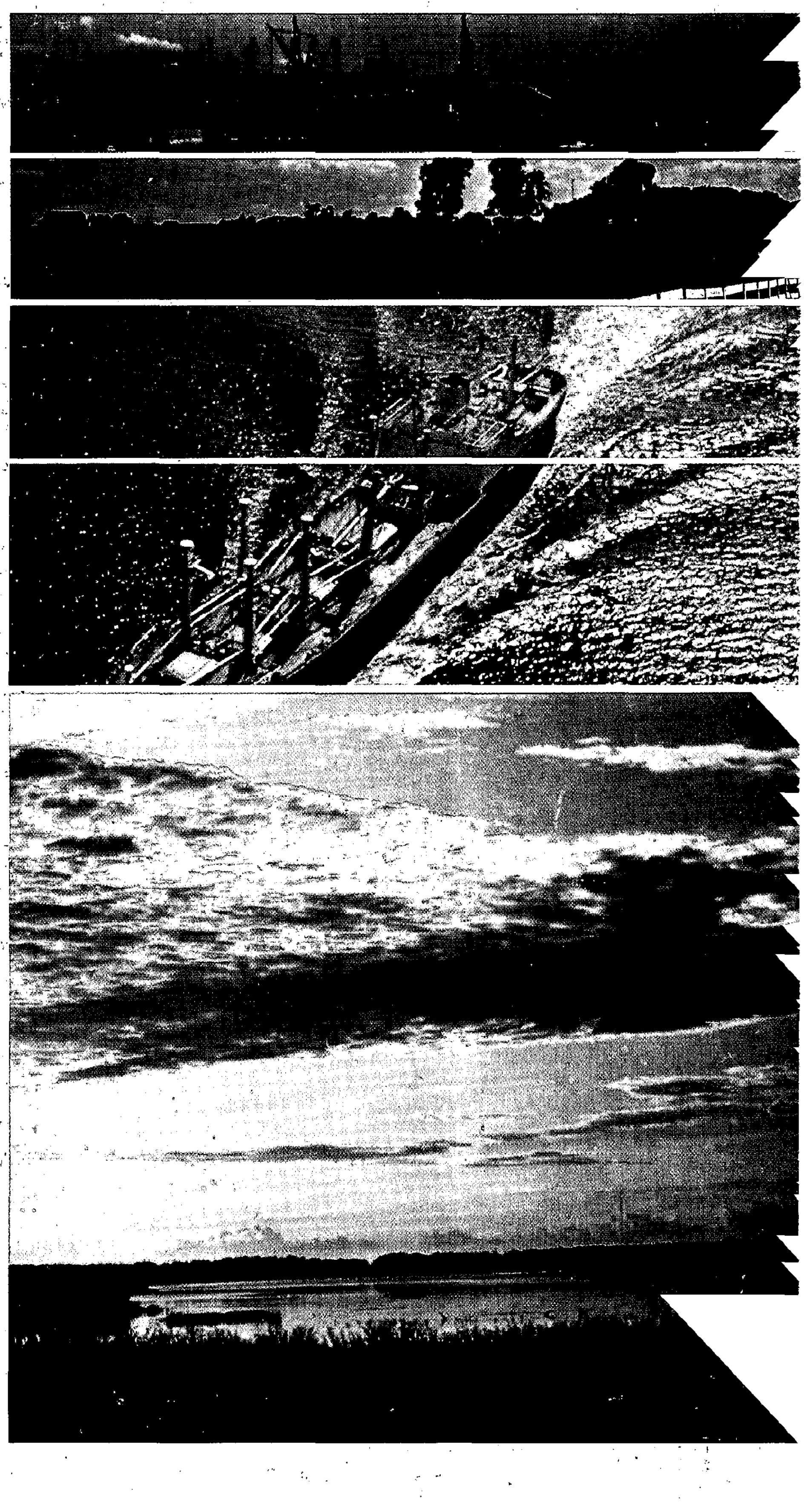
VOLUME 9
Fish and Wildlife



U.S. Army Corps of Engineers

Chesapeake Bay
FUTURE CONDITIONS REPORT

PREFACE

The Corps of Engineers' comprehensive study of Chesapeake Bay is being accomplished in three distinct developmental stages or phases. Each of these phases is responsive to one of the following stated objectives of the study program.

1. To assess the existing physical, chemical, biological, economic and environmental conditions of Chesapeake Bay and its related land resources.

2. To project the future water resources needs of Chesapeake Bay to the year 2020.

3. To formulate and recommend solutions to priority problems using the Chesapeake Bay Hydraulic Model.

In response to the first objective of the study, the initial or inventory phase of the program was completed in 1973 and the findings were published in a document titled Chesapeake Bay Existing Conditions Report. Included in this seven-volume report is a description of the existing physical, economic, social, biological and environmental conditions of Chesapeake Bay. This was the first published report that presented a comprehensive survey of the entire Bay Region and treated the Chesapeake Bay as a single entity. Most importantly, the report contains the historical records and basic data required to project the future demands on the Bay and to assess the ability of the resource to meet those demands.

In response to the second objective of the study, the findings of the second or future projections phase of the program are provided in this the Chesapeake Bay Future Conditions Report. The primary focus of this report is the projection of water resources needs to the year 2020 and the identification of the problems and conflicts which would result from the unrestrained growth and use of the Bay's resources. This report, therefore, provides the basic information necessary to proceed into the next or plan formulation phase of the program. It should be emphasized that, by design, this report addresses only the water resources related needs and problems. No attempt has been made to identify or analyze solutions to specific problems. Solutions to priority problems will be evaluated in the third phase of the program and the findings will be published in subsequent reports.

The Chesapeake Bay Future Conditions Report consists of a summary document and 16 supporting appendices. Appendices 1 and 2 are general background documents containing information describing the history and conduct of the study and the manner in which the study was coordinated with the various Federal and State agencies, scientific institutions and the public. Appendices 3 through 15 each contain information on specific water and related land resource uses to include an inventory of the present status and expected future needs and problems. Appendix 16 focuses on the formulation of the initial testing program for the Chesapeake Bay Hydraulic Model. Included in this appendix is a description of the hydraulic model, a list of problems considered for inclusion in the initial testing program and a detailed description of the selected first year model studies program.

The published volumes of the Chesapeake Bay Future Conditions Report include:

Volume Number	Appendix Number and Title
1	Summary Report
2	1 - Study Organization, Coordination and History 2 - Public Participation and Information
3	3 - Economic and Social Profile
4	4 - Water-Related Land Resources
5	5 - Municipal and Industrial Water Supply 6 - Agricultural Water Supply
6	7 - Water Quality
7	8 - Recreation
8	9 - Navigation 10 - Flood Control 11 - Shoreline Erosion
9	12 - Fish and Wildlife
10	13 - Power 14 - Noxious Weeds
11	15 - Biota
12	16 - Hydraulic Model Testing

CHESAPEAKE BAY FUTURE CONDITIONS REPORT

APPENDIX 12

FISH AND WILDLIFE

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

LIST OF PHOTOGRAPHS

LIST OF PLATES

LIST OF PLATES (CONTINUED)

CHAPTER I

THE STUDY AND THE REPORT

The Chesapeake Bay Future Conditions Report is a portion of a comprehensive study program to provide information which will aid in the development of management policies for the Bay region. In order to provide an understanding of the organization, the relative function of this report, and the relationship to the total Bay study program, this chapter will describe the authority under which the Bay study program was implemented, the purpose of the study, its scope, the supporting studies which were used as the basis of much of the information contained herein and the study participants and coordination.

AUTHORITY

The authority for the Chesapeake Bay Study and the construction of the hydraulic model is contained in Section 312 of the River and Harbor Act of 1965, adopted 27 October 1965. Additional authorization for completion of the study was provided in Section 3 of the River Basin Monetary Authorization Act of 1970, adopted 19 June 1970. Funding for the Fish and Wildlife Service and National Marine Fisheries Service was supplied through the U. S. Army Corps of Engineers. Congressional authorization for such activities on the part of the U. S. Fish and Wildlife Service is supplied by Section 1 of the Fish and Wildlife Coordination Act of 1958.

> SECTION I - For the purpose of recognizing the vital contribution of our wildlife resources to the Nation, the increasing public interest and significance thereof due to expansion of our national economy and other

> factors, and to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through the effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation for the purposes of this act in the United States, its territories and possessions, the Secretary of the Interior is authorized (1) to provide assistance to, and cooperate with federal, state, and public or private agencies and organizations in the development, protection, rearing and stocking of all species of wildlife, resources thereof, and their habitat, in controlling losses of the same from disease or other causes, in minimizing damages from overabundant species, in providing public shooting and fishing areas, including easements across public lands for access thereto, and in carrying out other measures necessary to effectuate the purposes of this Act; (2) to make surveys and investigations of the wildlife of the public domain including lands and waters or interests therein acquired or controlled by any agency of the United States; and (3) to accept donations of land and contributions of funds in furtherance of the purposes of this Act.

PURPOSE

Previously, measures taken to utilize and control the water and land resources of the Chesapeake Bay Basin have generally been oriented toward solving individual problems. The Chesapeake Bay Study provides a comprehensive study of the entire Bay Area in order that the most beneficial use may be made of the water-related resources. The major objectives of the Study are to:

a. Assess the existing physical, chemical, biological, economic, and environmental conditions of Chesapeake Bay and its water resources.

b. Project the future water resources needs of Chesapeake Bay to the year 2020.

c. Formulate and recommend solutions to priority problems using the Chesapeake Bay Hydraulic Model.

The Chesapeake Bay Existing Conditions Report, published in 1973, met the first objective of the Study by presenting an overview of the Bay

Area and the economy; a survey of the Bay's land resources and its use; and a description of the Bay's life forms and hydrodynamics.

The purpose of the Future Conditions Report is to provide a format for presenting the findings of the second phase of the Chesapeake Bay Study. Satisfying the second objective of the Study, the report describes the present use of the resource, presents the demands to be placed on the resource to the year 2020, assesses the ability of the resource to meet future demands, and identifies additional studies required to develop a management plan for Chesapeake Bay.

This particular volume, Appendix 12, deals with the fish and wildlife resources of the Bay Area. The information provided includes an existing conditions summary, a fish and wildlife demands and needs analysis, a problems and conflicts analysis, and a recommended research program for fish and wildlife resources. The purpose of this Appendix then, is to present existing natural resource information in a collated and coordinated form for use in determining the potential for impact on fish and wildlife by planning and management activities within interfacing resource use categories and to allow the minimization of such impacts.

SCOPE

The scope of the Chesapeake Bay Study and Future Conditions Report includes the multi-disciplinary fields of engineering and the social, physical, and biological sciences. The Study is being coordinated with all Federal, State, and local agencies having an interest in Chesapeake Bay. Each resource category presented in the Future Conditions Report projects demands and potential problem areas to the year 2020. All conclusions are based on historical information supplied by the preparing agencies having expertise in that field. In addition, the basic assumptions and methodologies are quantified for accuracy in the sensitivity section. Only general means to satisfy the projected resource needs are presented, as specific recommendations are beyond the scope of this report.

Investigations for study implementation have been limited to collation and interpretation of existing data sources. This minimal approach was necessitated by funding, manpower and time limitations and was thought to be the most valuable use of available resources. Original research and independent studies were not within the funding scope of this study. The major thrust was to provide generalized information and interpretations of that information for use by resource managers and management agencies. Accordingly, a "broad brush" approach has been used throughout this Appendix except where specialized problems can be better illustrated by detailed information and analysis.

This appendix deals with the fish and wildlife needs of the Chesapeake Bay Area. Included are projections of the expected demands on the commercially important fisheries. Also included are expected consumptive and non-consumptive demands on the Region's wildlife resources. The majority of the information in this appendix is not species specific. For more detailed information on a species by species basis, the reader is referred to Appendix 15 - Biota.

SUPPORTING STUDIES

The information which has been compiled for inclusion in the Future Conditions Report was gathered from several reference sources as well as through personal communications with authorities on various subjects. The major portions of baseline information were obtained from the Chesapeake Bay Existing Conditions Report Appendixes (1), Water Quality Conditions in the Chesapeake Bay System (2), North Atlantic Regional Water Resource Study (3), and an analysis of future demands, supplies, prices and needs for fishery resources of the Chesapeake Bay (4), which was contracted to Dr. R. J. Marasco through the National Marine Fisheries Service. Numerous additional studies were used as references for the various specific sections within this report. A bibliography is included at the end of this Appendix.

STUDY PARTICIPANTS AND COORDINATION

The Fish and Wildlife Coordination Group is responsible for preparing the Fish and Wildlife Appendixes for all segments of the Comprehensive Study. Additionally, the Coordination Group functions to coordinate other task group efforts as they relate to fish and wildlife resources. Fish and wildlife data is supplied to other groups regarding specific problem areas upon request.

Coordination Group membership is made up of representatives from U.S. Department of the Interior, U.S. Army Corps of Engineers, U.S. Department of Commerce, U.S. Environmental Protection Agency, District of Columbia, and the states of Delaware, Pennsylvania, Maryland, and Virginia. The lead agency is U.S. Department of the Interior, U.S. Fish and Wildlife Service. Primary responsibility for inputs to the Fish and Wildlife Study lie with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. Responsibility for final report coordination and production lies with the U.S. Fish and Wildlife Service.

CHAPTER II

FISH AND WILDLIFE IN THE CHESAPEAKE BAY REGION

A thorough description of the entire spectrum of fish and wildlife species, their relationship to Chesapeake Bay and to the activities of man which occur in the region is a task beyond the manpower and time limits of this study. Therefore, this chapter will discuss only the major factors which relate the utilization of all regional resources to the utilization of fish and wildlife resources in the Bay Area.

DESCRIPTION OF REGION

In order to provide a background knowledge of the fish and wildlife of the Bay, the description in this section is oriented toward those factors which have an effect upon or are related to the fish and wildlife resources or affect man's utilization of these resources.

THE CHESAPEAKE BAY REGION

In general, the study area is discussed in this Appendix includes the Chesapeake Bay, its tidal tributaries and adjacent uplands. However, due to the input from upstream sources and the effects of these inputs on the aquatic habitat, some consideration has been given to these upstream regions with respect to the changes that they produce in the environment of the Bay and its tributaries. The land areas within the Study Area extend from the fall line on the major rivers, Susquehanna, Potomac, and James, to the mouth of the Bay and include coastal portions of Maryland and Virginia (Figure 12-1). This land is situated physiographically in the Coastal Plain Province which extends from the fall line to the sea. The area is, in general, gently sloping toward the Bay and its tributaries, and contains a mixture of developed lands interspersed with hardwood and pine woodlands and agricultural lands. The shoreline areas are often developed and protected by man-made structures such as bulkheads or riprap, or have a significant degree of erosion or are bounded by an area of marsh which provides protection from storm waves and fulfills the habitat requirements of numerous species of fish and wildlife. The aquatic environment of the Bay and its tributaries consist mostly of relatively shallow waters, with an average depth of about 21 feet, and a maximum depth of 174 feet near the southern end of Kent Island.

The Chesapeake Bay was formed during the last 15,000 years by the inundation of the mouth of the Susquehanna River as sea level rose. The Susquehanna is also the major source of fresh water flowing into the Bay. It has a drainage area of 27,510 square miles, which is about 43% of the total drainage of the Bay. The other major drainage basins are the Potomac with 23% of the total area, the James with about 16%, and the Rappahannock and York drainages with less than 5% each. (1)

RESOURCES

Aside from the fish and wildlife of the Bay, resources which serve the uses of man include the water supplies for municipal, industrial, and agricultural users, navigation as a foundation for commerce, mineral supplies, and a base for a variety of receational activities. Water supplies for the numerous users in the Bay area are derived from the many tributaries flowing into the Bay and from ground water reserves of several aquifers. Navigation to protected harbors on the tributaries of the Bay was one of the primary factors in the development of the area as a center for industry and population and has continued to be foremost in the priorities of development of shoreline areas. The tributaries of the Bay provide in some cases, hydroelectric power which has, with the advent of nuclear and fossil fuel plants, become only a minor portion of the power utilized within the Study Area. Mineral resources which are mined in the study area are primarily sand and gravel from both upland sites and along the river bottoms in the upper portions of some tributaries.

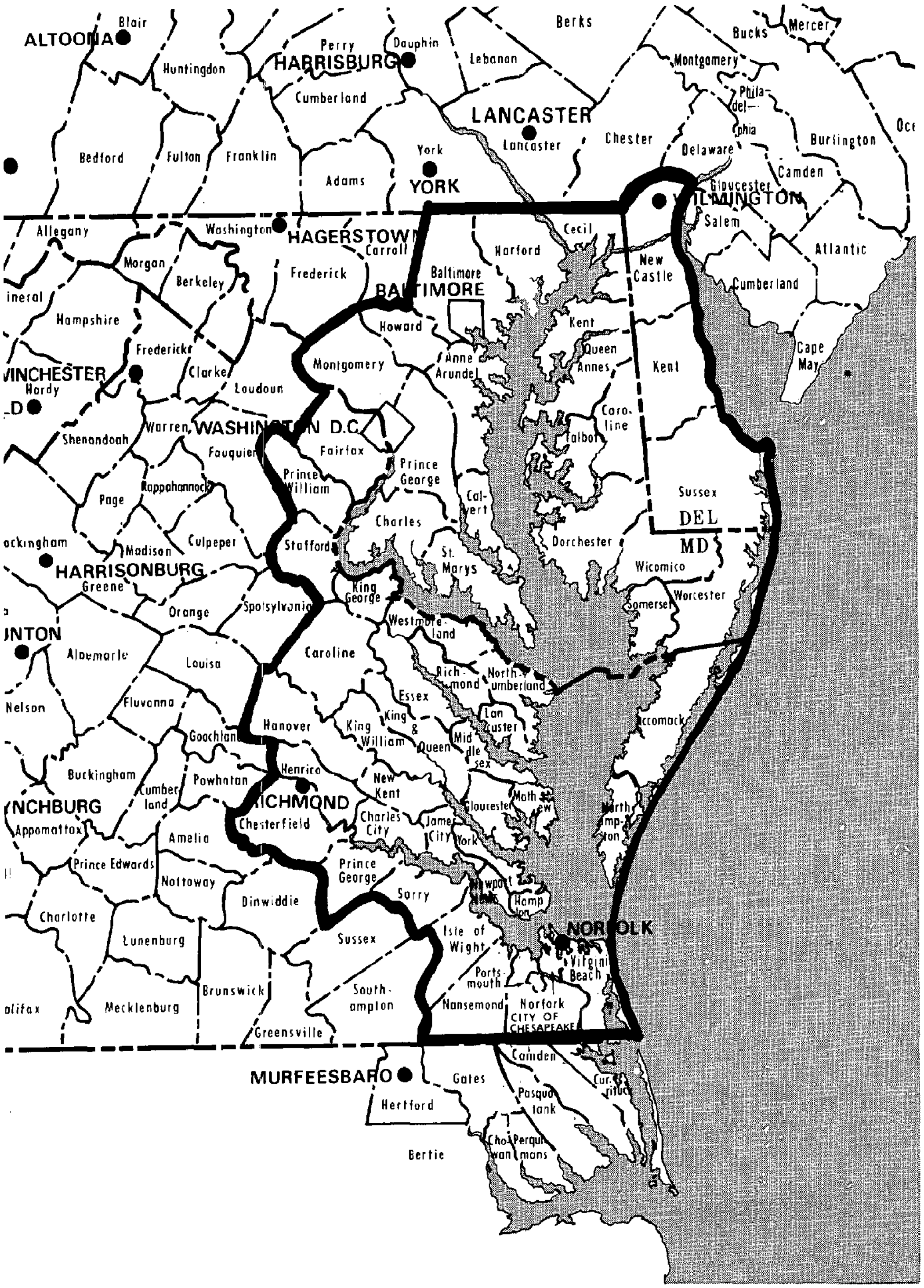


FIGURE 12-1
CHESAPEAKE BAY FISH AND WILDLIFE STUDY AREA

As a source of recreation, sites within the Study Area fulfill the requirements for camping, hiking, sailing, water skiing, and numerous other forms of recreation as well as the consumptive uses of fishing and hunting.

Intensive utilization of any of these resources by human development or activity presents a realized or potential threat to the maintenance of the fish and wildlife resources. The specific factors and the magnitude of their effects on the fish and wildlife resources of the Bay are discussed in the subsection on Existing Problems and Conflicts.

