilities construction, by restricting or preventing incompatible uses of specific areas, by regulating some activities to avoid depletion or quality deterioration of the resource base, or by transferring private areas or non-recreational public areas to public recreational uses. In general, however, such problems can usually be only ameliorated and can seldom be entirely "solved." And although many recreationists are traditionally accustomed to the "free use" of natural resources for their particular purposes, it is quite evident that even the easing of recreational problems will become increasingly costly, in terms both of direct investments and of other resource uses sacrificed. The extent to which such costs are worthwhile, as well as the extent to which they should be born by alternative programs of public subsidies or user fees, or left to private enterprise solutions are all relevant issues subject to current debate [2].

Evaluation of Problem

Ideally, one would like to be able to match demand and supply information for each specific shoreline recreational activity conducted within specific coastal areas of the Nassau-Suffolk region. However, the kinds of information necessary to perform such evaluations are not generally available at sufficient levels of detail or regional comprehensiveness. Therefore, given the fragmentary state of available information, the present evaluation is developed in the following four parts:

- The broad picture of coastline recreation demand in terms of general trends and certain features of its composition;
- Basic factors influencing the quantitative and qualitative aspects of the natural resource base;
- The question of public accessibility; and
- The present role of the private sector, including both commercial enterprise and private social organizations.

Probably the single most important indicator of recreational demand pressures in the Nassau-Suffolk region is data on resident population numbers. The population of Nassau County (approximately 1.45 million in 1969) has increased nearly 2.3 times in the past 20 years and that of Suffolk County (1.06 million) has increased by more than 3.8 times during the same period [8, pp. 5—6]. Projections by the Nassau-Suffolk Regional Planning Board indicate further increases during the next 10 years of over 200,000 in Nassau and more than 500,000 in Suffolk County [8, p. 14]. Resident demand is of course augmented by non-resident demand, and, in this respect, Long Island's proximity to New York City and its metropolitan environs is of the greatest significance.

In addition to population increase, per se, changes in per capita participation rates is a second important demand indicator. Although trend data specific to Long Island are not available, inferences may be drawn from national studies which indicate that participation in coastal recreation has been increasing substantially more rapidly than population for most major activities [10, pp. 4—5].* This trend of increasing participation rates is also expected to continue, based on such determinants as increases in average family incomes, leisure time, and mobility factors.

Either of these trend influences alone would be sufficient to yield substantial absolute increases in Nassau-Suffolk recreation demands; taken together, their implications are impressive.

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* The major possible exception would appear to be waterfowl hunting.

General indications of the popularity of specific activities may be inferred from national studies of the proportions of the population that engage in them and numbers of "participant days" or "occasions of participation" for various activities [10; 14]. Although definitions vary among studies, the general picture emerges that swimming is easily the most popular "active" shoreline recreational pursuit, followed by pleasure boating and fishing, each with about 25 to 30 percent as many individual participants [10, p. 3]. On the average, however, individual boaters and fishermen apparently participate more frequently during the year, owing in part to longer seasons; and they spend considerably more money per person than other recreationists.

The only detailed and comprehensive regional study of recreational participation on Long Island for which results are available is that by Wilkins for the Town of Southold [17], which includes an interview survey of both activity participation levels and socio-economic characteristics of participants, for the summers of 1964 and 1965. The Town of Southold is atypical of most Long Island towns in that it has a low resident population (only 14,444 in 1965), is still essentially undeveloped, has a rural environment, and is relatively isolated from metropolitan New York. Nevertheless this study is worth considerable attention, both because it is a potential prototype for other Long Island area studies and because it offers many insights into eastern Long Island recreational patterns.

Selected data from the Wilkins study, presented in Table 6, show summer levels of participation for the five major activities covered, together with the permanent places of residence of participants. In addition to the generally high levels of recreational activity indicated, and the outstanding relative popularity of "swimming" (which in this study included everyone observed on beaches whether they actually swam or not), the most impressive aspect of the data is the proponderance of non-resident participation, especially the relative importance of New York City residents.*

*The original study distinguishes between "visitors" (non-residents spending less than 31 days in the town) and "seasonal residents" (home owners and other spending 31 days to 24 weeks in the town). The latter category was estimated to include approximately 12,000 in 1964 [17, p. 8].

TABLE 6
SHORELINE RECREATION ACTIVITY PARTICIPATION, TOWN OF SOUTHOLD LONG ISLAND, SUMMER MONTHS, 1964—65*

Specified activities	Total number of participant days	Permanent Place of Residence of Participants (percent)							
		Southold	Other Suffolk County	Nassau County	New York City	Other New York State	New Jersey	Connecticut	Other
Swimming:									
Public beaches	303,521	30	7	20	29	4	7	2	3
Private beaches	190,304	11	6	29	38	5	7	1	4
Total	493,825	—	—	—	—	—	—	—	—
Fishing:									
Shore	17,940	15	9	18	42	5	6	2	5
Private boats	12,253	—	—	—	—	—	—	—	—
Rented rowboats	8,032	2	6	12	58	14	4	1	2
Charter boats	4,254	6	15	21	27	18	9	0	3
Open boats	2,178	5	5	24	42	17	2	2	2
Total	44,657								
Boating:	180,509	15	18	22	20	4	6	13	1
Picnicking:									
State park	28,829	12	41	13	24	4	1	3	3
Outside State park	13,173	13	17	17	38	0	9	4	0
Total	42,002	—	—	—	—	—	—	—	—
Clamming:	2,738	30	11	11	26	4	15	0	4

*"Summer months" included the period June 27 to September 7, 1964 and June 26 to September 6, 1965.
All results are presented as annual averages for the two years' data.
SOURCE: Adapted from [17, pp. 20—61, passim.].