HISTORY

Prior to the arrival of the early European settlers, Chesapeake Bay provided the Indians of the region with an abundant supply of finfish and shellfish as well as game animals and birds from along its shores. The impact of the utilization by the Indians was very slight and the resources of the Bay must have seemed inexhaustible to them.

When the early European settlers arrived, the many tributaries and natural harbors along the Bay provided safe anchorages and access to inland communities which relied upon shipping for supplies and a market for much of their produce. The commercial craft of that era were relatively shallow draft and the natural channels allowed them access to sites near the fall line on the major tributaries where the cities with their accompanying industry began to develop. Since the arrival of the early settlers, many changes have occurred which have impacted the resources and their uses to varying degrees. Large residential, commercial and industrial developments have displaced marshlands and shallow shoreline habitats and the waste products from these developments have been discharged into the tributaries. The results of these changes vary, with the overall effect being the complete loss of some resources and the degradation of others.

In addition to the effects of development, the fisheries harvest has continually increased to its present level, where the maximum sustainable yield of some species has already been reached under current levels of technology and existing management practices. The harvest of other species is only maintained by strict management practices. In addition to the commercial harvesting of resources, there has, in the past two decades, been a large increase in the number of sport fishermen, and it is presently estimated that the recreational harvest of some finfish species is equal to or greater than the commercial harvest.

DESCRIPTIVE PUBLICATIONS

In the study of fish and wildlife resources of the Bay, there are several publications and reference materials which provide information of a specific nature regarding the Bay's resources. For example, if information regarding the land contours or water developments is required, topographic maps published by the U. S. Geological Survey or navigation charts published by the National Ocean Survey could be used. The states of Maryland and Virginia have both conducted wetlands surveys and have published volumes entitled "Wetlands in Maryland"[5] and "Coastal Wetlands of Virginia."[6] These two studies provide information on the productivity and utilization of wetlands in general as well as information on specific wetlands within the Study Area. Wetlands maps, which are aerial photographs with wetlands areas delineated, are used by the Maryland Department of Natural Resources to give rapid information as to which lands fall within their jurisdiction as state wetlands. The Virginia Institute of Marine Science is in the process of performing a tidal marsh inventory by county for those counties within the Study Area. At this time, the inventories have been completed for 11 cities and counties and work is continuing on the other county inventories. Additionally, in Virginia, county level Shoreline Situation Reports are being prepared which are designed to aid in the comprehensive planning of shoreline utilization. Journals and publications concerned with particular species, physical parameters and locations within the study area are numerous. Scientific reports and journals are published by the National Marine Fisheries Service (Oxford Laboratory), the Chesapeake Biological Laboratory (CBL), the Virginia Institute of Marine Science (VIMS), and the Chesapeake Bay Institute (CBI). The last three organizations mentioned above together with the Smithsonian Institution also work in conjunction with each other as the Chesapeake Research Consortium, Inc.

PRESENT STATUS

The present status of the fish and wildlife resources of the Bay region has been determined by evaluating several factors, including the consumptive utilization of the resources, the land and water based development and utilization which have affected these resources and the management programs which have been initiated to maintain the resources. In order to provide an understanding of the current status of fish and wildlife in the Study Area, this section is divided into three subsections which are: a) Present Resource Use; b) Existing Problems and Conflicts; and c) Management Responsibilities.

PRESENT RESOURCE USE

The current utilization of the Chesapeake Bay resources have been discussed to some degree in the Chesapeake Bay Existing Conditions Report as well as the National Survey of Fishing and Hunting[8] and surveys by state fish and game agencies. The information in this discussion is essentially a summary of that contained in the Existing Conditions Report. These resource uses are divided into four major categories, commercial utilization of fishery resources, commercial utilization of wildlife resources, non-commercial utilization of resources, and non-commercial non-consumptive utilization of resources.

COMMERCIAL UTILIZATION OF FISHERY RESOURCES

The commercial fisheries harvest of the Chesapeake Bay for both finfish and shellfish averaged about 127.5 pounds per acre from 1966 to 1970.[1] For some species the commercial fishing pressure can be increased without exceeding the maximum sustainable yield (MSY) while the MSY for other species (primarily shad) is already being exceeded. The production of oysters, which are the single most valuable commercial commodity in dollars per pound, is already being managed to the degree within the Bay that the commercial harvest is directly related to the management practices being applied.

The commercial fishery for finfish can be divided into two segments, industrial, including menhaden and alewives, and non-industrial or edible including striped bass, shad, catfish, white perch, spot, croaker and others.

Within the Study Area 82 percent of the finfish harvest by weight was of industrial species (mainly menhaden) which constituted 55 percent of the total value (Table 12-1).[1] Of the major edible fish species, striped bass accounted for 14 percent of the total value, spot and shad, about 4 percent each with other species, including white perch, yellow perch, flounder, catfish, and croakers, accounting for another 14 percent of the total commercial value.

The commercial shellfish harvest from the Bay and its tributaries consist of crabs, clams and oysters with oysters accounting for 68 percent of total value, crabs 20 percent, and clams 12 percent (Table 12-2). The harvest of shellfish species is highly variable.

TABLE 12-1
SUMMARY OF COMMERCIAL FISHERY HARVEST (1)
AVERAGE ANNUAL 1966-1970
CHESAPEAKE BAY AND TRIBUTARIES (EXCEPT SUSQUEHANNA RIVER BASIN)
(IN THOUSANDS)

WATER AREA	ACRES	FINFISH EDIBLE		FINFISH INDUSTRIAL		SHELLFISH[1,2]		TOTAL	
		Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Chesapeake Bay[3]	2,041	24,177	1,443	234,976	3,590	54,244	8,166	313,397	13,199
Chester River	35	436	54	6	Negl.	2,012	889	2,454	943
Choptank River	69	880	118	7	Negl.	4,800	1,730	5,687	1,848
Nanticoke River	18	506	67	24	1	537	236	1,067	304
Patuxent River	30	260	39	5	Negl.	896	500	1,161	539
Wicomico River	10	96	11	9	Negl.	143	93	248	104
Potomac River	310	11,006	590	3,974	73	10,543	4,673	25,523	5,336
Rappahannock River	98	4,898	219	1,993	35	7,498	2,005	14,389	2,259
York River	55	2,513	113	1,577	30	3,856	572	7,946	715
James River	166	4,695	264	1,125	20	3,834	4,398	9,654	4,682
Seaside[4]	214	745	56	10	Negl.	6,222	2,653	6,977	2,709
Total Study Area	3,046	50,212	2,974	243,706	3,749	94,585	25,915	388,503	32,638

[1]Seed oysters included in value but not in weight.
[2]Bivalve mollusks reported as pounds of meat.
[3]Bay proper exclusive of tributaries.
[4]Atlantic coast inshore waters of Maryland and Virginia.

TABLE 12-2
SUMMARY OF COMMERCIAL SHELLFISH HARVEST (1)
AVERAGE ANNUAL 1966-1970
CHESAPEAKE BAY AND TRIBUTARIES (EXCEPT SUSQUEHANNA RIVER BASIN)
(IN THOUSANDS)

WATER AREA	ACRES	CRABS		CLAMS		OYSTERS[1]		MISC.		TOTAL	
		Pounds	Dollars	Pounds[2]	Dollars	Pounds[2]	Dollars	Pounds	Dollars	Pounds	Dollars
Chesapeake Bay[3]	2,041	45,081	3,652	3,806	1,341	5,097	3,144	260	29	54,244	8,166
Chester River	35	306	29	707	268	985	590	14	2	2,012	889
Choptank River	69	2,276	212	219	69	2,281	1,445	24	4	4,800	1,730
Nanticoke River	18	179	15	-	-	347	219	11	2	537	236
Patuxent River	30	65	7	85	23	746	470	-	-	896	500
Wicomico River	10	-	-	-	-	143	93	-	-	143	93
Potomac River	310	3,385	317	971	277	6,186	4,079	1	Negl.	10,543	4,673
Rappahannock R.	98	5,052	390	49	11	2,378	1,600	19	4	7,498	2,005
York River	55	3,334	228	136	83	386	261	-	-	3,856	572
James River	166	2,140	156	45	28	1,595	4,203	54	11	3,834	4,398
Seaside[4]	214	3,495	307	1,597	923	1,126	1,421	4	2	6,222	2,653
Total Study Area	3,046	65,313	5,313	7,615	3,023	21,270	17,525	387	54	94,585	25,915

[1]Seed oysters included in value but not weight.
[2]Reported as pounds of meat.
[3]Bay proper exclusive of tributaries.
[4]Atlantic coast inshore waters of Maryland and Virginia.

With the possible exception of oysters, over-harvesting of these species has not become a problem due to the relatively short life cycles, high reproductive rates, and the response to management practices.

The number of persons actually engaged full or part time in commercial fishing in Maryland and Virginia in 1970 was approximately 17,150 with over 11,000 vessels being used for this activity on the Bay and its tributary waters. In Maryland, the primary fishing effort has been oriented toward shellfish with a lesser effort involved in finfish harvest while the opposite has been true in Virginia. The industry has developed a diversity of effort toward different species because of the distribution of the resource and legal methods of harvesting. For example, the soft shell clam is distributed in commercial quantities primarily in the northern portions of the Bay and is not an important commercial species in Virginia; and menhaden are harvested by purse seines in Virginia which are no longer legal in Maryland.

Numerous methods of harvesting shellfish and finfish have been developed and are presently used in the Chesapeake Bay area. The following list describes the types of gear used for harvesting oysters, crabs, clams, and finfish.[1]

(1) Oyster Gear

(a) Dredge - A metal triangular or oblong frame to which is attached a bag net made of iron rings, S-hooks, and/or cotton cording. The frame is equipped with a raking bar generally with teeth on the lower edge. There is no standard design for a dredge; however, the tooth bar must not exceed 44 inches in length in Maryland. Dredges are towed across oyster bars by sailing vessels or by power boats on private leases. (i.e. submerged lands leased by private individuals from the states for the cultivation of oysters).

(b) Hand Tongs - Actually a pair of rakes attached to the end of two long poles (up to 20 feet in length) which are fastened together similar to scissors. A basket-like frame is attached to the backside of each rake in order to retain the catch. Operated from a small boat usually with only one or two persons on board, the oysters are held between the heads of the tongs and lifted to the deck of the boat.

(c) Patent Tongs - Patent tongs are a modification of hand tongs. They are somewhat larger than hand tongs and require hydraulic power in conjunction with a mast and boom aboard the vessel.

Relative Importance - Tongs accounted for 73 percent of the total oyster harvest in Maryland (1967), with dredges accounting for the remaining 27 percent. In Virginia, dredges accounted for 53 percent of the catch while tongs accounted for 47 percent.

(2) Blue Crab Gear

(a) Crab Pot - Usually cuboidal in shape, 2 feet on each side, and made of 1 to 1 1/2 inch hexagonal mesh. The pot is divided into two chambers; a lower bait chamber which contains a bait holder and an inward opening as an entrance. The second chamber is a trap chamber located over the bait chamber. The pots are baited (usually with alewife or menhaden) and left overboard until the next day when they are hauled up by the buoy line, the crabs are taken out, the pot rebaited and returned to the water.

(b) Trotline - The hand-dip trotline is a baited, hookless line anchored on the bottom in moderate to deep water. Each end of the line is attached to a buoy and an anchor line. In harvesting the catch the line is run over a spool attached to the boat which brings the baited line to the surface; the crabs clinging to the bait are then quickly scooped up with a dip net as the boat proceeds along the line.

(c) Crab Dredge - A heavy dredge consisting of a rectangular iron frame, bearing a 6-foot toothed drag bar on its lower edge and trailing a mesh bag made up of rings and cotton twine (legal only in Virginia). Crabs are dredged during the winter months while hibernating in the mud of the lower portions of the Bay.

(d) Scrape - A rectangular metal frame fitted with a bag made of cotton and iron rings. The scraping bar lacks teeth. Generally, the scrape is lighter than an oyster dredge. This gear is used extensively in the Smith and Tangier Island (Tangier Sound) area and is particularly effective for taking soft crabs. Scrapes are generally used in relatively shallow areas especially around grass beds where soft crabs are abundant.

(e) Crab Pound Net - An enclosure constructed of stakes and nettings. The crabs enter the pound net on high tide and are harvested during the subsequent low tide.

(f) Seine - An encircling type of net made of mesh webbing. The top or float line has attached floats to keep the net at the surface while the bottom or foot line is weighted with lead to keep the net vertical in the water.

(g) Dip Net - A simple piece of gear fabricated from cloth mesh or wire which is suspended from a metal oval hoop and fitted with a handle of varying lengths.

Relative Importance - The major types of gear utilized in the Maryland hard crab fishery (1967) are crab pots and trotlines. Crab pots accounted for approximately 49 percent of the catch, while trotlines accounted for 44 percent. In Virginia, crab pots took 65 percent of the hard crab harvest in 1967, dredges 27 percent, and the remaining 8 percent by pound nets, scrapes, trotlines, and dip nets. Sport fishing with dip net, single crab pot, trotline, or seine is a very popular activity during the summer months in Chesapeake Bay and its tributaries. There are no data available, however, on sport fishing landing figures. A reasonable estimate may be 50 percent of the commercial landing figures.

(3) Clam Gear

(a) Escalator Dredge - The escalator dredge was developed for harvesting soft clams and was introduced into Maryland around 1951. The dredge is attached to a boat and is slowly pushed through the soft bottom sediments. Clams loosened from the sediment by a high pressure spray of water are washed or scooped onto the chain mesh conveyor belt. The belt then carries the clams to the crew where commercial sized clams are removed. This method accounts for virtually 100 percent of the harvest in Maryland. The soft clam is not an important commercial species in Virginia.

The hard clam fishery is not extensive in Chesapeake Bay and practically all of the commercial stocks are found in the higher salinity water of Virginia. Tongs and non-mechanical dredges are responsible for the greater percentage of landings, although in recent years, hydraulic dredges like those used for soft clams have become popular in the shallow coastal bays.

(4) Finfish Gear

(a) Haul Seine - An encircling type of net made of mesh webbing and consisting of two wings and a bunt or bag. The top line has floats to keep it at the surface while the bottom or foot line is weighted with leads. A haul seine is set to encircle any fish in the area enclosed. It is generally set from a motor or rowboat and hauled to the shore by hand or power winch.

(b) Purse Seine - An encircling type of gear designed to catch schooling species near the surface such as anchovies, mackerel, and menhaden. The net is a long wall of webbing without a prominent bunt or bag. The top edge is floated by a series of corks (cork line) and the bottom edge is weighted with a number of leads (lead line). The essential feature of this net is the pursing accomplished by closing a drawstring. Capture is effected by surrounding the school, pursing the bottom line, and concentrating the catch.

(c) Pound Nets - A pound net usually consists of an enclosure (the pound proper) with a netting floor, a heart shaped structure the point of which enters the pound and a straight wall (the leader or runner) which extends shoreward. Fish swimming along the shore are turned towards the pound by the leader, guided into the heart, and then into the pound where they are harvested.

(d) Fyke Net - A conical, cylindrical net distended by a series of hoops covered by wire mesh or webbing and having one or more internal funnel-shaped throats whose tapered ends are directed away from the mouth of the net. Leaders are attached at the mouth of the net which direct the fish into the throat of the net.

(e) Gill Net - A gill net is an upright fence of netting in which the fish are caught in the meshes of the net. Various sizes of mesh are used depending on the species and size of the fish to be caught. Fish of the size for which the net is designed swim into the net and pass only part of the way through the mesh. When the fish struggles to free itself, the twine slips back under the gill cover and prevents the fish from escaping. Gill nets can be suspended at the surface, in midwater, or close to the bottom by controlling the number of buoy lines and the size and number of floats on the cork lines and weights on the lead lines.

(f) Anchor Gill Net or Stake Gill Net - The gill net is held in place either by anchors or stakes and generally set at right angles to the current.

(g) Drift Gill Net - The gill net is free-floating and fished at the surface or at intermediate depths. The gear is usually set across the current and attended by a fishing craft from which the net is periodically lifted.

Included in the economic aspects of commercial utilization of the Bay resources are the processing and wholesaling sectors of the fishing industry. In 1970, there were a total of 217 processing plants in the Chesapeake Bay area. Of these firms, 96 were located in Maryland and 121 in Virginia. The largest percentage of those in Maryland (85%) were sited on the Eastern Shore while in Virginia 75 percent were located on the Western Shore. Employment by these firms averaged 6,840 workers per month in 1970. Some of the labor force involved in seafood processing work on a seasonal basis; however, the importance of this seasonal employment in both Maryland and Virginia has decreased since 1966 such that the employment level is becoming stable on a year round basis.

COMMERCIAL UTILIZATION OF WILDLIFE RESOURCES

A significant resource of the Bay basin area but one that is often overlooked is the furbearing mammals of the wetland and terrestrial habitats found within the Study Area. Furbearer species commonly trapped in the Study Area are beaver, gray fox, red fox, mink, muskrat, opossum, otter, raccoon, skunk, weasel, and nutria. The muskrat is of primary economic importance since it provides more than half the income collected by Bay trappers. Table 12-3 presents information on the 1971-1972 fur harvest season in Maryland and Virginia. Although this information is not restricted solely to the Study Area

TABLE 12-3
1971-1972 FUR HARVEST, MARYLAND AND VIRGINIA*

Species	Harvest Maryland	Harvest Virginia	Total Harvest Md. & Va.	Value/Pelt**	Value Harvest
Beaver	181	4,883	5,064	27.50	$139,260
Gray fox	490	2,640	3,130	3.75	11,737
Red fox	600	1,687	2,287	9.00	20,583
Mink	310	2,146	2,456	6.00	14,736
Muskrat	277,608	146,905	424,513	2.42	1,027,321
Nutria	1,454	-	1,454	2.00	2,908
Opossum	1,383	5,885	7,268	.75	5,451
Otter	360	648	1,008	40.00	40,320
Raccoon	18,222	28,877	47,099	4.75	223,720
Skunk	166	249	415	1.50	622
Weasel	28	62	90	.50	45
Bobcat***	E	82	82		
Value of muskrat meats (estimate based on Maryland scale)					318,384
Value of raccoon and nutria meats (estimate based on Maryland scale)					21,848
Total value of fur harvest and meats, Maryland and Virginia					$1,826,937

*Harvest for Maryland and Virginia compiled from Maryland Wildlife Administration and Virginia Division of Game data.
**Value/pelt is based on Maryland Survey.
***Bobcat is not trapped in Maryland and is considered Endangered. (E)

and includes all of Maryland and Virginia, a major portion of the total catch did originate from the Bay and its tidal tributaries. It should be noted that the approximately one million eight hundred thousand dollar value placed on the fur harvest for the 1971-1972 season represents money paid trappers and does not represent economic activity generated in the processing and retailing sectors of the industry. Such "value added" economic data is not readily available.

A brief discussion of some furbearer life histories and their Bay Study Area distribution is provided. Their economic importance, their relationship to highly vulnerable Bay area wetland habitat, or their potential to become a nuisance species is a very necessary part of any report outlining wildlife resources of the Bay area. General information contained in the life history section was compiled from the following sources: Trippensee, 1953; Hamilton, 1963; Paradiso, 1969; and Burt and Grossenheider, 1964. Specific information regarding muskrat distribution and food habits came from Willner, Goldsberry and Chapman, 1974 and Dozier, 1947. Nutria information was supplied by Goldsberry, Maryland Wildlife Administation, and Settle, Virginia Game and Inland Fisheries.

Muskrat: (Ondatra zibethicus)

Distribution: The muskrat is the most abundant of commercially valuable furbearers. They are found throughout the Study Area but largest populations are concentrated in the extensive brackish water marshes such as are found along the lower Eastern Shore tributaries.

Diet: Muskrats are principally herbivorous. Their chief food plants are cattails, three squares, arrowhead and many other aquatic and marsh plants. Recent food habit studies by the Maryland Wildlife Administration indicate that many forms of filimentous algae constitute an important portion of the diet under certain conditions.

Breeding: The muskrat in the Bay area may conceive up to five litters during the quite long breeding season which extends from late January to October. Gestation is complete in approximately 30 days. The litter size ranges from one to nine and averages from four to five. After birth young and dependent on the mother's milk for only two to three weeks before they roam and feed on their own.

Otter: (Lutra canadensis)

Distribution: Universally distributed throughout the study area along streams, rivers, lakes, and marshes of the Chesapeake Bay.

Diet: Otter are carnivores feeding primarily on fish, shellfish, frogs, turtles and other aquatic organisms.

Breeding: The otter mating season is thought to occur in winter and early spring, although this has never been precisely determined. The young are normally born in mid-April to early May. The number of young per litter ranges from one to four. Only one litter is produced per year.

Nutria: (*Myocastor coypus*)

Distribution: Nutria are found along the Patuxent and Potomac Rivers on the Western Shore of Maryland. On the Eastern Shore they are found from the Chester River southward to the Pocomoke River. In Virginia, Nutria are restricted to the Back Bay area (Fairfax Settle p.c.). Figure 12-2 delineates the current distribution within the Study Area. The commercial fur farming industry of the 1940's is responsible for the introduction of this exotic species in Maryland. During the first years of their introduction, population levels remained very low and it appeared that Maryland's winters would keep the population in check. However, during the mid-1960's, increases in population began to be reported and presently population levels are extremely high in some areas. Blackwater National Wildlife Refuge recently reported approximately 8,900 nutria on less than 11,000 acres of marsh (Goldsberry p.c.).

Diet: Nutria consume a variety of aquatic plants and can be destructive unless properly managed. Additionally, nutria will feed on agricultural crops such as corn. A photograph taken at Blackwater National Wildlife Refuge demonstrates one nutria's taste for corn.

Breeding: Nutria produce two or three litters per year. Litter size ranges from seven to twelve young. Gestation period varies between 127 days and 134 days. Nutria are sexually mature at age five months. Mammae are located on the mother's back so that young can feed and travel in water immediately after birth. Because of their breeding potential and their potential impact to wetland habitat, native furbearers, and crop lands, the State of Maryland has instituted life history and management studies on the nutria.

Beaver: (*Castor canadensis*)

Distribution: Formerly beaver were found throughout the Study Area where suitable habitat existed. However, around the turn of the century beaver were nearly exterminated from their range. Today the beaver has been reintroduced through deliberate stocking programs and migration of populations in neighboring states. Presently its range extends over most of the western shore tributaries. Two separate populations exist on the upper eastern shore and the central eastern shore in Maryland.

Diet: As a vegetarian, the beaver feeds on sedges, rushes, various roots, tubers, the bark, leaves and twigs of bushes and trees. Its winter diet consists primarily of green branches of trees harvested and stored under water near the lodge.

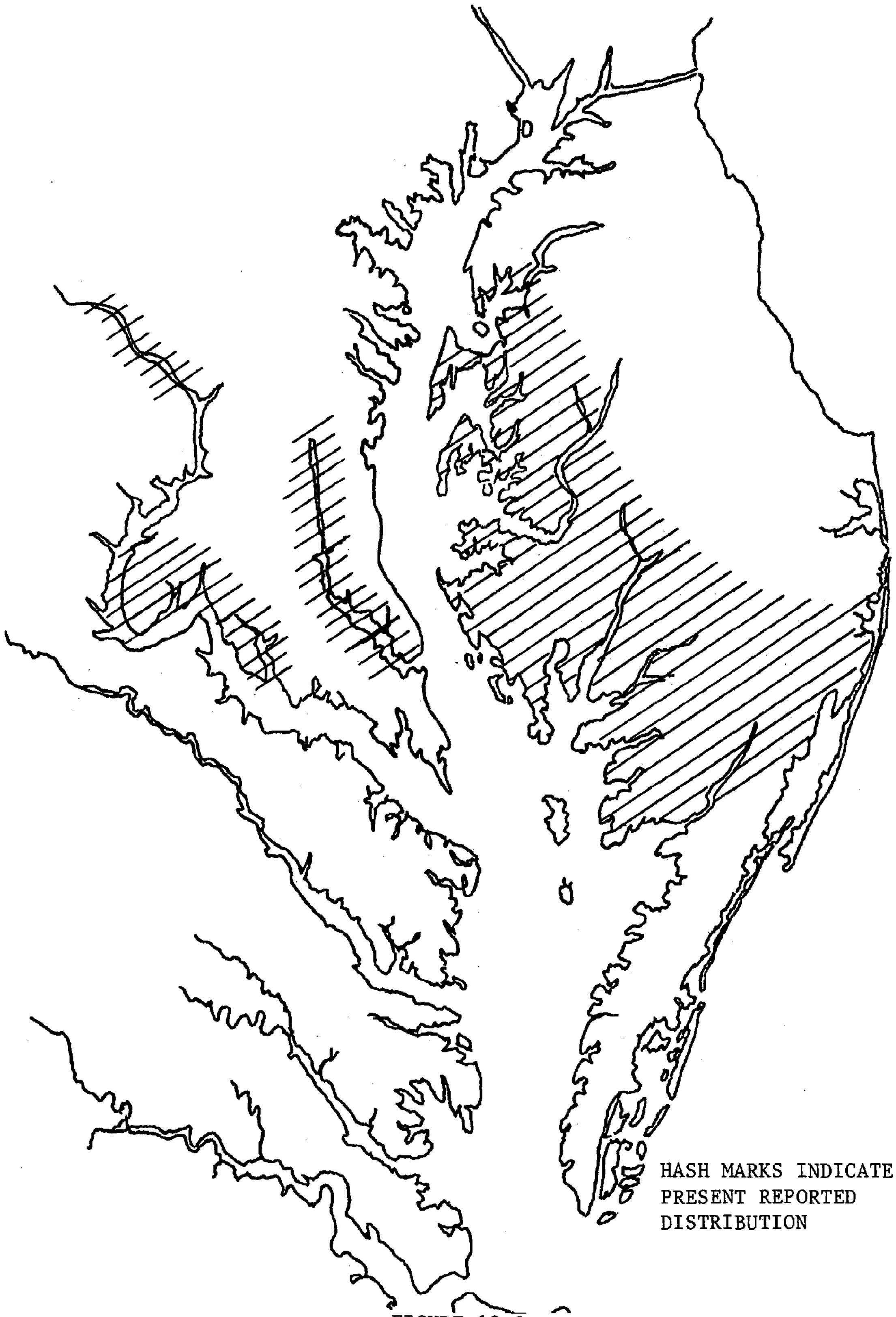


FIGURE 12-2
NUTRIA DISTRIBUTION IN CHESAPEAKE BAY STUDY AREA

NUTRIA EATING CORN

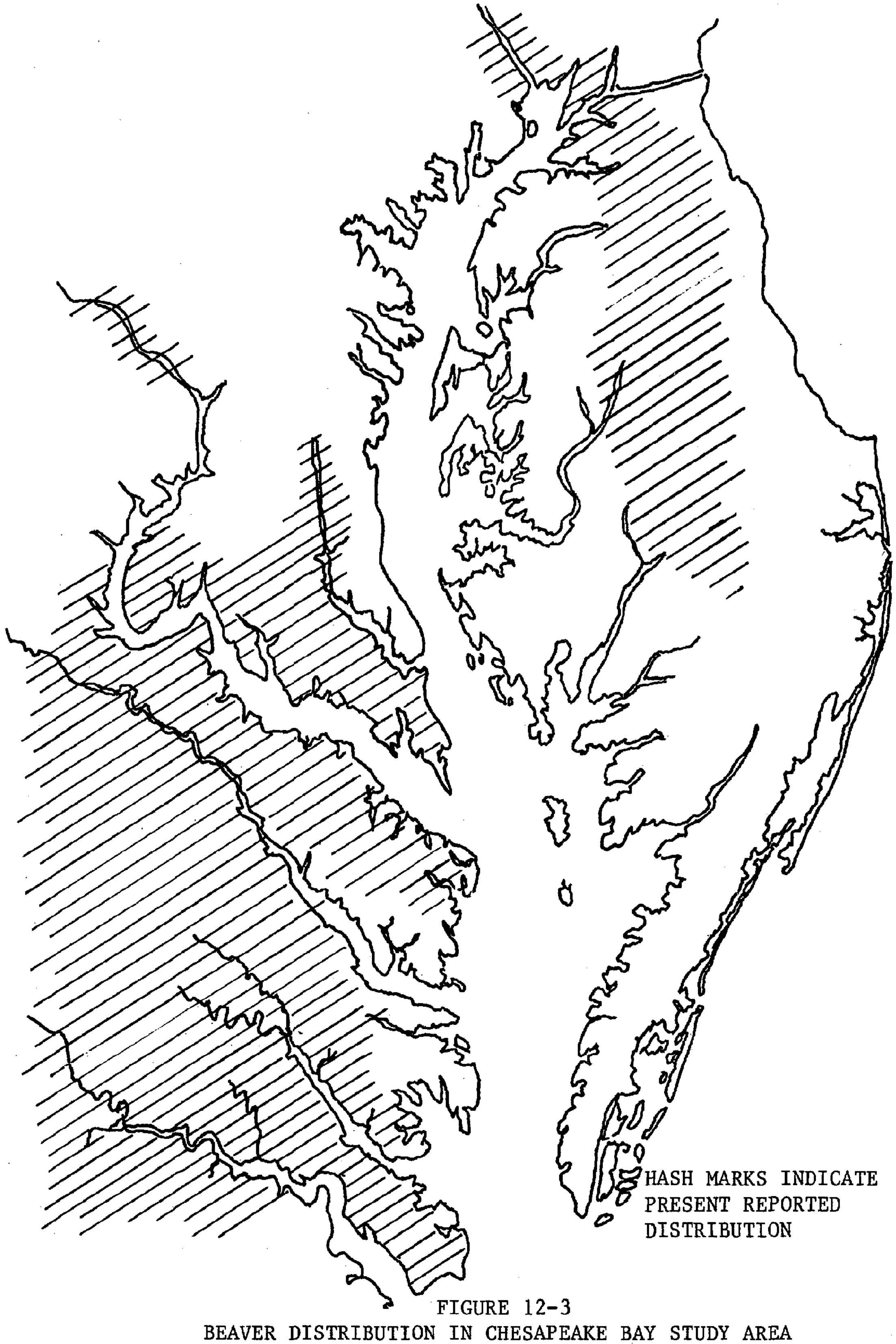


FIGURE 12-3
BEAVER DISTRIBUTION IN CHESAPEAKE BAY STUDY AREA

From personal communication with Jim Goldsberry and Fairfax Settle. On the Delmarva Peninsula, beaver were introduced by Delaware Game and Inland Fish Commission from Maine populations.

Breeding: It is believed these animals mate for life. Breeding occurs between mid-January and extends through February. Following a gestation period of approximately 120 days a litter varying in size from one to eight kits is produced. Only one litter is produced annually.

Opossum: (*Didelphis marsupialis*)

Distribution: The opossum occurs throughout the Study Area in wooded habitat. The opossum prefers low dense woodland near the water.

Diet: The opossum, being an opportunistic omnivore, consumes a wide variety of plants and animals. The foods taken are in the following order by frequency: insects; fruits; other invertebrates; mammals; reptiles; grains; birds and eggs. In addition, the opossum also eats carrion.

Breeding: Breeding normally begins in February. Gestation is short, taking approximately 13 days. The opossum gives birth to as many as eighteen young which are in a premature condition. The mother has but twelve mammae, therefore, any number above this are lost. Final development takes from four to five weeks. During this period others are lost so the number leaving the pouch environment after two months is narrowed to approximately seven to nine. The climate of the Chesapeake Bay area probably allows one litter per year.

Raccoon: (*Procyon lotor*)

Distribution: Universal distribution within the Study Area. The raccoon is common to all habitat types within the Bay Area and shows no marked preference for any specific habitat.

Diet: The raccoon is omnivorous, eating a variety of foods such as fish, crayfish, mussels, poultry, mice, birds, eggs, reptiles, and insects. Nuts, fruits, corn, berries, and other vegetable matter is eaten when available.

Breeding: Breeding takes place in January and February. Gestation takes about 63 days and the litter size varies from two to six young. Young raccoons are born blind and are suckled for about two months.

Mink: (*Mustela vison*)

Distribution: Found throughout the Study Area in diverse habitat types but is rarely found far from water.

Diet: The mink is carnivorous and feeds primarily on fish, frogs, aquatic insects, snakes, small mammals, and birds. In marshes where muskrats are abundant, mink may feed extensively on these rodents.

Breeding: Mating occurs from mid-February to early March. The gestation period lasts 42 to 44 days. Litter size varies from four to eight. Young are normally weaned at five weeks.

Long-tailed Weasel: (Mustela frenata)

Distribution: Universal distribution within Study Area. Prefers field borders, brushland, open woodland and woodland bordering cultivated fields and pastures.

Diet: The long-tailed weasel is a carnivore, consuming mice, rats, rabbits, squirrels, shrews, muskrats, and a small percentage of birds and reptiles.

Breeding: Mating occurs in July and August. Following a gestation period of approximately 279 days, six to eight young are born from mid-April to mid-May.

Striped Skunk: (Mephitis mephitis)

Distribution: The skunk is found throughout the Study Area, but is most abundant in the Piedmont sections. Striped skunk are scarce or lacking in many areas of the Eastern Shore. The skunk prefers brushland, sparce woods, weedy fields or pastures. It is common along brushy stream borders and thickets.

Diet: Although the skunk is a member of the order carnivora, plant material may comprise ten to twenty percent of its diet, with animal matter making up the bulk of its food intake. Of the animal matter consumed, insects form 50 percent with the remainder being rodents such as wood mice, meadow mice, squirrels and carrion of all types.

Breeding: The skunk is polygamous with mating occuring from February to March. The gestation period is 60 to 62 days. Between two and ten young are born in May or June.

Gray fox: (Urocyon cineoargenteus)

Distribution: Widely distributed throughout the Study Area. The animal is not abundant on the Eastern Shore. Prefers wooded areas, swamps and pine lands. The gray fox is an adept climber often taking to the trees when pursued by dogs.

Diet: As an omnivore, the gray fox consumes approximately 70 percent animal and 30 percent vegetable matter during the fall and early winter. Persimmon, corn, pear, apple, and beechnut make up its vegetable diet while a variety of rodents, rabbits, birds and insects make up its animal food.

Breeding: Breeding occurs once a year, usually in February. The gestation period is approximately 63 days. Two to seven young are born from March to May. The average litter size is four.

Red Fox: (Vulpes fulva)

Distribution: Universal distribution throughout the Study Area. Prefers farm land interspersed with wooded areas, marshes and streams.

Diet: Like the gray fox, the red fox is also omnivorous. During the fall, approximately 17 percent of red fox food consists of plant material. Persimmon, pokeberry, wild grape, and beechnut are common plant species consumed. Animal foods, primarily rabbit, rodents, and birds, make up the bulk of the red fox diet.

Breeding: The red fox is believed to have a single mate for life. Mating occurs in late January and February. Gestation varies between 49 and 55 days. Average litter size is four or five but can vary between one and eight. The young are weaned at approximately 16 weeks.

Factors affecting furbearer population levels and distribution are numerous and complex; however, some generalizations can be made. Food supply is, of course, an extremely important variable that has a major controlling influence over populations. Factors affecting food supply may be artificial (man induced) or natural phenomena.

Man-related impacts on wildlife food sources result from water pollution, wetland drainage, impounding or channelization for flood control or water supply purposes, conversion of habitat for industrial, commercial, and residential purposes, and a variety of other non-compatible practices. Water pollution in the form of acid mine drainage, for example, has resulted in the elimination of river otter along many reaches of the Potomac River. Low pH's have eliminated or reduced the quantity and diversity of fish and invertebrate populations to the extent that there is not enough food to support otter (Goldsberry, personal communication). Populations of other carnivora subsisting mainly on aquatic organisms must likewise be reduced in such situations. Drainage, channelization and filling result in the conversion of wooded swamp and marshland habitat to agricultural and urban uses of little or no value to the wildlife species that once existed there. The conversion of upland and wetland habitat to non-compatible land uses amounts to hundreds of acres per year in the Bay area.

Natural occurrences such as storms, droughts, wind tides and other climatic phenomena also result in impacts on food sources. In the Bay Area, salinity is a particularly important parameter in determining the organisms found in a given area. For example, muskrats prosper in brackish areas because of the availability of favored food plants that characterize the brackish water marsh. However, during prolonged droughts, salinities may be increased in these marshes as a result of evaporation and the influx of higher salinity Bay waters. Increased salinities result in the replacement of preferred brackish water food plants with salt tolerant species such as saltmarsh cordgrass and smooth cordgrass. Marshes characterized by this type of vegetation are of less value to muskrats and will not support large populations. This situation has occurred in the past and the resultant fluctuations in muskrat populations have been documented.

Although our native furbearer species are well adapted to severe winters, nutria, a species introduced from South America, is not. In the Bay area they are subject to wide fluctuations in population as a result of winter kill. Although a large population has built up over the past few years in response to mild winters, a severe winter would no doubt result in a significant winter mortality.

Diseases such as canine distemper and rabies also result in significant mortalities in some furbearer species. Fox, raccoons, opossums, and skunks are susceptible to such epidemics. During some years large portions of their populations have died as a result. In addition to the impact on wildlife, this can also create a serious human health hazard.

Another source of furbearer mortality is that which results from commercial trapping. In the past, unregulated trapping activities have severely impacted some populations. The beaver is a prime example. Nearly exterminated over much of its range by indiscriminant trapping and hunting, in conjunction with habitat destruction, it is only now being reestablished in areas where it was once abundant. It would, however, be a misconception to characterize trappers and the fur industry as a detrimental influence on our wildlife resources. Trapping regulations soundly based on an adequate body of biological knowledge of the individual species involved can only serve to sustain and enhance the resource. It should be noted, however, that for most furbearer species an adequate information base does not now exist and much basic life history research remains to be accomplished.

NON-COMMERCIAL UTILIZATION OF RESOURCES

Within the Study Area both population and available leisure time have been increasing during the past several years. Concurrent with these increases, there has been a parallel rise in the recreational fishing taking place on the Bay. Since the Bay offers quality fishing with a high success rate relative to other types of fishing in the region, a large percentage of the total fisherman days were spent on the Bay and its tidal tributaries. Recreational fishing accounts for a significant portion of the total landings for several species of fish within the Study Area. As illustrated in Table 12-4, sport fishermen harvest striped bass, weakfish, perch, spot, shad, croaker, and bluefish in quantities which are equal to or exceed those harvested commercially. Shellfish are also taken by a considerable number of people on a recreational basis. It has been estimated that blue crabs are sought by as many people as are game fish; however, the recreational catch of this species has not been accurately determined.

TABLE 12-4
SPORT AND COMMERCIAL CATCH FOR 1970

Species	Recreation catch[f] (lbs)	Commercial landings[g] (lbs)	Total Catch (lbs)
Alewife	0	21,110,300	21,110,300
Bluefish[a]	1,000,000	715,000	1,715,000
Catfish	1,100,000	1,339,600	2,439,600
Croaker[a]	2,000,000	121,300	2,121,300
Eel	200,000	1,492,900	1,692,900
Flounder[a]	1,900,000	2,675,000	4,575,000
Menhaden[b]	0	449,797,000	449,797,000
Scup[a]	200,000	2,081,000	2,281,000
Seabass[a]	400,000	1,684,000	2,084,000
Shad[d]	3,390,000	3,326,940	7,116,940
Spot[a,c]	11,300,000	2,892,667	14,192,667
Striped bass[a]	5,400,000	5,759,000	11,159,000
Weakfish[a,c]	3,550,000	1,624,333	5,174,333
White perch	5,300,000	1,925,400	7,225,400
Yellow perch	1,400,000	110,500	1,510,500
Soft clams[e]	NA	5,412,450	5,412,450
Crabs[c]	NA	61,373,133	61,373,133
Oysters	NA	23,741,800	23,741,800

a. Catch represent Bay and ocean landings.
b. Catch represents 1966-69 average catch for the Atlantic Coast Region
c. Catch represents average of 1968, 1969, and 1970 landings
d. Catch represents average of 1966 through 1970 landings
e. Catch represents 1967-68 average
f. Recreational catch figures where supplied by U. S. Fish and Wildlife Service. In cases where averages had to be calculated for years prior to 1970, regression equations were developed using the recreational catch as the dependent value and time as the independent variable
g. Commercial landings were supplied by National Marine Fisheries Service
NA Not available

Hunting is an important form of recreation within the Study Area and much of it is directly associated with the resources of the Bay. Within the Study Area are upland forest, farm lands, wetlands and open water. Each of these habitat types is utilized as a source of food or shelter for various species of game animals. The upland forest and farm land provide habitat for deer, rabbit, squirrel, woodchuck, raccoon, and opossum as well as game birds such as turkey, quail, dove, woodcock, and others. More closely associated with the Bay are the many species which depend on the wetlands and open water for their habitat requirements. The most significant of these are the numerous species of waterfowl which winter in the Bay area and provide many man days of hunting as well as an economic benefit to the region. Expenditures for licenses, land and hunting leases, food, lodging, gasoline, club memberships and equipment were estimated in Maryland's wetland study[5] to amount to $300 to $500 annually per waterfowl hunter. The estimated annual value of waterfowl hunting in the state of Maryland is 10.5 to 17.5 million dollars.