Additional participant data accumulated in the Southold survey but not reviewed here included, for each of the individual activities listed: age distributions, annual family income, and primary factors attracting participants to the particular activity or location and to the general Southold area. Less extensive surveys were also conducted for camping (no formally provided public or private camping areas in the town) and waterfowl hunting.

Although not yet published, a recent study of recreation on Long Island conducted under the auspices of The New York State Office of Planning Coordination [13] should shed a much more comprehensive light on some of these same issues for the entire Nassau-Suffolk region. It will include results from a current survey of public recreation areas and facilities (together with certain capacity estimates), as well as information from both an on-site user survey and a mailed questionnaire survey of Long Island households relating to socio-economic characteristics, activity participation and location preferences, travel distances and modes, and indications of satisfaction with existing facilities and additional desired opportunities.

Turning next to the supply side of shoreline recreational opportunities on Long Island, we will first present evidence relating to the quantitative and qualitative picture for the overall natural resource base itself, and then discuss accesibility to these resources and the availability of man-made facilities.

Data have been presented previously, in the section on Wetland Destruction, concerning physical destruction and deterioration of marshlands over the recent past. During the 1954—64 decade, Nassau and Suffolk Counties lost an estimated 33 percent and 17 percent, respectively, of their marshland acreages to developmental land filling, coastal harbor and other marine excavation, and dredging spoil disposal, with attendant direct losses of waterfowl hunting, bird watching and other natural-area recreational opportunities.* Additional, but as yet unquantified, marshland losses are known to have occurred in the period since 1964.

*It should be noted that, of the total losses, seven percent for Nassau County and eleven percent for Suffolk County were attributed to marine, dock, and channel construction, which were no doubt largely beneficial to recreational boaters and boat fishermen.

Further, much of the remaining marshland was considered to have deteriorated in quality as wildlife habitat because of the presence of pesticide residues and, in some areas, because of shifts to inferior vegetation types induced by heavy siltation from dredging and spoil disposal operations. As a result, some wildlife species, including certain crustacians and amphibians, osprey, and other shore birds, are apparently at, or close to, levels of extinction in certain areas [15].

According to a report prepared for the Outdoor Recreation Resources Review Commission [4], New York State was estimated to have 196 miles of recreational beach shoreline at the beginning of the present decade, most of this being in the Nassau-Suffolk region. We have found no evidence that beach land has been destroyed to any significant degree by man-caused development activities. This is undoubtedly due to the recognized commercial and personal values to owners of this type of natural real estate. However, some significant losses of beach <u>area</u>, if not shoreline footage, have occurred through shore erosion, particularly on the ocean side of Fire Island. In addition, it was reported that eleven beach areas (extent and location unspecified) were closed to swimming for public health reasons as of the mid 1960's due to domestic and municipal waste pollution [9, p. 3—12].

Water quality deterioration has also directly reduced the available acreage of shellfishing waters, as discussed in the section on <u>Shellfish</u>. Excessive algae blooms, attributed to the combined influence of domestic and duck waste disposal and reduced water circulation, have been a periodic nuisance to recreationists in Great South and Moriches Bays, and have had known adverse effects on oysters in these same areas. Offensive odors and other water quality problems from duck waste disposal have also, as previously noted, been factors adversely affecting recreational opportunities in Moriches Bay. Whether these various water quality problems will be overcome in the near future depends of course on how soon and how well the pollution abatement programs in these areas progress.

It may be noted at this point that, whereas recreational oyster gathering in Long Island waters apparently now exists in memory only, hard clam populations have significantly increased in many nearshore waters, particularly in Great South Bay, thus affording expanded recreational opportunities of improved quality.

The resource base for sport fishermen, as discussed in the section on Sport and Commercial Finfish, has always been subject to significant fluctuations, in terms of abundance of most of the important individual fish species. Several of the species of greatest importance to the recreational fishery have shown significant declines in recent years. Most notable among these have been the spotted weakfish (sea trout), and, more recently, fluke (summer flounder) and porgy (scup). The weakfish decline has been of such long duration that its natural recovery is extremely doubtful. Whether the declines in other species are only temporary, and due to natural factors, are questions that can only be answered by additional research and/or the passage of time.

Another factor relating to changes in the natural environment of recreationists is the question of eelgrass growth, also discussed at length previously. Extensive increases of this densely growing aquatic plant have occurred in most of the south shore bays in recent decades, with particular acceleration since the 1950's. Its primary direct recreational impact has been on boating and fishing, with complaints relating specifically to its presence as a navigational impediment and as an obstruction to sport fishing, and, in the latter part of the season, to its accumulation on shorelines as an unsightly and odorous nuisance. Although various methods have been applied for its control and removal—primarily mechanical cutting—costs are quite high; eelgrass management is still essentially in a research and development stage. A complicating factor is the recognized ecological value of eelgrass as a primary food producing species and as a source of habitat for marine organisms.

From the standpoint of individual recreationists, accessability to natural resource areas can be of equal importance to their existence. While we have seen that the quantities and qualities of the resources themselves have diminished somewhat, overall access, both for Nassau-Suffolk residents and others, has generally increased over the past 10 to 20 years through public acquisition programs of federal, State, County and local governments and as a result of highway and bridge construction.

Perhaps most notable in this regard has been the establishment of the Fire Island National Seashore, the only major federal acquisition for recreation on Long Island.

Begun in 1963 and still in process of expansion, this area will ultimately include 30 miles of shorefront preservation involving some 5,100 acres under the National Park Service [6, p. 25; 7, p. 6].

Although the major portion of New York State coastal park and conservation areas were acquired prior to World War II, a substantial amount of expansion has occurred more recently. These coastal areas now include almost 14,000 acres, predominantly in Suffolk County, making the State by far the largest holder of public recreation lands in the region. At the county government level, Suffolk County's acquisition program has been accelerated during the past decade to the point where it now holds about 3,900 acres in coastal areas; however, seashore holdings under Nassau County government jurisdiction totaled less than 250 acres in 1968 [7].

In addition, most of the towns and villages and a number of unincorporated local districts own small acreages of beach and other shore areas. In 1968 their combined holdings totaled some 4,400 acres [7]. Although the practice is not universal, it should be noted, however, that a majority of these areas are restricted to use by local residents [12, p. 95ff.; p. 103ff].

Accessability for activities such as boating and fishing from boats is primarily a question of availability of launching, docking, and other boat service facilities, as well as boat rental and commercial charter fishing opportunities. In addition, shoreline fishing depends significantly in certain areas on the existence of piers, jetties, breakwaters and other single or multi-purpose access points. Although comparative historical data are not available for trend analysis, the quantities of most such facilities have been increased, both at public areas and on the part of private commercial enterprise. Relevant 1968 figures indicated 286 private marinas (primarily commercial) and some 52 publicly operated marinas (including many restricted to local residency use) [7, pp. 72—83]. While numbers and locations of marinas are known, additional information on overall capacities and utilization rates for assessing present adequacy of supply relative to demand is not presently available.*

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*The previously mentioned New York State Office of Planning Coordination forthcoming report [13] will contain considerable new information on such facilities for publically administered areas.

The role of the private sector, including both non-profit clubs and social organizations as well as commercial recreational enterprises of various types, is unquestionably the least well-developed area of information pertaining to the supply of recreational opportunities in the Nassau-Suffolk region.

Survey data developed by the Nassau-Suffolk Regional Planning Board [7, pp. 67—71] listed a total of 85 private yacht and beach clubs within the bi-county region in 1968. However, although many of these private organizations are known to be restricted by fee or other entrance requirements to upper income groups, basic systematic information on membership numbers, social, economic or residential composition, and other factors relating to the precise nature and function of these various private organizations in the overall recreational picture for Long Island is almost completely lacking.

Certain types of recreational activities and facilities on Long Island are provided for largely, sometimes completely, by private commercial enterprise. This is typically true, for example, with respect to charter-boat fishing, boat, motor and other equipment rentals, and the provision of private-boat launching, docking and other marina facilities. Assuming sufficient demand for such facilities or services, and the absence of artificial barriers to entry into the field by private entrepreneurs, it generally follows from economic theory that competitive markets will ensure an adequate supply of such facilities and services at reasonable prices [2]. We have thus far found no concrete evidence that such is not the case, at least in reasonable approximation, for the Nassau-Suffolk region. However, it must be reemphasized that, to our knowledge, almost no substantative economic research has been conducted on the private commercial sector.

Public Policy Background

A complete list of public agencies with responsibilities in some way or another related to shoreline recreation problems would include virtually all the agencies discussed in previous sections of this report in addition to many not previously mentioned. To avoid repetition, this section treats only those agencies with direct recreational responsibilities, including the provision and management of public recreation lands and facilities, and related fish and wildlife functions.

Major federal activities relating directly to shoreline recreation are centered in three agencies within the U. S. Department of the Interior: the National Park Service, the Bureau of Sport Fisheries and Wildlife (Fish and Wildlife Service), and the Bureau of Outdoor Recreation. The National Park Service is specifically charged with acquiring, developing and managing coastal park lands, such as the Fire Island National Seashore. National parks are managed for a broad spectrum of recreational activities and are thus developed with the dual purpose of maintaining natural scenic and wildlife values and providing space and facilities for intensive-use activities such as bathing, camping and pleasure boating.