NON-CONSUMPTIVE UTILIZATION OF RESOURCES

The wetland and upland habitat as well as the waters of the Bay and its tributaries provide habitats which support an extensive variety of flora and fauna. These organisms provide a source of recreation to large numbers of people who enjoy bird watching, nature walking and nature photography. The 1970 National Survey of Fishing and Hunting[8] indicates that the number of people utilizing the resource in these non-consumptive ways, is about 9 percent higher than the number fishing and hunting. Aside from the enjoyment which is gained from an association with the natural resources of the area, the Bay, its tributaries, associated wetlands, and upland areas are often used as a classroom for natural science studies. Because of the diversity of species and habitat types which can be found in nearby areas this region affords a unique opportunity for these non-consumptive uses of the resources.

Land Use

When the early European settlers first arrived in the Chesapeake Bay region very little land had been developed for human utilization. Since that time major portions of the land have been cleared for agriculture or developed for commercial, industrial or residential utilization. Of the remaining undeveloped areas, some have preserved as wildlife refuges, recreational and natural areas while others are potential sites for future developments. The disappearance of undisturbed areas in the Bay region has, in recent years, caused a great concern among many conservationists and resource managers. With the expansion in development along the shores it becomes increasingly evident that certain areas should be preserved for future generations. Preservation of vital areas along the shores of the Bay could insure the continuance of numerous fish and wildlife species, including some which are threatened with extinction in the Bay region.

The present land use has been broken down into eleven categories which are listed in Table 12-5 with the acres and percentage of the Bay Area which are utilized by each category. The areas which have been developed to the exclusion of most wildlife species are residential, commercial, industrial and highways which, when combined, account for almost 6 percent of the total land area in the Bay region. (This calculation assumed an average width for all highways of 33 feet).

Aside from the development which has already taken place there is an increasing demand for residential construction along the shores of the Bay and its tributaries. Since many of the prime building sites have already been developed, developers have turned toward the utilization of filled wetlands and dredged canals in order to provide waterfront homesites which are in great demand. (54,55) The areas which are seen by the developers as potential building sites may be considered as essential fish or wildlife habitat by resource managers. Although some degree of control of development in these "vital areas" have been afforded to the resource managers through wetland laws and environmental legislation, development of many areas with unique environmental conditions cannot be controlled. Because of this lack of control over the development of some areas, numerous individuals and organizations have proposed the purchase of lands which provide habitat of an unusual type, support communities considered to be of ecological importance, or are utilized by threatened or endangered species. Areas which may be included in these categories are salt, brackish, and fresh water marshes, bogs, nesting and feeding sites of endangered species, and locations containing rare or endangered plants. A recent report by the Center for Natural Areas, Ecology Program, Smithsonian Institution, entitled "Natural Areas of the Chesapeake Bay Region: Ecological Priorities", (56) has developed a system of ratings for natural areas and has classified many areas within the Chesapeake Bay region. The rating system which was used in the report is given in Table 12-6, and list of the primary natural areas selected using that rating system is given in Table 12-7.

This list contains the State, County, location name and numerical rating of 62 areas in the Bay region which should be considered for procurement and preservation as natural areas. Aside from these areas which have unique characteristics indicating a need for preservation, there are other areas which, although not unique to the region, are of significant importance to the fish and wildlife resources. Of primary importance among these are the wetland areas which surround many portions of the Bay and its tributaries, and provide food and shelter for hundreds of species including the juveniles of many sport and commercial fish species and wintering waterfowl using the Atlantic flyway. The locations of the major wetland areas are depicted on plates 12-4, 12-5, and 12-6.

TABLE 12-5

BREAKDOWN OF LAND USE BY CATEGORY (1)

Land Use Type	Total Number of Acres (Miles)	Percentage of Total Bay Area
Residential	497,250	3.6
Commercial	52,000	0.4
Industrial	83,400	0.6
Public/Semi-Public	541,250	3.9
Agricultural	4,202,400	30.4
Woodlands	6,812,100	49.3
Park Lands	272,900	2.0
Open Lands	595,200	4.3
Wetlands	666,650	4.8
Railroads	2,000 miles (0.2 miles per 1,000 acres)	Not Available
Highways	42,000 miles (3 miles per 1,000 acres)	Not Available

TABLE 12-6

CRITERIA AND QUANTITATIVE VALUES (56)
FOR SELECTION OF NATURAL AREAS

Criteria		Points
1. Ecosystem Types		
Diversity of ecosystem types		1 (each)
Little or no past and present disturbance		2
High diversity of species		2
Type not represented in National Research Natural Area System		4
2. Endangered, or Threatened Biota and Gene Pool Species		
Endangered and threatened plant or animal species		4 (each sp.)
Rare, declining, or depleted species		2 (each sp.)
3. Range Phenomena		
Outliers, disjuncts, or relict species		1 (each sp.)
Limits or range - N, S, E, W		1
Restricted and endemic species		1
4. Seasonal Concentrations of Animals		
Seasonal breeders - nesting, spawning		1
Overwintering concentrations		1
Migratory concentrations		1
5. Commercial, Game, or Unusual Animal Populations		
Ungulates, game birds, fur bearers		1
Fish, clams, oysters, crabs		1
6. Paleontological, Geological and Archeological Features		
Bones and artifacts, deposits of fossils, peat, lignite, sediments, structural and geomorphological features		1 (each feature)
7. Sites of well documented scientific research or discovery and records over period of years		1
8. Oldest, largest, or otherwise exceptional individuals or associations		1 (each)
9. Size of area		
Acres	Hectares	
Under 100 acres	Under 45	1
100 - 1,000	45 - 457	2
1,000 - 5,000	457 - 2,270	3
over 5,000	over 2,270	4

TABLE 12-7

SIGNIFICANT NATURAL AREAS (56)

STATE/COUNTY	AREA NAME	ECOLOGICAL RATING
MARYLAND/ANNE ARUNDEL	Bacon Ridge Branch	12
MARYLAND/ANNE ARUNDEL	Fresh Pond	14
MARYLAND/ANNE ARUNDEL	Round Bay Bog	7
MARYLAND/CALVERT	Hellen Creek Hemlock Preserve	10
MARYLAND/CAROLINE	Hemlock Stand on Mill Creek	6
MARYLAND/CAROLINE	Frazier Neck	12
MARYLAND/CAROLINE	Choptank River - Lyford Landing	12
MARYLAND/CAROLINE-TALBOT	Tuckahoe Creek	11
MARYLAND/CHARLES	Mattawoman Creek	11
MARYLAND/CHARLES	Zekiah Swamp	24
MARYLAND/CHARLES	Nanjemoy Creek - Wards Run	15
MARYLAND/CHARLES	Perry Branch	12
MARYLAND/CHARLES	Chicamuxen Creek	11
MARYLAND/CHARLES	Maryland Neck	12
MARYLAND/CHARLES	Cedar Point Neck	13
MARYLAND/CHARLES	Lloyd Creek	13
MARYLAND/DORCHESTER	Lower Marshy Hope Creek	11
MARYLAND/DORCHESTER	Chicone Creek - Big Creek Marsh	12
MARYLAND/DORCHESTER	Green Brier Swamp	11
MARYLAND/DORCHESTER	Blinkhorn Creek	8
MARYLAND/KENT	Cedars, The - Church Creek - Ringgold Point	17

TABLE 12-7 (Continued)

STATE/COUNTY	AREA NAME	ECOLOGICAL RATING
MARYLAND/QUEEN ANNE	Wye River	11
MARYLAND/QUEEN ANNE	Reed Creek - Gordon Point - Wright Neck	14
MARYLAND/QUEEN ANNE	Andover Branch	6
MARYLAND/QUEEN ANNE TALBOT	Wye East River	12
MARYLAND/ST. MARYS	Spring Creek	12
MARYLAND/ST. MARYS	Poplar Hill Creek	12
MARYLAND/ST. MARYS	Killpeck Creek - Trent Hall Creek	12
MARYLAND/TALBOT	Miles Creek	17
MARYLAND/TALBOT	Bow Knee Point	12
MARYLAND/TALBOT	Choptank River (Bruceville)	11
MARYLAND/TALBOT	Lloyd Landing	12
MARYLAND/TALBOT	King Creek - Kingston Landing	10
MARYLAND/WORCESTER - WICOMICO - SOMERSET	Pocomoke River Swamp	22
VIRGINIA/CHARLES CITY	Parsons Island - Olk Neck	11
VIRGINIA/CHARLES CITY	Weyanoke Point	12
VIRGINIA/CHARLES CITY - JAMES CITY	Chickahominy, Lower - Providence Forge	19
VIRGINIA/GLOUCESTER - KING AND QUEEN	Poropotank Marsh - Purtan Marsh	15
VIRGINIA/HENRICO - HANOVER - NEW KENT	Chickahominy, Upper	13
VIRGINIA/ISLE OF WIGHT - SOUTHAMPTON	Blackwater River	16

TABLE 12-7 (Continued)

STATE/COUNTY	AREA NAME	ECOLOGICAL RATING
VIRGINIA/JAMES CITY	Yarmouth Islands - Simpson - Wight	12
VIRGINIA/JAMES CITY	Powhatan Creek	14
VIRGINIA/JAMES CITY	Gordon Island	12
VIRGINIA/JAMES CITY	Passmore Creek	13
VIRGINIA/JAMES CITY	Chisel Run Bog	10
VIRGINIA/KING AND QUEEN	Garnetts Creek Marsh	12
VIRGINIA/KING AND QUEEN KING WILLIAM	Mattaponi River, Lower	18
VIRGINIA/KING AND QUEEN MIDDLESEX	Dragon Run Essex	22
VIRGINIA/KING GEORGE	Choptank Creek	14
VIRGINIA/KING GEORGE	Smoot Tract	12
VIRGINIA/NEW KENT	Lilly Point Marsh	15
VIRGINIA/NEW KENT - CHARLES CITY - HENRICO	Chickahominy, Middle	18
VIRGINIA/NEW KENT - JAMES CITY	Terrapin Point	12
VIRGINIA/NEW KENT	West Island	11
VIRGINIA/NORTHUMBERLAND	Bluff Point Marsh	12
VIRGINIA/PRINCE GEORGE-SURRY	Upper Chippokes Creek	13
VIRGINIA/RICHMOND - ESSEX	Broad Creek Marsh	11
VIRGINIA/STAFFORD	Accakeek Creek	11
VIRGINIA/SURRY	Sunken Meadow	11

TABLE 12-7 (Continued)

STATE/COUNTY	AREA NAME	ECOLOGICAL RATING
VIRGINIA/WESTMORELAND	Hollis Marsh	14
VIRGINIA/WESTMORELAND	Currioman Bay	13
VIRGINIA/WESTMORELAND - ESSEX	Drakes Marsh - Otterburn Marsh	11

Rare and Endangered Species

Development of the Bay region for the utilization by man has at the same time caused a loss of habitat for numerous species of fish and wildlife. For some of the species, this loss has caused confinement to an increasingly smaller range until they have become threatened or endangered within the study area.

The species which are included in this discussion are listed as endangered or threatened species by the U. S. Fish and Wildlife Service, Office of Endangered Species and International Activities or by one of the states within the study region. Not all species listed by the states are discussed since a species may be abundant in one portion of the Study Area and considered endangered in another portion. For example, the black bear is on the endangered species list of Maryland and is, at the same time, a game species in portions of Virginia. Also, many of the species which are threatened or endangered within the Study Area may be relatively abundant on a national basis; however, due to habitat loss or degradation, they have declined or are at low population levels within the Study Area. Table 12-8 lists those species which may be considered endangered or threatened throughout the study region and are discussed in this section.

The Endangered Species Act of 1973 (Public Law 93-205, 87 Stat. 884) (57) which became effective December 28, 1973, established two categories of endangerment.

1. Endangered Species are those species which are in danger of extinction throughout all of a significant portion of their range.

2. Threatened Species are those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

A status-undetermined species or subspecies is one that has has been suggested as possibly threatened with extinction, but about which there is not enough information to determine its status.

A Rare species is one that never attains large population levels because of range requirements, restricted habitat or other natural limiting factors. An example of a rare species would be the Eastern Perigrine Falcon which even prior to intrusion by man never reached levels of more than 50 to 100 breeding pairs in the Eastern United States.

TABLE 12-8

THREATENED AND ENDANGERED SPECIES OF THE UNITED STATES, MARYLAND AND VIRGINIA FOUND IN THE STUDY AREA

BIRDS	STATUS UNITED STATES	MARYLAND	VIRGINIA
Southern Bald Eagle*	E		E
Red-cockaded Woodpecker*	E		E
Eskimo Curlew*	E		
Arctic Peregrine Falcon*	E		
Ipswich Sparrow (Savannah Sparrow*)	T		
Bachman's Warbler*	E		
Eastern Brown Pelican	E		
Upland Plover			R
Least Tern			R
Lowland Swainson's Warbler			R
Florida Grackle			R
Henslow's Sparrow			R
Bachman's Sparrow			R
American Osprey	S U		
Eastern Pigeon Hawk	S U		

E - Endangered
T - Threatened
R - Rare
SU - Status Undetermined

TABLE 12-8 cont'd

MAMMALS	STATUS UNITED STATES	MARYLAND	VIRGINIA
Delmarva Peninsula Fox Squirrel*	E	E	E
Coyote		E	
Bobcat		E	
Porcupine		E	
Least Weasel		E	
Mountain Lion (Eastern Cougar*)	E	E	E
Black Bear		E	
Dismal Swamp Lemming Mouse			E
Virginia Big-eared Bat*	T		E
Rafinesque's Big-eared Bat			E
Indiana Bat*	E		E
Northern Flying Squirrel			E
Long-tailed Shrew			R
Bachman's Shrew			R
Pigmy Shrew			R
Dismal Swamp Short-tailed Shrew			R
Star-nosed Mole			R
Gray Myotis			R
Le Conte's Big-eared Bat			R
Varying Hare			R
Marsh Rabbit			R
Southern Fox Squirrel			R
Gapper's Red-backed Vole			R

TABLE 12-8 cont'd

REPTILES	STATUS UNITED STATES	MARYLAND	VIRGINIA
Wood Turtle			E
Bog Turtle*	T	E	E
Northern Pine Snake			E
Scarlet Kingsnake			E
Canebrake Rattlesnake			E
Atlantic Green Turtle*	T	E	
Atlantic Hawksbill Turtle*	E	E	
Atlantic Loggerhead		E	
Atlantic Ridley*	E	E	
Atlantic Leatherback*	E	E	
Mountain Earth Snake		E	
Rainbow Snake*		E	R
Coal Skink*		E	R
Map Turtle			R
Cumberland Turtle			R
Yellow-bellied Turtle			R
Eastern Spring Softshell Turtle			R
Eastern Slender Glass Lizard			R
Brown Water Snake			R
Red-bellied Water Snake			R
Eastern Mud Snake			R
Coastal Plain Milk Snake			R
Southeastern Crowned Snake			R
Eastern Cottonmouth			R

TABLE 12-8 cont'd

AMPHIBIANS	STATUS UNITED STATES	MARYLAND	VIRGINIA
Hellbender		E	
Eastern Tiger Salamander		E	
Eastern Narrow-mouthed Toad		E	
Mudpuppy			E
Dwarf Waterdog			E
Greater Siren			E
Carpenter Frog			E
Black Mountain Dusky Salamander			R
Pigmy Salamander			R
Northern Shovel-nosed Salamander			R
Peaks of Otter Salamander			R
Shenandoah Salamander			R
Spot-bellied Salamander			R
Blue Ridge Spring Salamander			R
Blue Ridge Red Salamander			R
Blue Ridge Two-lined Salamander			R
Oak Toad			R
Squirrel Treefrog			R
Barking Treefrog			R
Little Grass Frog			R

TABLE 12-8 cont'd

FISH	STATUS UNITED STATES	MARYLAND	VIRGINIA
Shortnose Sturgeon*	E	E	
Maryland Darter*	E	E	
Rustyside Sucker	S U (Found in Virginia)	-	
Atlantic Sturgeon**		T	
Glassy Darter**		T	
Stripeback Darter**		E	
Trout Perch**		E	
Blackbanded Sunfish**		T	
Mud Sunfish**		T	

*Threatened and Endangered Species Throughout the Chesapeake Bay Region.

**These species are proposed by the State of Maryland for designation as endangered or threatened.

The information in this section has been extracted from the 1973 edition of Threatened Wildlife of the United States (58) with information on species not included in that report compiled in a similar manner from references and field guides. Additional information can be obtained from the U. S. Fish and Wildlife Service, Office of Endangered Species and International Activities, various state agencies and the references listed after each species discussion.

Southern Bald Eagle - *Haliaectus l. leucocephalus*

Present distribution: Nests primarily in estuarine areas of Atlantic and Gulf coasts, locally from New Jersey to Texas, and lower Mississippi Valley southward from eastern Arkansas and western Tennessee, and through southern states west to California and Baja, California. Nest sites within the study area are presented on Figure 12-4. Some birds move northward in summer after the nesting season to northern United States and southeastern Canada. The adult population of southern Florida is essentially resident.

Status: Generally decreasing. Reproduction apparently less successful than formerly except in Everglades National Park, where about 52 pairs nested in 1965 with a success of 50 percent and a production of 1.46 young per successful nest.

Reasons for decline: Increase in human population in primary nesting areas. Disturbance of nesting birds, illegal shooting, loss of nest trees, and possible reduced reproduction as a result of pesticides ingested with food by adults.

Protective measures already taken: Federal laws in the United States protect both the bald and golden eagles. The Bureau of Sport Fisheries and Wildlife and the state game departments enforce these laws. The Bureau is also studying the effects of pesticides on bald eagles. Eight National Wildlife Refuges in the southeastern United States have bald eagles nesting on them. The National Audubon Society is conducting intensive investigations of bald eagle distribution, status, breeding biology, and limiting factors.

Florida Aububon Society has obtained agreements with landowners for 2,300,000 acres where nests are located to be treated as bald eagle sanctuaries. The Society makes annual inspections of these nesting sites. Access to eagle nesting areas on National Wildlife Refuges is restricted. Timber cutting, road traffic, and pesticide use have been reduced or eliminated. Cooperation of the public is being sought in reducing human activity in areas adjacent to refuges in vicinity of eagle nests. Potential nest sites (trees) are being preserved in existing and promising nesting areas. The Patuxent Wildlife Research Center has developed facilities where propagation of the northern and southern races is underway. The Center is studying pesticidal contaminants in the environment of the bald eagle and is developing captive propagation methods to produce birds to bolster wild populations or restore breeding pairs to unoccupied habitat.