One of the missions of the Bureau of Sport Fisheries and Wildlife has been to acquire and administer the National system of wildlife refuges, which includes, on Long Island, the Elizabeth Morton National Wildlife Refuge in Southampton and the Wertheim National Wildlife Refuge in Brookhaven. These are designed to preserve breeding, feeding and wintering grounds for waterfowl and other migratory birds and endangered species, and to provide for limited development of facilities to enhance recreational opportunities. The Bureau of Sport Fisheries and Wildlife is also charged with broader research and management functions, including law enforcement. relating to the conservation and preservation of migratory birds and fish species,* and with representing wildlife conservation interests with respect to other federal agency programs, such as dredging and highway construction.

The third of these federal agencies, the Bureau of Outdoor Recreation, was established in 1962 to serve as the federal coordinating and extension agency for outdoor recreation [8, p. 9—10]. In 1964 it was given the added responsibility of administering the Land and Water Conservation Fund, created by Congress to finance park and other recreational land acquisition, planning and development programs. Under the act establishing the Fund, sixty percent of the Fund's annual resources (financed out of federal recreation area entrance and user fees, motorboat fuel taxes, and other sources) are available to state and local agencies on a 50-50 matching grant basis, with the remainder going to the various federal agencies for the above mentioned purposes.

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* Major Federal ocean fisheries responsibility is centered in the Bureau of Commercial Fisheries, also within the U. S. Fish and Wildlife Service.

At the New York State level, the Long Island State Park Commission and the Department of Conservation carry on functions analogous to those of the federal agencies discussed above, including acquisition, development and management of state public park and wildlife areas and the management of fish and wildlife resources. In many respects, the activities of the state agencies are more significant to Long Island than those of the respective federal agencies, since they presently administer far greater amounts of shoreline acreage (over 13,800 acres as opposed to some 1400 federally managed) and have greater primary responsibilities for local fish and wildlife, other than waterfowl. The state agencies are also responsible for administering state-appropriated acquisition and development funds as well as the origination of applications for federal matching grants under the Federal Land and Water Conservation Fund.

The Nassau County Division of Recreation and Parks (within the Department of Public Works) and the Suffolk County Park Department represent the major county level public recreation agencies. Both presently manage substantial inland park and recreation acreages. However, the Nassau County Division of Recreation and Parks' combined seashore holdings in 1968 included less than 250 acres at but two locations [7], and their use was restricted to County residents [12, p. 95]. The Suffolk County Park Department's seashore holdings are somewhat larger—on the order of 3,900 acres in 1968—but include only one large unit, Smith Point Park, which occupies about 1500 acres on Fire Island [7].

Most of the Long Island towns and coastal villages, as well as certain special districts in unincorporated areas, maintain local shoreline park and recreation areas. Many also provide boat launching and mooring facilities in conjunction with or in addition to their recreational lands. Although the practice is by no means universal, most of the towns and villages restrict use to residents and guests only [12, p. 95ff; p. 103 ff.].

Indicated Information Needs

Information is required, basically, to specify where and for what particular activities and socio-economic groups the major shortages of natural resources or facilities for shoreline recreation are, or are likely to become, most acute. Specific needs, as we see them, can be grouped for purposes of discussion below under four major headings:

(1) Characteristics of Long Island shoreline recreation demand.

(2) Characteristics of the natural resource base for marine shoreline recreation.

(3) Institutional and legal issues relating to public and private sector supply possibilities.

(4) The role of private sector supply.

The Wilkins study for the Town of Southold [17] and the forthcoming report on the broader Nassau-Suffolk Region by the New York State Office of Planning Coordination [13] both contain much pertinent information on socio-economic, residency, and activity participation characteristics of Long Island recreationists. Although both these studies unquestionably make significant contributions to an understanding of factors influencing recreational demand, it would appear that neither study digs very deeply into basic consumer attitudes and preferences, relating for example, to such questions as the following:

- How do resident and non-resident recreationists themselves evaluate their Long Island recreational experiences and opportunities?
- To what extent (or at what density levels) does crowding of space or facilities reduce the value of their experience? What types of rationing measures would they prefer (higher use fees, advance reservations, etc.) for reducing over-crowded conditions at particular sites?
- How much would they be willing to pay, personally, for improved opportunities and facilities relating to particular activities and locations?

In addition, the needs of recreation planners would also seem to require an integrated demand-projection study for the major recreation activities, utilizing information from the above mentioned sources together with basic population, income and other regional planning projections.

Regarding the coastal natural resource base itself, it would be useful to have more comprehensive summary information, stated in terms specifically relevant to shoreline recreation activities, relating to both the quantitative extent and qualitative characteristics of existing natural features. Principal shortcomings of existing resource information include the facts that this information is largely restricted to public areas and, even for these, is extremely fragmentary on questions of actual present utilization and potential capacities for increased future utilization by specific types of activities. Thus future regional surveys should cover all coastal areas in a region, whether public or private, and should develop data on present resource utilization for specific activities.

However, before very much can usefully be said about local regional or site "resource capacities" to accommodate particular activities, it appears that further basic research is required on the "recreation experience" itself and the subjective values of users relating to such issues as crowding and mutual compatibility among different combinations of activities. The relevance and usefulness of various "capacity standards" currently employed by some recreation planning agencies is quite apparently in need of serious review [10, p. 8; 2]; and for certain activities such as fishing and boating, the whole question of capacity-evaluation measures is at present conceptually undeveloped.

A third area warranting additional investigation is that of existing legal, political and other institutional factors tending either to discourage or to encourage private or public sector shoreline recreational developments or utilization. Specific reference here can be made to the implications of historic land ownership titles and qualifications, town zoning ordinances, issues relating to public acquisition, and special legal instruments available for acquiring scenic or other special easements, public rights of way, and the like. Worthy of special mention in this regard is the uncertain and ambiguous ownership status of much of the coastal wetlands in certain areas of Suffolk County for which land title records are either absent or unclear [15].

Finally, the role of private sector supply in Nassau and Suffolk counties requires considerable elucidation, with regard both to exclusive and semi-exclusive private clubs and social groups and private commercial operations. As far as we can determine, these have simply not yet been rigorously surveyed or analyzed in terms of such characteristics as the social and economic compositions of memberships or clientele, activity and facility capacities, intensity of utilization, or capabilities for future expansion to accommodate increases in regional demands. Effective public sector planning for efficient development of Long Island coastal recreational potentials could be significantly aided by better information on private sector capabilities.

Selected References

1. Boating Almanac, 1967: G. W. Bromley & Co., Inc. New York, N. Y.

2. Clawson, Marion, and Jack L. Knetsch, 1966: Economics of Outdoor Recreation. The Johns Hopkins Press for Resources for the Future, Inc., Baltimore, Md.

3. Duel, David G., and John R. Clark, 1968: The 1965 Salt Water Angling Survey. Bureau of Sport Fisheries and Wildlife, Washington, D. C., July.

4. George Washington University, 1962: Shoreline Recreation Resources of the United States. Report to the Outdoor Recreation Resources Review Commission (Report 4). Washington, D. C.

5. Nassau County Planning Commission, 1964: Parks and Recreation: A Study of Public and Private Recreation Facilities—An Appraisal of Future Needs. Nassau County Planning Commission, Mineola, New York.

6. Nassau-Suffolk Regional Planning Board, 1968: Existing Land Use. Nassau-Suffolk Regional Planning Board, Hauppauge, L. I., N. Y.

7. —, 1968: Inventory of Public Lands and Facilities. Nassau-Suffolk Regional Planning Board, Hauppauge, L. I., N. Y.

8. —, 1969: Population: Current Population and Projections for Nassau and Suffolk Counties 1965—1985. Nassau-Suffolk Regional Planning Board, Hauppauge, L. I., N. Y.

9. —, 1966: The Status and Potential of the Marine Environment, Report of the Oceanographic Committee. Nassau-Suffolk Regional Planning Board, Hauppauge, L. I., N. Y.

10. New England Marine Resources Information Program, 1969: Outdoor Recreation Uses of Coastal Areas. Publication No. 1. (Reprint of a section of Volume 3 of the Panel Reports of the Commission on Marine Science Engineering and Resources). New England Marine Resources Information Program, Narragansett, R. I.

11. New York State Conservation Department, 1960: Outdoor Recreation Survey. A Report to the Governor. State of New York Conservation Department, Albany, N. Y.

12. —, 1966: Statewide Comprehensive Outdoor Recreation Plan. Part 2: Municipal Responsibility. New York State Conservation Department, Albany, N. Y.

13. New York State, Office of Planning Coordination. Long Island Outdoor Recreation System (in preparation and to be published in 1970).

14. Outdoor Recreation Resources Review Commission, 1962: Outdoor Recreation for America. A Report to the President and to the Congress by the Outdoor Recreation Resources Review Commission, Washington, D. C.

15. Taormino, Anthony, Regional Supervisor, Division of Fish and Game, New York State Conservation Department, Ronkonkoma, L. I., N. Y. Personal interview, May 12, 1969.

16. U. S. Department of Interior/New York State Department of Conservation, 1961: Preservation of Hempstead and South Oyster Bay Wetlands. U. S. Bureau of Sport Fisheries and Wildlife, Boston, Mass.

17. Wilkins, Bruce T., 1967: Outdoor Recreation and the Commercial Fishery in the Town of Southold. Department of Conservation, New York State College of Agriculture, Ithaca, N. Y., June.

Introduction

In the absence of man's intervention. natural processes will demonstrably alter landforms in the coastal zone. Figure 3, which shows temporal variations in the form of East Rockaway Inlet, dramatizes the extent of possible change.