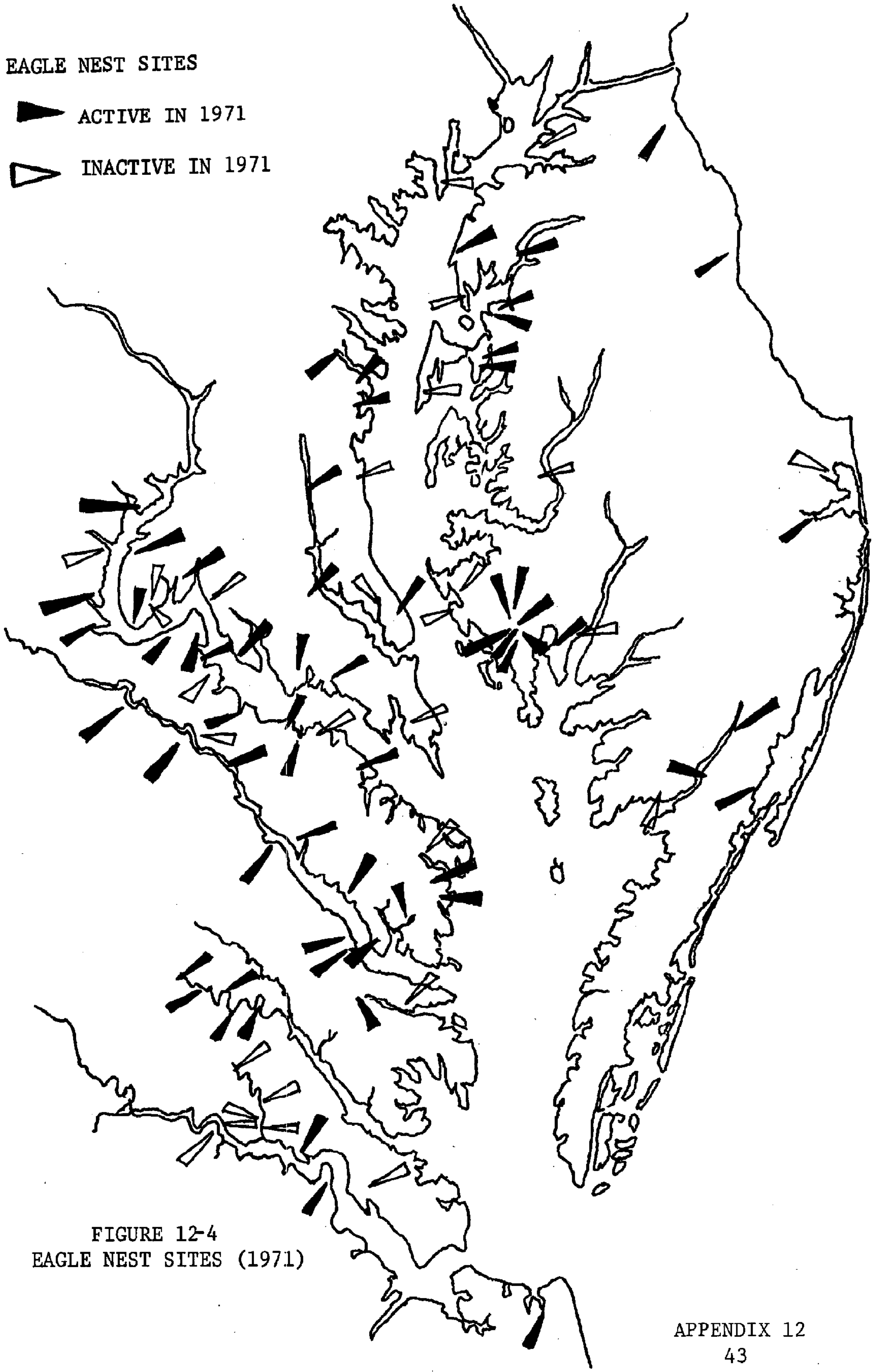


FIGURE 12-4
EAGLE NEST SITES (1971)

Red-cockaded Woodpecker - Dendrocopos borcalis

Present distribution: Resident in open, old age pine woodlands from southeastern Oklahoma, Arkansas, western Kentucky, southeastern Virginia south to Gulf Coast and southern Florida.

Status: Vulnerable, because of limited number of specialized nesting sites in old, living pines infected with red-heart disease, and current trend in forestry practice to eliminate such trees.

Protective measures already taken: Federal and some state forestry agencies have policies to save some large pine trees infected with red-heart disease in limited areas where red-cockaded woodpeckers are known to occur.

Eskimo Curlew - Numenius borealis

Present distribution: One or two spring migrants seen on the Texas coast in 1950, 1959, 1960, 1961, and 1962. Not recorded there since. Specimen taken in fall migration of 1963 in Barbados, West Indies, now in Philadelphia Academy of Natural Sciences. A sight record was made at Cape May, New Jersey, September 20, 1959, and another near Charleston South Carolina, July 15, 1956.

Status: Apparently very rare. Known only from one or two migrants seen occasionally in spring migration, and one recent fall migrant specimen. No record since 1963. Present breeding and wintering range unknown. Last winter record was for Province of Buenos Aires, Argentina in 1939 (Wetmore 1939).

Reasons for decline: Excessive shooting formerly. Present limiting factors unknown.

Protective measures already taken: Along with all other Scolopacidae, except the common snipe and woodcock, there has been complete protection from hunting by law in the United States and Canada for many years. Canadian Wildlife Service field personnel are alerted to pay special attention to curlews in hopes that more information can be obtained on their distribution.

Arctic Peregrine Falcon - Falco peregrinus tundrius

Present distribution: Breeds in the treeless tundra area of Arctic Alaska, Canada, and western Greenland. Migrates south chiefly through eastern and middle North America to gulf coast of United States, Central and South America as far south as Argentina and Chile. Band recoveries indicate that southward migration along the Atlantic coast may be chiefly from breeding areas in western Greenland (Shor 1970).

Status: Production of fledglings per occupied nest on Colville River, Alaska, dropped from 1.40 in 1952 to 0.5 in 1971; 53 percent of aeries unoccupied in 1970 and 1971. Mean eggshell-thickness for this population decreased 21.7 percent since 1974; egg contents average over 800 ppm DDE (lipid basis); and there is a highly significant negative correlation between shell-thickness and DDE concentration in eggs (T. J. Cade and co-workers).

Reasons for decline: All field and laboratory evidence points to cumulative effects of chlorinated pesticides and their breakdown products obtained from prey, especially DDT and DDE, which have increased adult mortality and reduced production of young by affecting reproductive mechanisms and causing eggs to become thinshelled or otherwise nonviable.

Protective measures already taken: Peregrine falcons are protected at all times of the year by Federal laws and the laws of most states and provinces. Bureau of Sport Fisheries and Wildlife, Canadian Wildlife Service, about 20 falconer-aviculturists, and Cornell University are studying artificial propagation techniques with peregrines.

Ipswich Sparrow (Savannah Sparrow) - *Passerculus princeps*

Present distribution: Breeds on Sable Island off Nova Scotia. Winters among sand dunes along Atlantic coast from Sable Island south to southern Georgia.

Status: Vulnerable because oil exploitation in its limited habitat on a small breeding island. Limited to narrow belt of Atlantic coast sand dunes, particularly the outer dunes, for winter habitat. Reported in recent years to be less common on wintering grounds than formerly. The bulk of the population probably winters from New Jersey to Virginia (Stobo and McLaren 1971)

Reasons for decline: Reduction in size of breeding area by progressive washing away of already very small Sable Island (Dwight, 1895 and Erskine, 1964). Interference with winter habitat by residential development along the Atlantic coast beaches.

Protective measures already taken: Establishment of Chincoteague, Back Bay, Pea Island, Cape Romain, Blackbeard Island, Wold Island, and Tybee National Wildlife Refuges, and of Cape Cod, Assateague Island, and Cape Hatteras National Seashores will assure continuation of Ipswich sparrow sand dune wintering habitat in these places.

Bachman's Warbler - Vermivora bachmanii

Present distribution: Known only from recent (Since 1950) observation of nonbreeding individuals near Lawton, Virginia, and Charleston and Francis Marion National Forest, South Carolina and three localities in Alabama.

Status: So infrequently seen that nothing is known of its present breeding or winter distribution. Only an occasional nonbreeding individual observed.

Reasons for decline: Obscure. Possibly the cutting of practically all the virgin swamp or bottomland timber in the southeast. Excessive collecting along restricted migration route in Florida may have caused decline in earlier years.

Protective measures already taken: Protected by Federal law since revision of interpretation of provisions of the Migratory Bird Treaty Act in 1965, also by the laws of states in which it formerly occurred. Some of the National Wildlife Refuges in the southeast have river swamp forests which may be potential habitat for this species.

Eastern Brown Pelican - Pelecanus occidentalis carolinensis

Present distribution: Breeds on the Atlantic Coast, North Carolina to Florida, Gulf Coast of Florida, remnant breeding population on south coast of Texas and northern coast of Panama, also Bahamas and Cuba. Winters more extensively on waters surrounding breeding areas (occasional visitor to the lower Chesapeake Bay).

Status: North Gulf Coast population extirpated from Mississippi Delta to Arkansas Bay. Atlantic Coast population has greatly reduced reproduction resulting from thinning and collapsing of eggshells. This condition is most acute at northern end of range and decreases southward in eastern United States. Condition in extensive breeding range south of the border largely unknown but indication of eggshell thinning in Panama.

Reasons for decline: Almost certainly caused by collapse of thinshelled eggs or other impairment of reproductive success. Thin eggshells have been shown to be associated with excessive amounts of DDE in the food fishes, the contents of pelican eggs, and the tissues of these birds. Dieldrin is also probably associated with lack of reproductive success.

Protective measures already taken: Protected by most states. Many colonies protected by Federal and State refuges or the National Audubon Society sanctuaries. State, Federal, and private cooperative research has been directed toward analysis of the thin eggshell condition.

Delmarva Peninsula (Bryant) Fox Squirrel - Sciurus niger cineraus (Linneaus)

Present distribution: Queen Anne's, Dorchester, Talbot, Wicomico, Somerset, and Worcester Counties, Maryland and on Eastern Neck, North West Region, Kent County, Maryland, which is managed for the Delmarva Fox Squirrel. The center of population appears to be in in the Drawbridge district of Dorchester County.

Status: Occurs in limited numbers in restricted areas. Flyger (1964) considered race as "threatened with immediate extinction."

Reasons for decline: Destruction of habitat through timber cutting construction, road building, forest fires, etc.

Protective measures already taken: Establishment of the Blackwater National Wildlife Refuge (1933) and of the Pocomoke State Forest has helped to preserve some habitat. Introduced to Chincoteague National Wildlife Refuge in 1968. Lecompte Wildlife Management Area designated as refuge for species by the State of Maryland in 1970. The State of Maryland closed the hunting season on this squirrel in 1971. The U. S. Fish and Wildlife Service has formed a Delmarva Fox Squirrel Discovery Team which is presently developing a Recovery Plan for this Species.

Mountain Lion or Eastern Cougar - Felis concolor cougar

Present distribution: One specimen taken in New Brunswick in 1932; one taken in Maine in 1938; one in Pennsylvania in 1967 (Wright, 1971). There is some question as to whether the Pennsylvania specimen was an escapee from captivity. In addition to the above, there have been hundreds of sightings reported from eastern Canada to the Carolinas in recent years. Many of these sightings have been by reliable observers (National Park rangers, zoologists, etc.) and have to be given credence. On the basis of his analysis of these reports of sightings, Wright (1971) says: "...the range of the supposedly extinct eastern panther runs across the Laurentians from central Ontario to the Atlantic coast of Cape Breton Island, and between the Mississippi and the Atlantic south to where it merges with the range of F. c. coryi."

Status: Formerly regarded as extinct. Over the vast range where sightings now indicate that the eastern panther may occur, Wright (1971) says: "...its numbers must be the smallest fraction above the limit of survival and its gene pool must be the smallest possible."

Reasons for decline: Hunted and trapped relentlessly as a "pest" species elimination of habitat through extensive deforestation; decline in numbers (until comparatively recently) of primary prey species, the white-tailed deer.

Protective measures already taken: Protected by law in New Hampshire since 1967; both North Carolina and Virginia passed laws in 1971 giving the panther complete protection.

Virginia Big-eared Bat - Plecotus townsendii virginianus

Present distribution: In the caves of Pendleton County, West Virginia, with a few colonies in neighboring counties. Also a colony in Tazewell County, Virginia, and one in Lee County, Kentucky.

Status: Numbers apparently stable.

Reasons for decline: This race is a relict of a western species and has probably had a natural decrease in range during past geologic epochs. The species is very intolerant to human disturbance.

Protective measures already taken: None. The Forest Service, U. S. Department of Agriculture, is negotiating to obtain the private inholding housing the colony in Kentucky.

Indiana Bat - Myotis sodalis

Present distribution: Midwest and eastern United States from the western edge of Ozark region in Oklahoma to central Vermont, to southern Wisconsin, and as far south as northern Florida. Distribution is associated with major cavernous limestone areas and areas just north of cave regions. (Hall, 1962:7)

Status: Decreasing in number.

Reason for decline: Commercialization of caves in which Indiana bats roost. Wanton destruction of large numbers of Indiana bats by vandals. Roosts being disturbed by increasing numbers of spelunkers and others seeking recreation. Disturbances during bat banding programs. Colonies frequently raided for laboratory experimental animals. Insecticide poisoning may possibly be new threat.

Protective measures already taken: Construction of a gate across entrance to Carter Cave, Kentucky, where over 100,000 Myotis sodalis winter, to keep irresponsible persons from entering and destroying bats. Wyandotte Cave, a winter hibernating area, purchased by Indiana Department of Natural Resources. A U. S. Fish and Wildlife is presently developing a recovery plan for this species.

Sea Turtles

Atlantic Green Turtle - Chelonia m. mydas

Atlantic Hawksbill - Eretmochelys i. imbricata

Atlantic Ridley - Lepidochelys kempi

Atlantic Leatherback - Dermochelys c. coriacea

Atlantic Loggerhead - Caretta c. caretta

Present distribution: These turtles are generally found in the warmer waters of the Atlantic Ocean with all species occasionally found as far north as New England, Nova Scotia or Newfoundland and south to the tropical seas. Nesting of some species occurs along the Gulf coast and Atlantic coast of the southern states.

Status: All species are depleted throughout their range.

Reasons for decline: Both the turtles and their eggs are used for food in some regions and are subject to intense harvesting pressures. Eggs and young are subject to heavy predation.

Protective measures already taken: These species are protected by various laws throughout their ranges; including closed seasons, limited harvests and restricted licenses. All are protected as endangered species in Maryland.

Bog Turtle - Clemmys muhlenbergi

Present distribution: Isolated colonies from Connecticut to southwestern North Carolina, restricted to freshwater marshes, meadows, and bogs.

Status: Very uncommon in most localities.

Reasons for decline: Extensive destruction of habitat for cultivation and building construction; collected for sale in pet trade where they command a high price due to their rarity.

Protective measures already taken: Now protected by law in New York State under small game section of fish and game laws. The law, passed in 1968, makes it illegal to collect, own, or sell the species in the State, and offenders have been arrested. Pennsylvania has protective laws for the species. It is fully protected in Maryland.

Rainbow Snake - Farancia erytrogramma

Present distribution: Found from southern Maryland to central Florida and from the East Coast to eastern Louisiana.

Status: The Chesapeake Bay Study Area is at the extreme northern limits of the range of the rainbow snake which is considered endangered by Maryland and rare by Virginia even though it is not listed by the U. S. Fish and Wildlife Service.

Reasons for decline: No data is available to substantiate a decline in population.

Protective measures already taken: Protected as an endangered species in Maryland.

Northern Coal Skink - Eumoces a. anthracinus

Present distribution: Found in the upland areas of the Northeast from southwestern Virginia and eastern Kentucky north to Lake Ontario in New York.

Status: Found only in the westernmost counties of Maryland and Virginia which form the eastern limits of its range.

Reasons for decline: No data is present to indicate a decline.

Protective measures already taken: Protected as an endangered species in Maryland and listed as rare in Virginia.

Shortnose Sturgeon - Acipenser brevirostrum

Present distribution: All recent U. S. records are from the Hudson River except one Florida specimen.

Former distribution: Atlantic seaboard rivers from New Brunswick to Florida, including the Hudson, Delaware, Potomac, Connecticut, Salmon Creek (North Carolina) and St. Johns River watershed (Florida). There have been a few records in saltwater (New Jersey).

Status: In peril. The species is gone in most of the rivers of its former range. Is probably not as yet extinct.

Reasons for decline: Pollution is probably the major factor. Overfishing has also been likely since this species has been intensively fished on spawning areas, also has been taken in shad gill nets over a wide areas of the Hudson and other rivers.

Protective measures already taken: Other than some routine regulations such as 20 inch size limit, no protective measures seem to have been taken.

Maryland Darter - Etheostoma sellare

Present distribution: Known only in Harford County, Maryland, predominantly in Deer Creek.

Status: Precarious condition. Specimens have been collected as late as 1974.

Reason for decline: There are no data to support a statement that they have declined.

Protective measures already taken: Biologists have been requested not to disturb the habitat.

EXISTING PROBLEMS AND CONFLICTS

Extensive fish and wildlife resources, the largest estuary in the United States, the East Coast center for waterborne commerce, a major population center, a regional water recreation resource, one of the most important waterfowl wintering areas in the United States, the seat of the national government--these phrases all characterize the Chesapeake Bay region to some degree. The fact that any given individual may select one of the above phrases as its prime characterization, to the extent that all others are nearly excluded, has in part resulted in the multiplicity of problems and conflicts that presently surround the use of Bay region resources.

The basis for most of the problems and conflicts that will be discussed in this section is the rapidly expanding human population within the Bay region. From 1950 through 1969, the area population increased by 37 percent and by 1980, is projected to be almost double the 1950 population. Per capita income between 1950 and 1969 increased by approximately 59 percent and by 1980 will have increased by approximately 76 percent[1]. Although the relationships between this burgeoning, affluent population and Bay resource problems are not always obvious to the uninformed layman, its symptoms are painfully obvious to the commercial waterman who has just been told that another productive shellfish bed has been closed as a result of pollution. The sportsman who has observed a once productive fishing area being transformed into the sewer of an industrial complex may not understand his relationship as a consumer to the offending plant, but is certainly appalled at the consequences of his community's affluence. Although all of the ramifications of these economic, and demographic changes cannot be adequately discussed in this section, no resolution of the numerous problems to be discussed can be possible without an acute awareness of these underlying influences.

This section has been divided into three broad categories, water quality, finfish and shellfish mortalities and conflicts. Individual problem areas and conflicts within these three categories will be identified and discussed. Supporting data will be provided where feasible but in many cases, there has been no standard mechanism for collecting and reporting information and evidence is fragmentary and scattered. In some cases, a discussion of the problem as it is intuitively understood will be offered as well as recommendations directed toward a quantification approach.

It is hoped that this report will provide an increased awareness on the part of its readers of the complex interrelationships between the activities of man and the health of the Bay region environment. Only through such an awareness can our institutions and public officials properly evaluate the environmental ramifications of such actions.

WATER QUALITY

One of the foremost problems and perhaps the most insidious and difficult problem to understand and control is man's impact on the quality of Chesapeake Bay water. Almost every activity of man produces an effluent, the common carrier of which is water. Even the most routine personal actions can, in the conglomerate, exert an appreciable effect on the aquatic chemical and biological environment. One man fertilizing his lawn will produce an undetectable increase in the nutrient loading of the water course. Thousands of men innocently taking the same action may produce a blue-green algae bloom and dissolved oxygen depletion.

Many of these activities and their resultant effluents are easily identified and resolutions readily available. Only a commitment by the public and the infusion of money is required to install effective treatment measures. Other activities will require a long term public education process and the development of an environmental ethic by the general population. Traditional methods of dealing with effluents that developed over centuries of life must be evaluated in terms of this ethic and retained or rejected on the basis of their acceptability within a framework of total environmental management. This section will attempt to delve into man's activities and relate them to water quality conditions in Chesapeake Bay and its tributaries. An attempt will also be made to relate these conditions to the fish and wildlife resources of the Bay Area and to discuss the consequences of our activities on its natural resources.

Nutrients

Historically, the nutrient levels in the Chesapeake Bay have been increasing at an accelerating rate. Documentation of these increasing nutrient levels has been made by the Environmental Protection Agency and various state agencies for several areas throughout the Bay system. The symptoms of these increases in nutrient levels are easily observable in the form of extensive blue-green algae blooms, dinoflagellate blooms and disolved oxygen sags caused by decaying organic material.

Record of the nutrient levels and types of aquatic vegetation in the Potomac River (Figure 12-5)(2) are an indication of the processes of degradation which have occurred in the past due to increasing nutrient levels. In the early 1920's, the upper tidal Potomac became infested with water chestnut (*Trapa natans*). As the nutrient levels increased during the 1940's and 1950's, Eurasian water milfoil (*Myriophyllum spicatum*) and local blue-green algae blooms (*Anacystis sp.*) became predominant. Further increases in nutrients led to greater concentrations of blue-green algae which reduced the distribution of rooted aquatic plants.