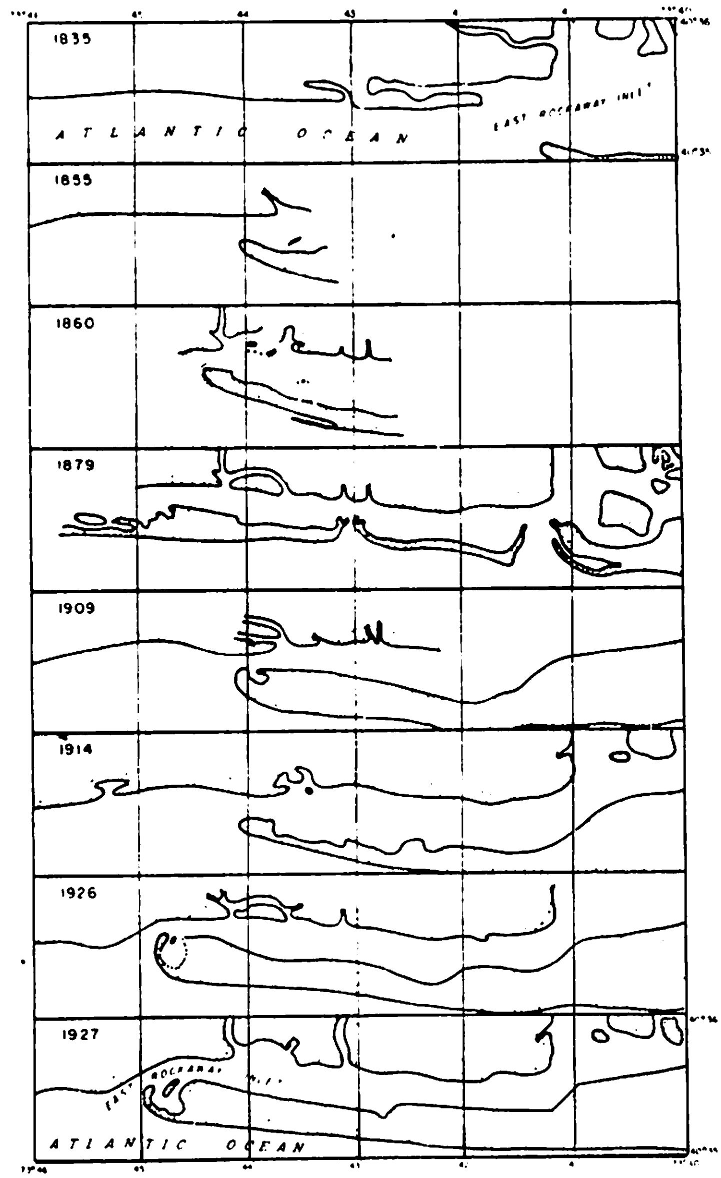


Fig. 3. Shoreline changes, East Rockway Inlet, New York (after U. S. Army, as presented by Wiegal [8, p. 379]).

The various processes bringing about such changes have been succinctly described by Wiegel [9, p. 344] as follows:

> [Shore changes] ...may be relatively slow, such as the erosion by waves of resistant headlands or coral reefs; they may be rapid, as the erosion of a beach foreshore during the course of a storm which lasts perhaps but a few hours; they may occur at intermediate rates, like the building of dunes by winds along sections of beaches being furnished a surplus of sediments by littoral drift; shore changes may also alternate, receding in winter and advancing in summer, or between spring and neap tides. Whatever the physical causes and whatever the rate, all shores are changing constantly.

The impacts of the natural destruction of coastal areas can be quite diverse. Such impacts include loss of life and property by storm-induced wave overtopping and the loss of shore front recreation opportunities by beach erosion. Also, changing landforms influence water circulation patterns in bays and estuaries, with consequent effects on salinity and temperature profiles and on the ability of coastal waters to disperse wastewater discharges. Consequently, changes in the type of biological species present may also be expected.

There are several structural methods to control the direction and rate of change of coastal landforms or to minimize the impacts of storm inducted wave action. These include [9, Chapter 17]:

- Breakwaters—to cause reductions in wave height.
- Seawalls—to maintain a fixed barrier between land and sea, and to prevent overtopping by water.
- Jetties—to confine and direct river or tidal flow at estuary entrances and thereby induce channel scouring to maintain specified depths.
- Groins—to prevent or retard the erosion of an existing beach, or to provide a beach where none exists.

An additional technique for controlling coastal landforms involves the use of dredges to remove and redeposit bottom materials (e.g., sand pumping for beach replenishment). Also, a host of non-structural measures exist for controlling landforms (e.g., dune stabilization by planting vegetative cover) and reducing the extent of property damage from storms (e.g., restrictive zoning for uses of shorefront land, and denial of insurance protection to homeowners building in flood plains).

Evaluation of Problem

We have outlined briefly the causes of coastline modification, the means to control it, and some of the potential impacts on activities and characteristics of the coastal zone. Specific issues concerning the Nassau-Suffolk region are discussed below. One such issue is the damage resulting from intermittent hurricanes and storms. Severe storms in September, 1938 and March, 1962 resulted in danger to life and substantial damage to property, especially along the barrier beaches on the south shore [5]. Damage from the storm of 1962 along the Atlantic shoreline of New York State included "the destruction or loss of hundreds of homes, the erosion of miles of protective dunes and beach front, destroyed streets and roads, boardwalks and other facilities and properties..." [7, p. 1].

Problems also result when south shore bay inlets are shoaled or closed by drifting materials, causing interference with navigation and tidal exchange. Tidal exchange is of critical importance for the flushing and dilution of materials in wastewaters discharged to south shore bays, and there has been considerable discussion in favor of stabilizing Moriches and Shinnecock Inlets [7, p. 22; 8, pp. 295—298]. While such a stabilization program might improve navigation and bay flushing, there is some question regarding the impact of consequent changes in salinity on biological activity (notably shellfish production) in these bays [8, pp. 268, 457—462].

Beach erosion, including the complete breakthrough of south shore barrier beaches, is also an issue. Although beach erosion is accelerated by storm conditions, it also results from continuous natural processes. Beach erosion and breakthrough problems as of 1962 are discussed in reference [7]. Recently (1969), Levine [3] described a potential barrier beach breakthrough in the vicinity of the

Ocean Beach water tower. The use of sand replenishment and groins are being considered in efforts to stabilize this zone.*

One especially noteworthy aspect of the coastline stabilization problem concerns the use of public funds for private purposes. The Temporary State Commission on Protection and Preservation of the Atlantic Shore Front described the situation as follows:

> There is no excuse for spending large sums of public money to improve vacant, privately owned barrier beaches for easy minute subdivision and huge profits. Nor is it justifiable under the head of disaster to repair at public expense summer houses built too close to the ocean and badly planned boardwalks and utilities. A total of over $22,000,000 of state and local funds has been spent on beach protection since 1945. This entire expenditure has afforded only temporary relief and has been of little permanent value [7, p. 18].

Public Policy Background

Responsibilities for stabilizing the coast and minimizing property damage from storms are shared by Federal, state and local government agencies. The Corps of Engineers [1] has an active program in shore erosion control and storm protection; their programs often involve cooperative funding between Federal, state, and local agencies. On the state level, the Superintendent of Public Works is authorized to construct "erosion control works upon lands and lands under water owned by political subdivisions, along the Atlantic coast and the shores of Long Island..." [2, p. 105].

Local governments participate in coastline stabilization efforts to the extent that they share the costs of projects undertaken by the Corps of Engineers or the State Department of Public Works. Local governmental agencies also participate by means of town or county dredging programs. In terms of non-structural controls, local governments can influence the extent of storm damages by restrictive zoning of shorefront lands.

*There is a noteworthy interdependence between dredging activities and coastline stabilization. Information on the former is contained in the section on Dredging.

Major coastline stabilization activities planned for the south shore are noted in the 1968 Suffolk County Annual Report. The report indicates:

> Negotiations are in progress with the Army Corps of Engineers for the construction of at least six additional erosion-prevention groins on the Atlantic shorefront, together with dune reconstruction relative thereto.
>
> Continuous negotiation with the Federal government is in progress for the rebuilding of both Shinnecock and Moriches Inlets [6, p. 11].

Indicated Information Needs

In developing programs for coastline stabilization, information concerning the details of design of structural and non-structural stabilization methods is needed. The technology of structural measures for controlling coastal landforms is well established, and well known to engineers. (See, for example, Wiegel's Oceanographical Engineering [9]). Information relating to non-structural means of coastline stabilization is also available, but appears, according to McHarg [4, p. 7], to be little used.

Other relevant information includes the ability to estimate the impact of proposed stabilization programs on such factors as circulation patterns, salinity and water temperature. An understanding of how changes in these factors influence waste dispersion and biological activity is also important.

Available information should be utilized in formulating an overall stabilization and land use plan for the coastal zone. In this connection, note that the report of the Temporary Commission on Protection and Preservation of the Atlantic Shorefront [7] contains a description of problems and proposed solutions for the south shore. We have not been able to identify similar documentation for the north shore; such a study would be worthwhile.

Selected References

1. Caldwell, J. M., 1969: Corps of Engineers Programs in Coastal Waters, presented at Annual Meeting, National Security Industrial Association, Ocean Science and Technology Advisory Committee, Washington, D. C., April 23—24, 1969.

2. George Washington University, 1962: Shoreline Recreation Resources of the United States. Report prepared for the Outdoor Recreation Resources Review Commission. Rpt. No. 4, U. S. Government Printing Office, Washington, D. C.

3. Levine, H., 1969: Statement at public hearing on water pollution and estuarine protection, New York Joint Legislative Committee on Environmental Management and Natural Resources, Mineola, Long Island, New York. October 23, 1969.