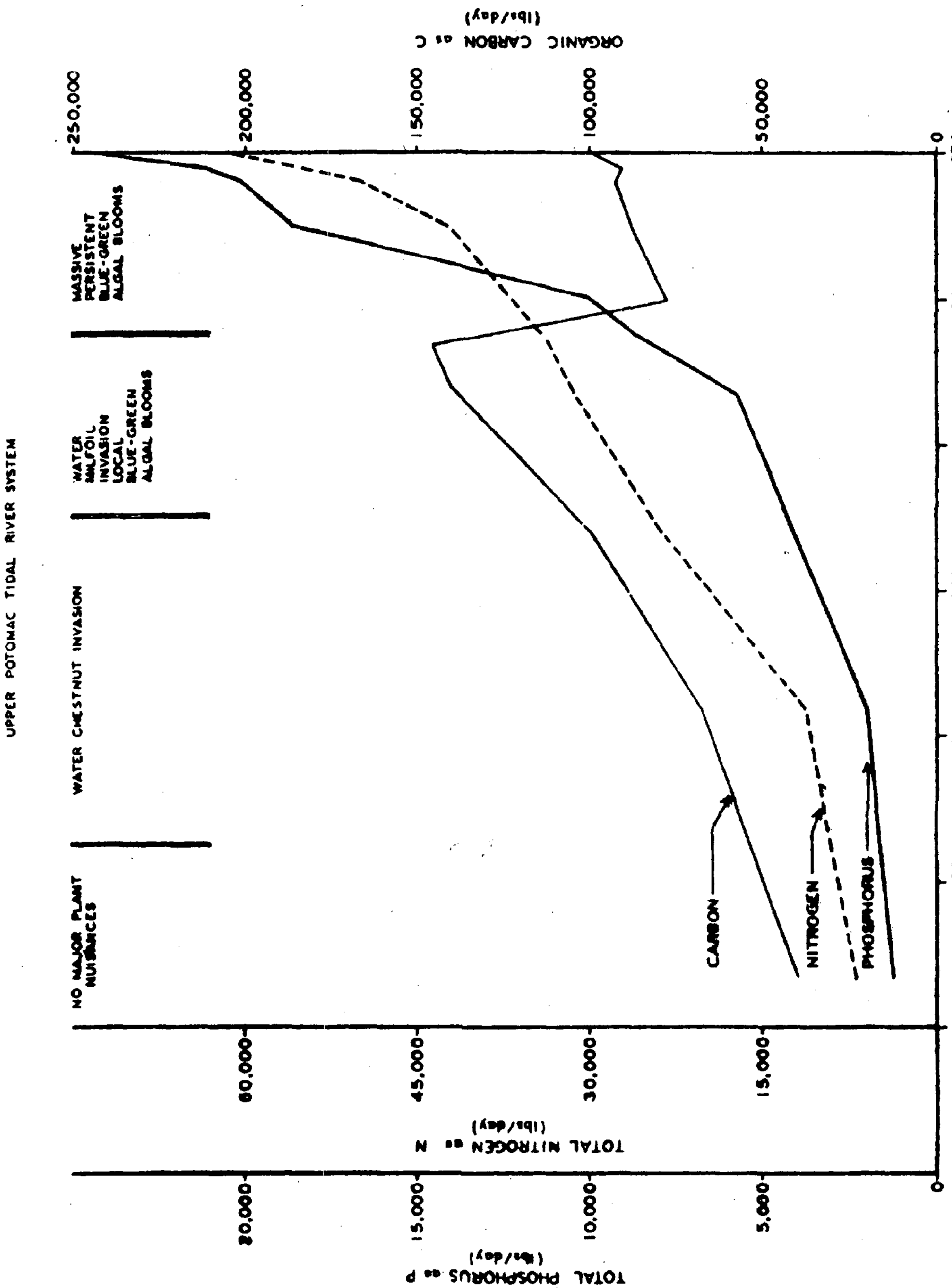


FIGURE 12-5
POTOMAC RIVER NUTRIENT LEVELS

A partial explanation of this condition is that the existing high nutrient levels are conducive to high concentrations of phytoplankton (including the blue-green algae). It is theorized that these high concentrations coupled with heavy silt loads from runoff have increased the turbidity of many areas to such a degree that the rooted plants do not receive sufficient light to become successfully established. If actions are initiated to bring about a reduction in the nutrient levels in the Bay, it is probable that conditions would improve so that the rooted plants would be reestablished much as they were previous to the infestation by the blue-green algae. In this case, even though a problem would still exist, the quality of the aquatic environment would be improved. Due to a higher degree of light penetration and a lower decay rate, dissolved oxygen levels would remain higher than with the heavy infestations of the blue-green algae. Until such time as measures are initiated to control the input of excessive nutrients to the Bay and its tributaries, these infestations of rooted aquatic plants and blue-green algae will probably continue as a recurring problem. However, before any such control measures can be effected, it is necessary to delineate the source and character of the problem. In the case of the Potomac River, the source of excessive nutrients is known to be primarily the waste effluent from the Washington Metropolitan Area. During periods of low flow in the Potomac, 90 percent of the nitrogen and 96 percent of the phosphorous in the river are derived from these waste water discharges.[2] In other drainage areas, the primary source of nutrient input may be from agricultural runoff, urban runoff, septic tank leaching or other sources. Each individual drainage area or portion thereof has its own particular nutrient sources and therefore, each drainage area must be dealt with on a source-by-source basis. In order to accomplish this it would be necessary to identify the major sources and institute programs for their control within each basin. In the Potomac, it is apparent that the effluent from the waste treatment facilities of the Washington Metropolitan Area are the primary source of excess nutrients for that tributary which contributes approximately 25 percent of the nutrients entering the Bay (Table 12-9). Improved sewage treatment facilities would alleviate much of the excess nutrient problem in the Potomac estuary.

In the Susquehanna River, which contributes about 50 percent of the fresh water input and more than 50 percent of the nutrient input to the Bay (Table 12-10) , the source of the nutrients is not so easily determined. The Susquehanna drainage covers an area of 27,510 square miles which is nearly two times greater than the drainage of the Potomac. Within this drainage 53 percent of the land is forest, 33 percent is in pasture and crops, and 4 percent is urban.(1) Along the course of this river and its tributaries are several dam sites which impound the waters for flood control, recreational uses, water and power supply. The presence of these structures allows some of the nutrients flowing from the various municipalities and agricultural lands along the course of the river to be trapped in the impounded areas by sediments or aquatic vegetation.

TABLE 12-9
POTOMAC RIVER NUTRIENT INPUT (2)

Parameter	Monthly Average[1] (lbs/day)	Percent Contribution to Bay
Total Phosphates as PO_4	23,000	33
Inorganic Phosphorous	9,900	27
Total Kjeldahl Nitrogen as N	35,000	23
Nitrite + Nitrate as N	57,000	25
Ammonia as N	6,000	15
Total Organic Carbon	267,000	27

[1]Period June 1969 to August 1970.

TABLE 12-10
SUSQUEHANNA RIVER NUTRIENT INPUT (2)

Parameter	Average Monthly Concentrations[1] (mg/1)	Average Monthly Contribution (lbs/day)	Percent Input to Bay
Total Phosphates as PO_4	0.18	33,000	49
Inorganic Phosphorous	0.12	20,000	54
Total Kjeldahl Nitrogen as N	0.67	93,000	60
Nitrite + Nitrate as N	0.91	153,000	66
Ammonia as N	0.23	29,000	71
Total Organic Carbon	3.64	513,000	51

[1]Period June 1969 to August 1970.

Because of the length (453 miles) of the river and the changing from fluvial to lacustrine, and agricultural to municipal along its course, the utilization and character of the nutrients vary from one area to another. These variations necessitate the breakdown of this river system into numerous smaller areas in order to define the source and character of the nutrient input problem and to establish priorities for management of the system.

Once the sources and character of the excessive nutrients entering the entire Bay system have been defined it will be possible to confront the problem with the ultimate goal of reducing the detrimental effects of these excessive nutrients.

Industrial Discharges

Many industries located in the Chesapeake Bay region remove water, add various pollutants, and then return the waters in their degraded condition to the Bay. Although some industries are connected to the waste water treatment facilities of the city where they are located, the major water users discharge directly into the Bay or its tributaries. These major users include producers of chemicals, petroleum, and metals. The effluents from their manufacturing processes carry heavy metals, acids, organic and inorganic compounds. Some of the discharges contain materials such as arsenic and cyanide in amounts greater than established fish toxicity levels. Other products increase bio-chemical oxygen demand (Figure 12-6) in the receiving waters or add an accumulative poison such as some of the heavy metals.(9) The combined effect of these industrial discharges place limits on the types of organisms which can inhabit regions of disposal. A 1971 study entitled "A Biological Study of Baltimore Harbor"(10) documents a reduction in species diversity and biomass of benthic invertebrates in the heavily polluted harbor. Twenty-seven species were found in Baltimore Harbor compared to fifty-one species in the less polluted Chester River. The average biomass reported for the Harbor ranged from 2.90 g/m^2 at its mouth to 0.02 g/m^2 in the inner Harbor. The Chester River compares with 19.65 g/m^2.

Much concern has been expressed over the recent pollution of the James River by a toxic chemical named kepone. Kepone, a potent insecticide, was discharged into the James River during a sixteen month period that ended in July 1975. The chemical has persisted to varying degrees in both the water column and the bottom sediments and has caused the closing of portions of the James River to fishing.

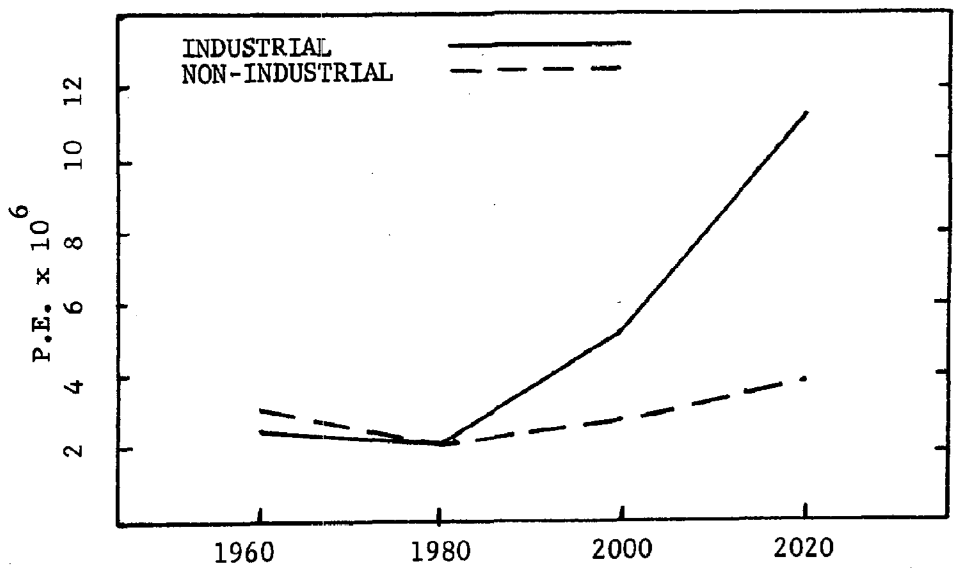


FIGURE 12-6 Projected Industrial and Non-Industrial Organic Waste Load Entering Chesapeake Bay (3)

NOTE: P. E. (Population Equivalent) is an expression of the strength of organic material in wastewater. Domestic wastewater consumes, on an average, 0.17 lb. of oxygen per capita per day, as measured by the standard BOD test. This figure has been used to measure the strength of organic industrial waste in terms of an equivalent number of persons. For example, if an industry discharges 1,000 lbs. of BOD per day, its waste is equivalent to the domestic wastewater from 6000 persons (1000÷0.17=6000).

Although it would be difficult to select any particular discharge source or combination of effluent discharges as a primary causual factor in the reduction of biological productivity, one can say with unequivocal certainty that the ultimate result has been the establishment of physical and chemical conditions in the Harbor waters and sediments that preclude the maintenance of a healthy and viable biotic community. These conditions are documented in an Environmental Protection Agency report entitled "Distribution of Metals in Baltimore Harbor Sediments."(11) Table 12-11 from this report gives a comparison of metal concentrations in Baltimore Harbor and Chesapeake Bay sediments. Table 12-12compares metal concentrations from Baltimore Harbor, a highly industrialized region, to those found in the Delaware River, a less industrialized tidal system, the Potomac River, an estuary with mainly municipal inputs, and the James River, a system with both industrial and municipal inputs. A cursory examination of these data provides considerable insight into the magnitude of the problem of heavy metal contamination by industrial discharge. Appendix 15, Biota, also contains information on the toxicity of various pollutants.

It has been suggested that some areas of the Bay should be committed to use as a disposal ground since the production of many pollutant-producing materials are essential to the economy. However, if the remainder of the Bay and its biota are to be preserved and utilized this cannot be considered an acceptable solution to the problem. There are no boundaries which will contain contaminated waters or restrict the migration of fish. Even if such boundaries did exist, the quantities of material being produced would eventually expand beyond the capacity of their container and necessitate the commitment of a larger area. In an attempt to reduce the chemical discharges into the Bay, the Maryland Environmental Service (MES) has organized a "by-products brokerage" which will list the waste products of various industries. These products will be made available for use by other industries instead of becoming a burden on the environment. If the participating companies can realize a mutual profit, this service will undoubtedly be utilized. However, since participation is voluntary, there is little incentive for the companies to actively seek users for these waste products. Even with extensive participation on the part of industries it is doubtful that dramatic improvements to Bay water and sediment quality in the vicinity of heavy industrial areas would result. The quantities and gross quality of past and ongoing discharges have contaminated the waters and sediments to such an extent in certain areas that only extreme actions by regulatory agencies and time will allow a significant improvement.

TABLE 12-11
METALS IN BALTIMORE HARBOR AND CHESAPEAKE BAY SEDIMENTS (11)

Metal	Baltimore Harbor	Chesapeake Bay
Chromium, mg/kg		
Low	10	18
Average	492	25
High	5745	42
Copper, mg/kg		
Low	1	1
Average	342	6.4-7.0
High	2926	22
Lead, mg/kg		
Low	1	9
Average	346	27
High	13890	86
Zinc, mg/kg		
Low	31	33
Average	888	128
High	6040	312
Cadmium, mg/kg		
Low	1	1
Average	6.3-6.6	1
High	654	1
Nickel, mg/kg		
Low	12	5
Average	36	12
High	94	27
Manganese, mg/kg		
Low	121	218
Average	739	690
High	2721	1608
Mercury, mg/kg		
Low	.01	.01
Average	1.17	.061-.067
High	12.20	.31

TABLE 12-12
METALS IN BALTIMORE HARBOR, DELAWARE RIVER, POTOMAC RIVER AND JAMES RIVER SEDIMENTS (11)

Metal	Baltimore Harbor	Delaware River	Potomac River	James River
Chromium, mg/kg				
Low	10	8	20	NO
Average	492	58	--	
High	5745	172	80	DATA
Copper, mg/kg				
Low	1	4	10	NO
Average	342	73	--	
High	2926	201	60	DATA
Lead, mg/kg				
Low	1	26	20	1
Average	341	145	--	27
High	13890	805	100	55
Zinc, mg/kg				
Low	31	137	125	10
Average	888	523	--	131
High	6040	1364	1000	708
Cadmium, mg/kg				
Low	1	1	1	NO
Average	6.3-6.6	2.9-3.1	--	
High	654	17	.60	DATA
Nickel, mg/kg				
Low	12	NO	20	NO
Average	36		--	
High	94	DATA	45	DATA
Manganese, mg/kg				
Low	121	NO	500	NO
Average	739		--	
High	2721	DATA	4800	DATA
Mercury, mg/kg				
Low	.01	.01	.01	.02
Average	1.17	1.99	--	.32
High	12.20	6.97	.03	1.00

-- Data taken from tables - range only

It is true that numerous water quality standards have been promulgated and the condition of some waters has improved. However, continued implementation and enforcement of these standards will be required to attain lasting water quality improvement.

Agricultural Runoff

Runoff from agricultural lands often introduces sediments, insecticides, herbicides, fertilizers and animal waste into the Bay and its tributaries. As agricultural practices have tended toward higher production per unit of land, increased use of chemicals for control of pests and weeds along with increased use of chemical fertilizers has occured. Some of these agents are washed from the cropland into the Bay and tributaries where, in sufficient quantities, their effects become readily detectable. The effects of these substances are discussed in the Storm Water Runoff sub-section of the Water Quality section and in the Agricultural Water Supply Appendix of this report.

Additional water quality degradation occurs from feed lot production of livestock. High concentrations of livestock produce waste which may be equivalent to or greater than the sewage output of a small city. It has been calculated that the waste from one cow is equivalent to that of sixteen people, one pig equivalent to two people and seven chickens equivalent to one person. In general, these livestock produced waste are not treated and are thus far not economical for use as fertilizers for large scale farm operations because of handling and transportation cost. Thus, much of this waste is periodically washed into the surrounding waters or leached into the ground water. These waste carry not only the nutrients conducive to eutrophic conditions but also waste materials which increase the oxygen demand on the receiving waters. Effective reduction of animal waste entering the Bay system is contingent on economically viable utilization of this material. With the rapidly increasing cost of chemical fertilizers, the incentive for large scale utilization of animal waste is also increasing, however, no major shift had yet taken place.

Municipal Discharges

One of the most obvious sources of pollutants entering the Bay and its tributaries is the waste water from the numerous municipalities within the Study Area. Discharges from sewage treatment plant receive various degrees of treatment and may consist of only domestic waste, combined storm water and sanitary sewage or these and industrial waste products. Thus, the pollutants entering the receiving waters may vary greatly from one municipality to another. The overall effect on the aquatic environment is directly dependent on the degree of treatment and the biological and chemical parameters involved. The biological effects of many of the constituents entering through municipal discharges are discussed in the sub-sections of nutrients and storm water runoff and will not be included here.

Storm Water Runoff

Of the numerous sources of polluting materials which enter Chesapeake Bay, storm water runoff originating from bayside urban, industrial and residential areas poses one of the most complex and difficult pollution control problems. Land use change associated with population growth increases the amount of runoff entering Chesapeake Bay and its tributaries. Along with these land use changes there has also been a significant alteration in our community life styles which in aggregate results in the deposition ofenormous amounts of deleterious substances.

Table 12-13 presents information regarding typical contaminants found on street surfaces and their concentrations.This data was developed based on an E P A study of eight U. S. cities which represent a broad range of conditions. (59) These weighted means certainly cannot be interpreted as a typical situation in any selected city since individual parameters varied widely within individual cities. However, the magnitude and significance of the problem is certainly well demonstrated. Table 12-14 presents runoff data on a hypothetical city of one hundred thousand population. This data is presented in the form of calculated quantities of pollutants which would enter receiving waters following a one-hour rainstorm.

In order to assess the impact of storm water runoff on the estuarine ecosystems receiving such discharges, brief discussion will be presented here in five major segments. They are: Suspended and Settleable Solids, Oxygen Demand, Nutrients, Heavy Metals, and Pesticides.

Suspended and Settleable Solids - Suspended and settleable solids may impact the organisms inhabiting areas affected by storm water runoff through several mechanisms. Rooted aquatic vegetation and bottom dwelling invertebrates may be physically buried and killed by settleable solids. Substrate type may be changed through discharge of sediments resulting in changes in species composition and diversity. Transmissivity of the water to light may be altered to such an extent that rooted vascular plants and benthic algae are shaded out. Sight feeding predatory fish and invertebrates require reasonable water clarity in order to obtain food; discharged sediments which reduce clarity to a significant extent cause a shift in the predator-prey relationship. In addition, Bay organisms may be killed through clogging of gills and digestive organs.

A major impact of suspended sediments is their ability to transport metals, halogenated hydrocarbons, microbes, and nutrients adsorbed, or absorbed to their surface.(17) It is through this mechanism that significant amounts of polluting materials reach receiving waters. The impact of these substances are discussed separately below.

Oxygen Demand - Dissolved oxygen levels in the waters supporting aquatic organisms is one of the most immediate and vital parameters to those organisms. Introduction of sufficient amounts of oxygen-demanding substances into the receiving waters places an immediate stress on the animals inhabiting it. In the Bay area, near large

TABLE 12-13
TYPICAL CONTAMINANTS FOUND ON STREET SURFACES (59)

MEASURED CONSTITUENTS	WEIGHTED MEANS FOR ALL SAMPLES (lb/curb mile)
Total Solids	1400
Oxygen Demand	
BOD_5	13.5
COD	95
Volatile Solids	100
Algal Nutrients	
Phosphates	1.1
Nitrates	.094
Kjeldahl Nitrogen	2.2
Bacteriological	
Total Coliforms (org/curb mile)	99×10^9
Fecal Coliforms (org/curb mile)	5.6×10^9
Heavy Metals	
Zinc	.65
Copper	.20
Lead	.57
Nickel	.05
Mercury	.073
Chromium	.11
Pesticides	
p,p-DDD	67×10^{-6}
p,p-DDT	61×10^{-6}
Dieldrin	24×10^{-6}
Polychlorinated Biphenyls	$1,100 \times 10^{-6}$

The term "org" refers to "number of coliform organisms observed"

TABLE 12-14
CALCULATED QUANTITIES OF POLLUTANTS WHICH
WOULD ENTER RECEIVING WATERS - HYPOTHETICAL CITY(59)

	STREET SURFACE RUNOFF (following 1 hr. storm) (lb/hr)	RAW SANITARY SEWAGE (lb/hr)	SECONDARY PLANT EFFLUENT (lb/hr)
Settleable plus Suspended Solids	560,000	1,300	130
BOD_5	5,600	1,100	110
COD	13,000	1,200	120
Kjeldahl nitrogen	880	210	20
Phosphates	440	50	2.5
Total coliform bacteria (org/hr)	4000×10^{10}	$460{,}000 \times 10^{10}$	4.6×10^{10}

The hypotetical city has the following characteristics:

- o Population - 100,000 persons
- o Total land area - 14,000 acres
- o Land-Use distribution:
  - residential - 75%
  - commercial - 5%
  - industrial - 20%
- o Streets (tributary to receiving waters) - 400 curb miles
- o Sanitary sewage - 12×10^6 gal/day.

It should be noted that these calculations are for a situation in which streets are cleaned (intentionally or by rainfall) on the average of about once every five days. Thus, the above discharge of contaminated runoff could conceivably occur many times in the year. On the basis of this information, there is little question that street surface contaminants warrant serious consideration as a source of receiving water pollution, particularly in cases when such discharges of contaminants coincide with times of low stream flow or poor dispersion.

cities such as Baltimore, Washington, Norfolk, and Richmond, dissolved oxygen levels are often already depressed because of industrial discharges and sewage effluents. Surges of oxygen-demanding substances due to storm water discharge can cause DO to drop to levels that result in kills of those organisms intolerant to low DO levels. The ultimate result in an area of chronic low oxygen levels is a permanent shift in species composition and species diversity. A prime example of this effect in the Chesapeake Bay area is Baltimore Harbor. The number of benthic species is reduced compared to other areas of the Bay and species composition indicates a preponderance of those organisms tolerant to low dissolved oxygen levels.(10) A report entitled "Water Pollution Aspects of Street Surface Contaminants" by E P A (59) clearly documents the significance of oxygen-demanding substances found in street runoff to the receiving waters. The following bar graphs (Figures 12-7 and 12-8) present data on COD and BOD loadings as lbs/curb mile on streets according to land use categories. The significance of these loadings to the estuarine system is obvious.

Nutrients - Nutrient loading from storm water runoff often results in indirect adverse impacts on fish and wildlife using the receiving waters. Commonly the result of nutrient enrichment is the tendency for aquatic vascular plants and unicellular algae to "bloom" in response to the increased nutrients. Common occurrences associated with bloom conditions are shading out of rooted aquatic plants of value as nursery areas to fish or as food to waterfowl. Animal kills can result from drinking toxins produced by certain algae. Dissolved oxygen kills of fish and invertebrates take place during periods of low light intensity, low photosynthetic activity and high plant respiration. Fish and invertebrate populations may be altered through the deposition of organic material and subsequent changes in substrate necessary for spawning and setting. Table 12-15 and Figure 12-9 present data on loading concentration according to land use type.

Heavy Metals - Heavy metals are of particular concern because of their known toxicity to fish and invertebrates. Table 12-16 and Figures 12-10, 12-11, 12-12, and 12-13 present information regarding loading intensities for various land use categories.

Pesticides - The following discussion is devoted to a class of chemicals known as chlorinated hydrocarbons. The major characteristics of these chemicals which lead to concern are their persistence in the environment, their resistence to degradation, their wide spread use and subsequent world wide distribution, their ability to act as biocides at varying concentrations, their known and unknown sublethal effects and the fact that the products of their degradation may be more toxic than the parent compound. Some of these compounds routinely found in street runoff are: DDT, DDE, dieldrin, endrine, lindane, chlordane and P.C.B.'s. Although P.C.B.'s are not used as pesticides they are included here because they are a chlorinated hydrocarbon in common industrial usage, they exhibit the same characteristics as the pesticides and they are a common constituent of street runoff. Table 12-17 presents information on pesticide concentrations as related to

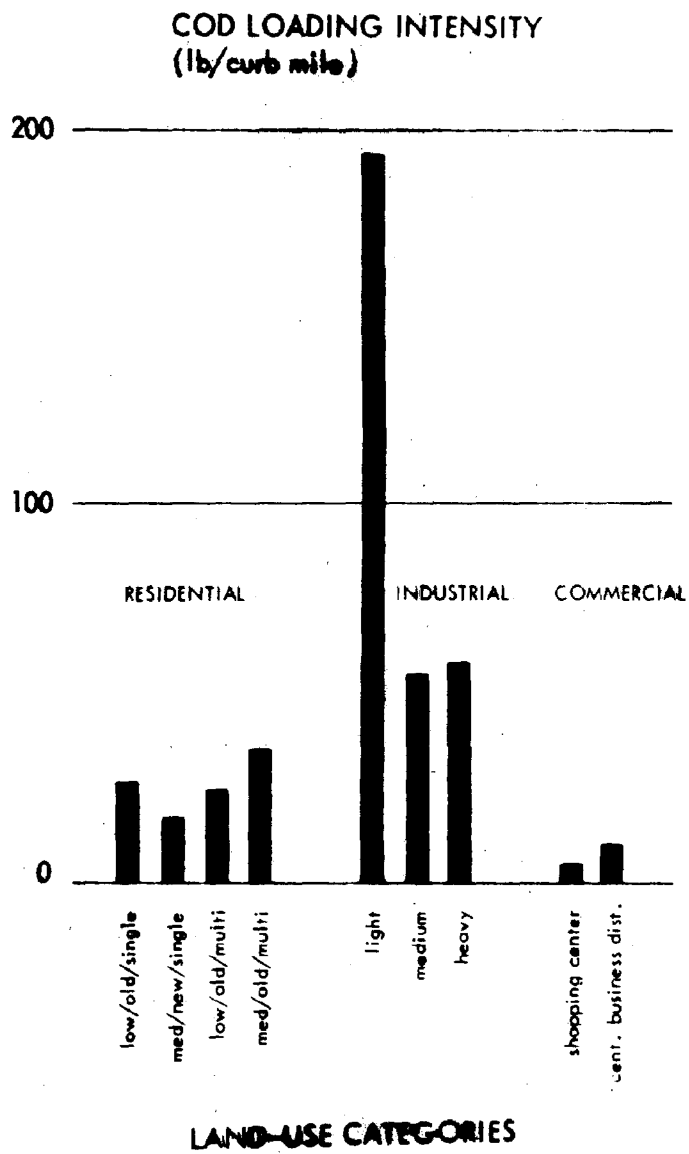


Figure 12-7 COD Loading Intensitities on Streets - Variation With Land Use (59)

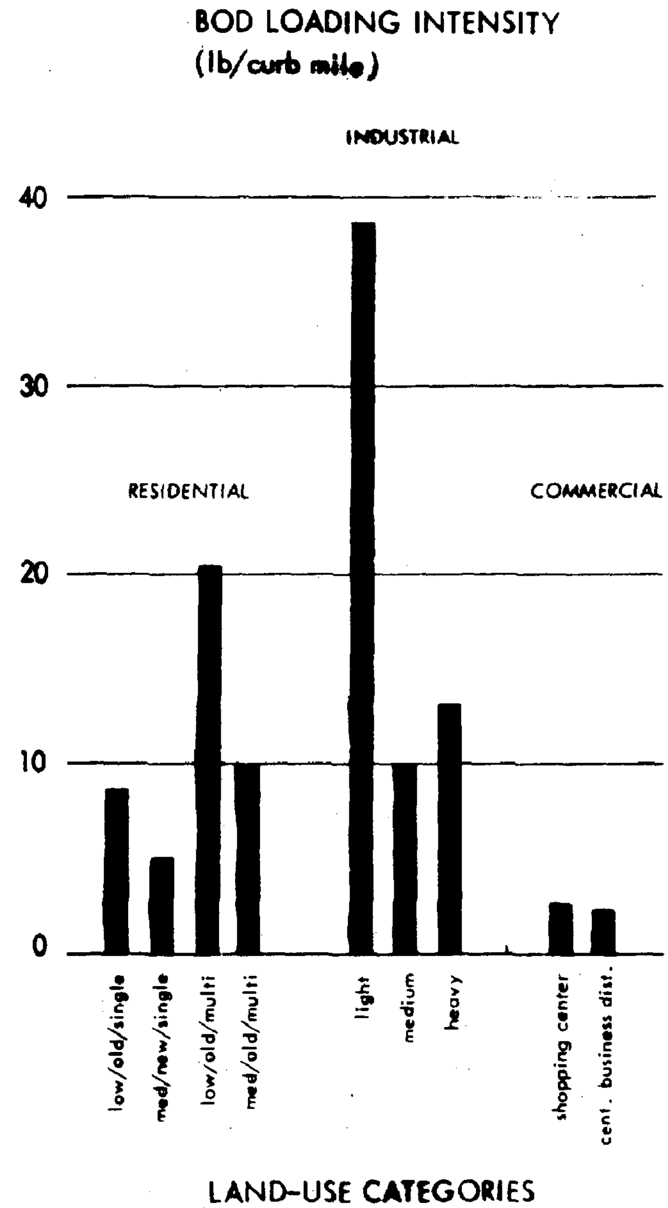


Figure 12-8 BOD Loading Intensities on Streets Variation With Land Use (59)

TABLE 12-15
NUTRIENTS IN STREET SURFACE CONTAMINANTS
VARIATION WITH LAND-USE CATEGORY (59)

	STRENGTH (% by weight)	LOADING INTENSITY (lb/curb mi)	(lb/1000 sq ft)
Phosphates			
Residential	0.113	1.07	12.3
Industrial	0.142	3.43	39.4
Commercial	0.103	0.29	3.41
Kjeldahl Nitrogen			
Residential	0.218	2.04	23.8
Industrial	0.163	3.94	67.1
Commerical	0.157	0.45	5.17
Nitrates			
Residential	0.0064	0.063	0.70
Industrial	0.0072	0.178	2.00
Commercial	0.0600	0.172	1.96

Note: The term "strength" as used here refers to the amount of contaminant contained in the dry solids collected from the street surface (on a weight basis). A phosphate value of 0.1 percent would be equivalent to 1 lb of phosphate per 1000 lb of sample.

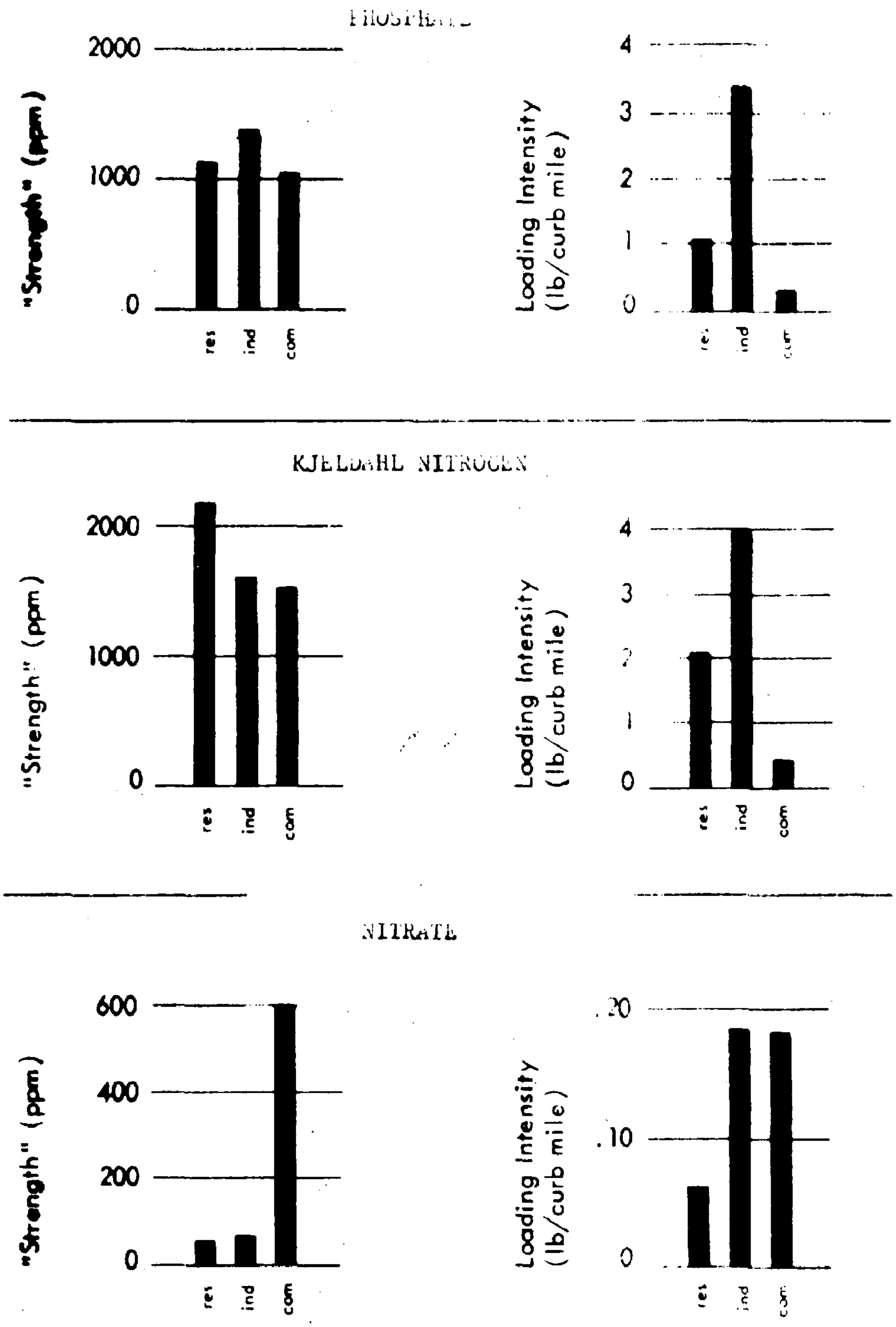


Figure 12-9 Nutrient loading intensities and waste "strengths"
Variation with land use

TABLE 12-16
HEAVY METALS LOADING INTENSITIES (59)
(lb/curb mile)

	ZINC	COPPER	LEAD	NICKEL	MERCURY	CHROMIUM
San Jose-I	1.4	.49	1.85	.19	.20	.10
San Jose-II	.28	.020	.90	.085	.085	.14
Phoenix-II	.36	.058	.12	.038	.022	.029
Milwaukee	2.1	.59	1.51	.032	-	.047
Baltimore	1.3	.33	.47	.077	-	.45
Atlanta	.11	.066	.077	.021	.023	.011
Tulsa	.062	.032	.030	.011	.019	.0033
Seattle	.37	.075	.50	.028	.034	.081
Arithmetic Means	.75	.21	.68	.060	.080	.12

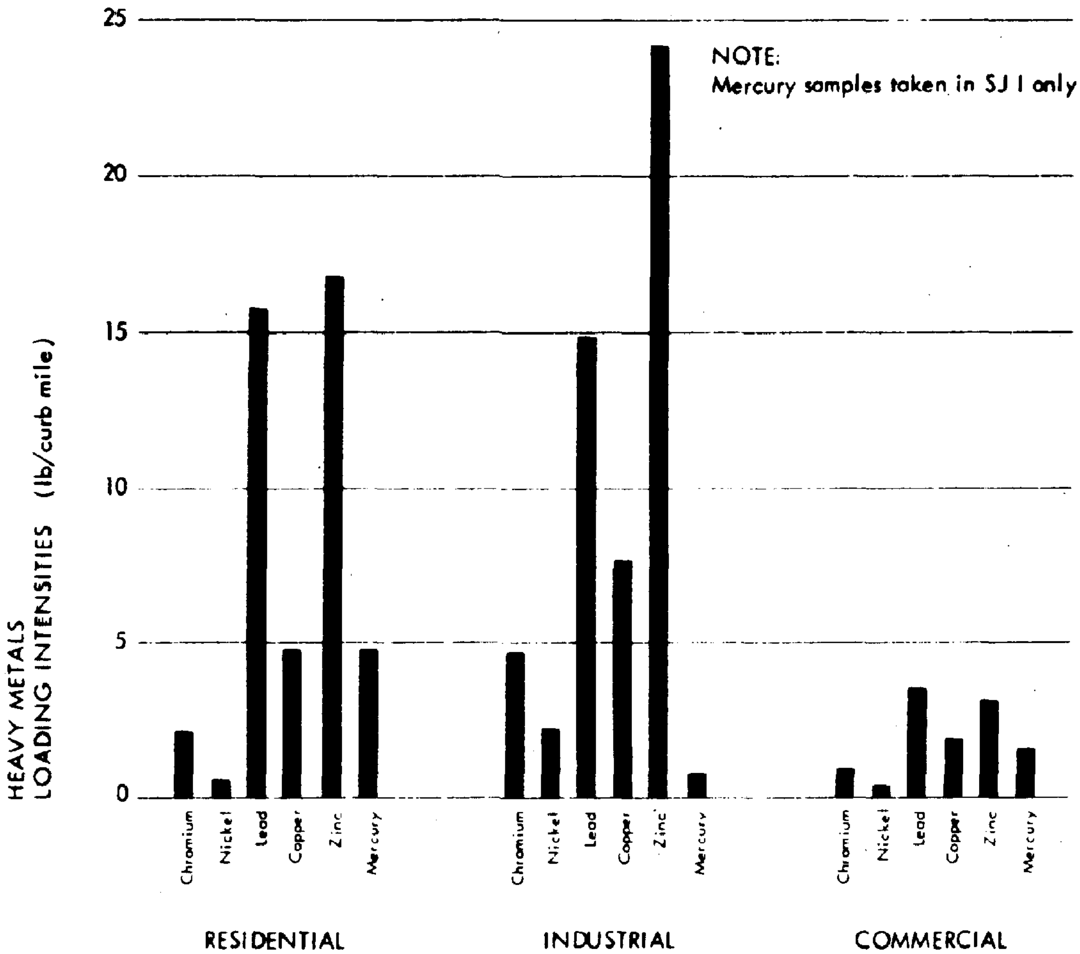


Figure 12-10 Heavy Metal Loading Intensities on Street Surfaces Variation with Land Use (59)