4. McHarg, I. L., 1969: Design with Nature, (Garden City, New York, Natural History Press.)

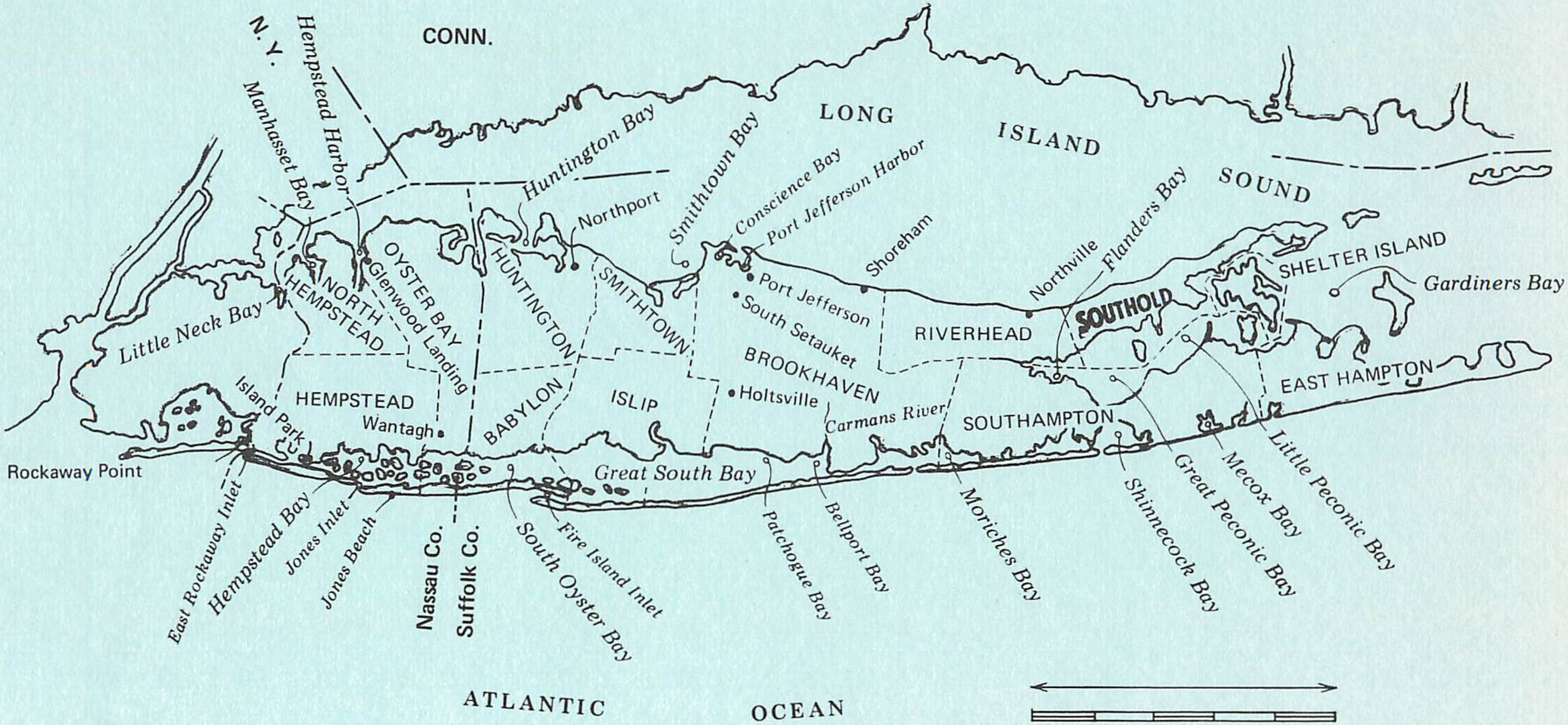
5. Perdikis, H. S., 1967: Hurricane flood protection in the United States, Proceedings. Amer. Soc. of Civil Engrs., Journal of Waterways and Harbors Division, Vol. 93. No. WW1. February, pp. 1—24.

6. Suffolk County, 1968: Annual Report to the Suffolk County Board of Supervisors, Office of the County Executive, Riverhead, Long Island, New York.

7. Temporary State Commission on Protection and Preservation of the Atlantic Shorefront, 1962: The protection and preservation of the Atlantic shorefront of the State of New York—Final Rpt, Albany, New York.

8. U. S. Department of Interior, FWPCA, 1966: Proceedings, conference in the matter of pollution of the navigable waters of Moriches Bay and the Eastern Section of Great South Bay and their tributaries, Patchogue, New York, September 20—22, 1966.

9. Wiegel, R. L., 1964: Oceanographical engineering, (Englewood Cliffs, New Jersey, Prentice-Hall, Inc.)


CONN.
N. Y.
LONG ISLAND SOUND
Hempstead Harbor
Manhasset Bay
Huntington Bay
Smithtown Bay
Conscience Bay
Port Jefferson Harbor
Shoreham
Northport
Flanders Bay
Northville
SHELTER ISLAND
Gardiners Bay
SOUTHOLD
RIVERHEAD
Port Jefferson
South Setauket
BROOKHAVEN
Holtsville
Carmans River
SMITHTOWN
HUNTINGTON
OYSTER BAY
Glenwood Landing
NORTH HEMPSTEAD
Little Neck Bay
HEMPSTEAD
Wantagh
Island Park
BABYLON
ISLIP
Great South Bay
SOUTHAMPTON
EAST HAMPTON
Rockaway Point
East Rockaway Inlet
Hempstead Bay
Jones Inlet
Jones Beach
Nassau Co.
Suffolk Co.
South Oyster Bay
Fire Island Inlet
Patchogue Bay
Bellport Bay
Moriches Bay
Shinnecock Bay
Great Peconic Bay
Mecox Bay
Little Peconic Bay
ATLANTIC OCEAN