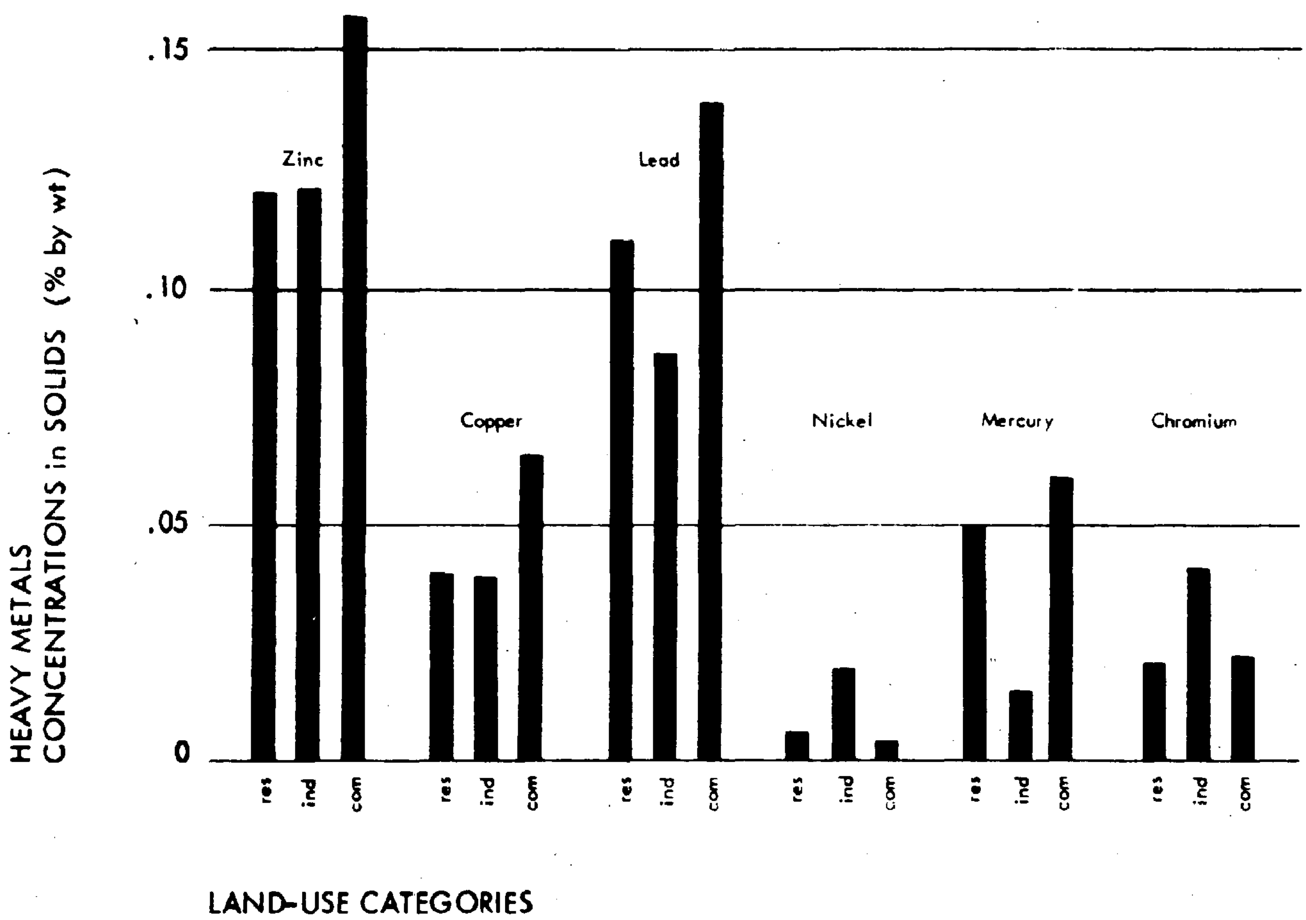


Figure 12-11 Heavy Metals - Concentrations Variation with Land Use (59)

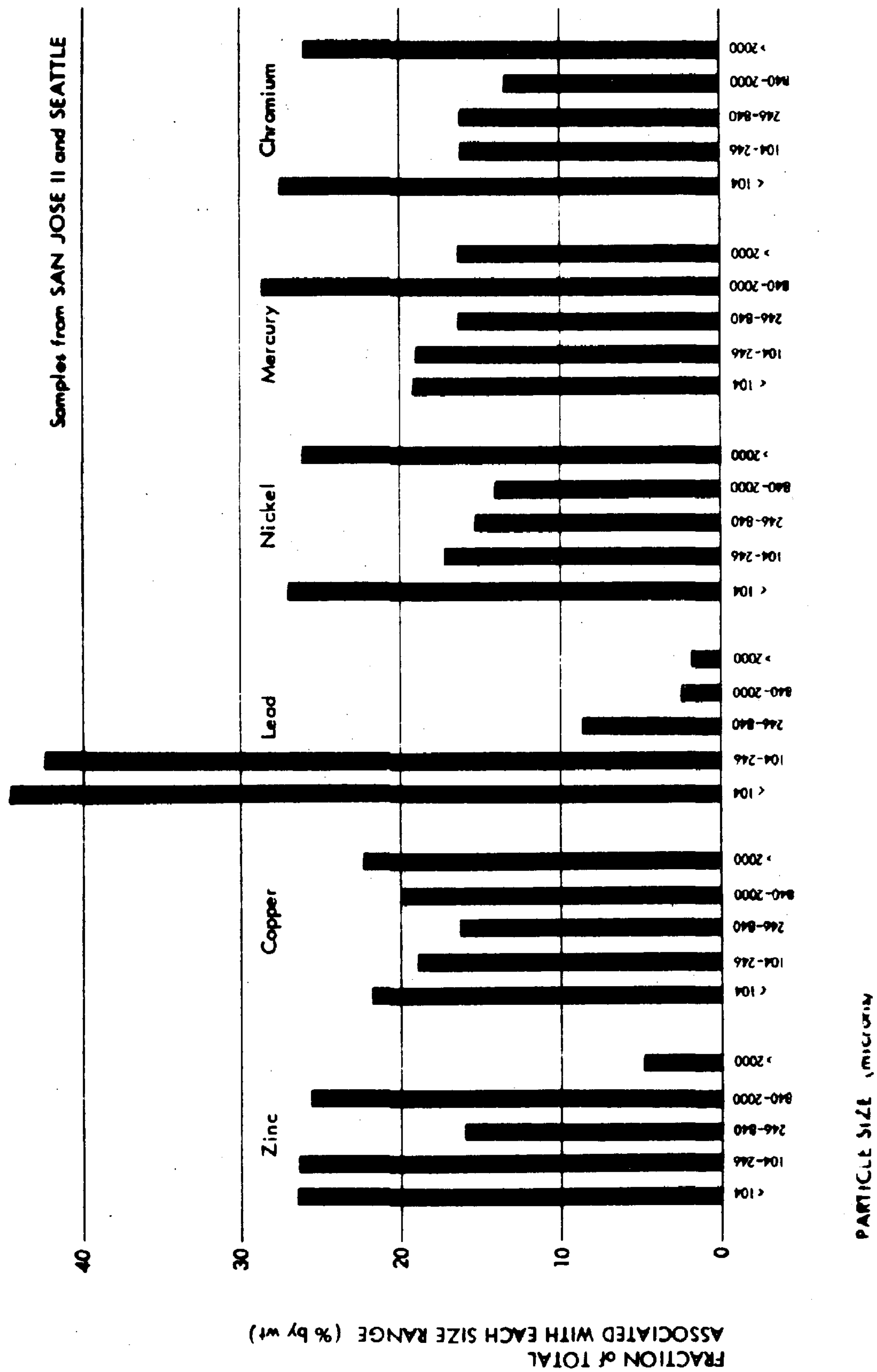


Figure 12-12 Heavy Metal Concentrations Variation With Particle Size (59)

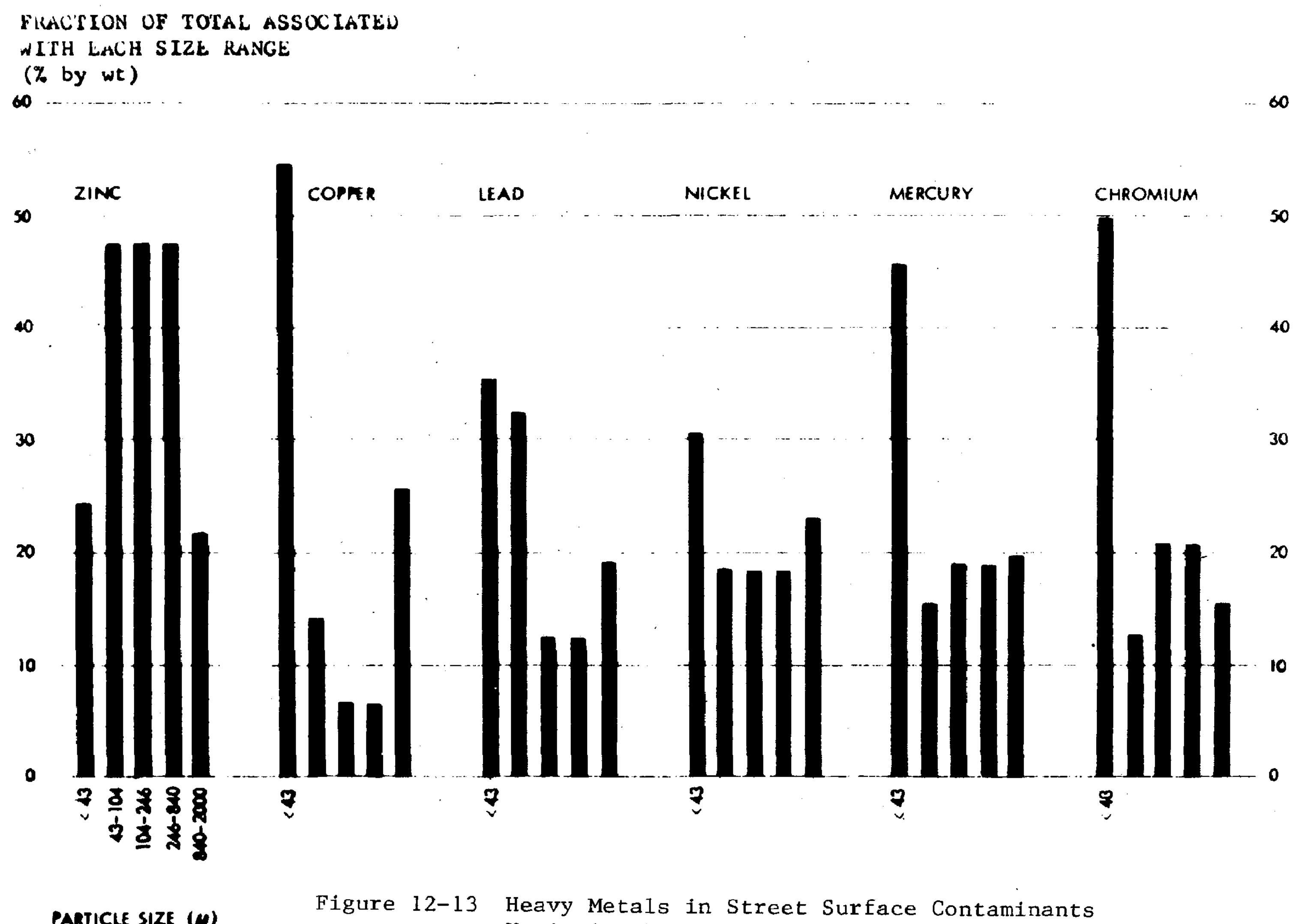


Figure 12-13 Heavy Metals in Street Surface Contaminants Variation by Particle Size for Bucyrus, Atlanta, Tulsa and Phoenix II (59)

TABLE 12-17
PESTICIDE CONCENTRATIONS IN TOTAL SOLIDS (ppm) (59)

	p,p-DDD	p,p-DDT	DIELDRIN	ENDRIN	LINDANE	METHOXY-CHLOR	METHYL PARATHION	P.C.B.'s
Residential								
San Jose 1	0.082	0.15	0	0	0	0	0	0.81
Milwaukee	0	0	0.009	0	0	2.5	0	2.0
Baltimore	0.11	0.030	0	0	0	0.19	0	0.99
Industrial								
San Jose 1	0.060	0.091	0.031	0	0.031	0	0.037	1.5
Milwaukee	0	0	0	0	0.001	3.6	0	2.0
Baltimore	0.020	0.020	0.018	0	0	0	0	1.0
Commercial								
San Jose 1	0.040	0.030	0	0.058	0	0	0	0.60
Milwaukee	0.020	0.031	0	0	0	1.8	0	0.99
Baltimore	0.020	0.031	0	0	0	0	0	0.51

land use categories and Figure 12-14 shows distribution of pesticides associated with particle size. Tables 12-18 and 12-19 present pesticide loading intensities in terms of pounds per curb mile in eight major U. S. cities. Generally, these compounds are associated with fine particles. A notable exception is the association of P.C.B.'s with coarser particles. Since the phenomena of higher concentrations being associated with fine grained particles is a function of surface area per unit volume, there is no readily available explanation for this data. It is interesting to note that in similar analyses of Chester River sediments, P.C.B.'s are associated with fine grained sediments as would be predictable.(17) These data are presented in Figures 12-15, 12-16, and 12-17, related to DDT and chlordane respectively are provided for comparison. Some known effects of chlorinated hydrocarbons on organisms in the Bay are reproductive failure, notably the thin shell syndrome in fish-eating birds, modification of shell structure in oysters and soft shell clams and direct kills due to exceedingly high levels. Table 12-20 provides information on P.C.B.'s, DDT, and chlordane levels in the biota and sediments of the Chester River, a relatively unpolluted drainage. These concentrations are believed to result primarily from Susquehanna River discharges, the sources in the Susquehanna system are undoubtedly agricultural and urban runoff.

The information presented in the preceding subsection clearly identifies the significance of urban and suburban runoff as a pollution input source to Chesapeake Bay. It should also be noted here that the magnitude of the problem increases as land use patterns change and that much of the significance of non-point source pollution is the difficulty in treatment. Data presented in E P A publications No. 47(60) and No. 56(61) document changing environmental conditions in the Upper Chesapeake Bay as a result of nutrient loading from the Susquehanna River Basin. As more of the Susquehanna Basin is developed these conditions can be expected to become more severe and the Upper Bay may ultimately be stressed to the point that it may become a biologically unproductive and unattractive area rather than a valuable natural resource. Similar conditions are also documented for the Potomac River, James River and other western shore tributaries. This effort on the part of E P A represents the preliminary steps necessary for the development of an urban runoff control program. Identification of the problem is only a beginning which must be followed by an adequate program for implementation of legislation, enforcement and control measures necessary to preserve the aquatic communities while providing for the needs of our society.

Thermal Additions and Power Plants

In the past decade a recognition and concern has developed in regard to possible pollution of aquatic resources. Many industries have been returning heated effluent to our tributary and estuarine waters for a number of years; however, the volumes which are produced by these industries are dwarfed by those associated with atomic and fossil fuel

TABLE 12-18
PESTICIDE LOADING INTENSITIES (59)
(10^{-6} lb/curb mi)

	p,p-DDD	p,p-DDT	DIELDRIN	ENDRIN	LINDANE	METHOXY-CHLOR	METHYL PARATHION	PCB'S	TOTAL OF ALL PESTICIDES AND PCB's
San Jose I	67	110	11	2	17	0	20	1200	1427
San Jose II and Seattle	120	170	27	0	0	0	0	1100	1417
Phoenix II, Atlanta and Tulsa	34	13	24	0	0	0	0	65	136
Milwaukee	0.5	1.0	10	0	3.1	8500	0	3400	12000
Bucyrus	83	60	17	0	0	1600	0	650	2451
Baltimore	100	30	3.0	0	0	170	0	1000	1300

TABLE 12-19
Pesticide Concentrations (59)
(10^{-9} lb of pesticide/lb of dry solids)

	p,p-DDD	p,p-DDT	DIELDRIN	ENDRIN	LINDANE	METHOXY-CHLOR	METHYL PARATHION	PCB's
San Jose I	73	120	12	2.2	19	0	22	1300
San Jose II	20	28	4.4	0	0	0	0	180
Phoenix I	-	-	-	-	-	-	-	-
Phoenix II	37	14	26	0	0	0	0	71
Milwaukee	0.19	0.38	3.8	0	1.2	3100	0	1300
Bucyrus	61	43	12	0	0	1200	0	470
Baltimore	100	30	3.0	0	0	170	0	1000
Atlanta	79	20	55	0	0	0	0	150
Tulsa	100	39	74	0	0	0	0	200
Seattle	270	380	59	0	0	0	0	2300

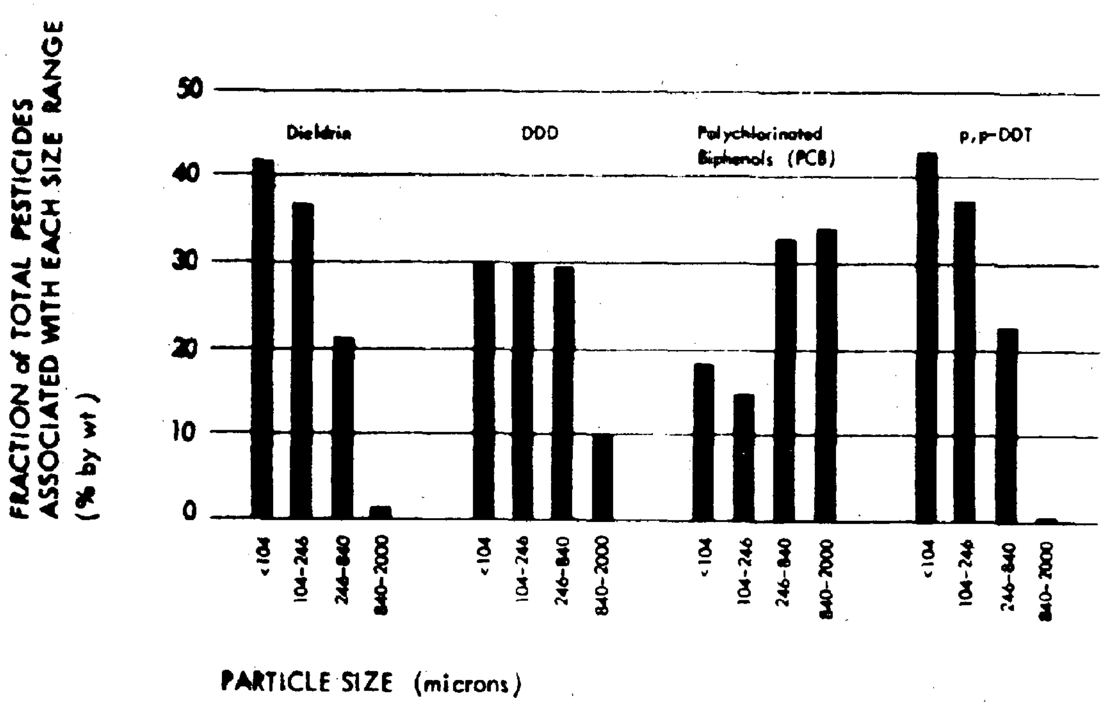


Figure 12-14 Pesticide Concentrations - Variation with Particle Size

TABLE 12-20
LEVELS (PARTS PER BILLION) OF PCB's
AND CHLORINATED PESTICIDES FOUND IN THE BIOTA
AND SEDIMENTS OF THE CHESTER RIVER

SAMPLE	PCB's		DDT (Total)		Chlordane	
	Average	Range	Average	Range	Average	Range
Oysters	55	16-250	43	0-150	36	9-160
Soft-Shelled Clams	58	13-180	21	4.1-130	14	0-38
Fish	185	2-570	134	50-260	74	34-180
Crabs	20	.4-51	33	18-28	.14	3-24
Sediments	87	0-310	16	0-63	5.2	.2-14

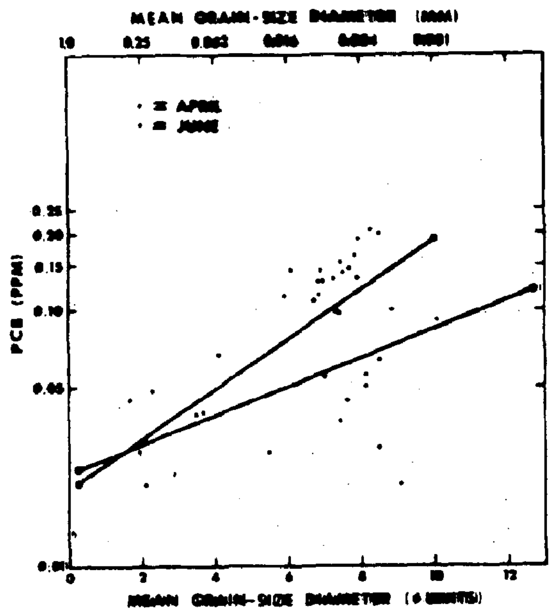


Figure 12-15 Relationship between mean-grain size of sediments and PCB concentrations for samples collected from Chester River. Concentration increases as mean-grain size decreases

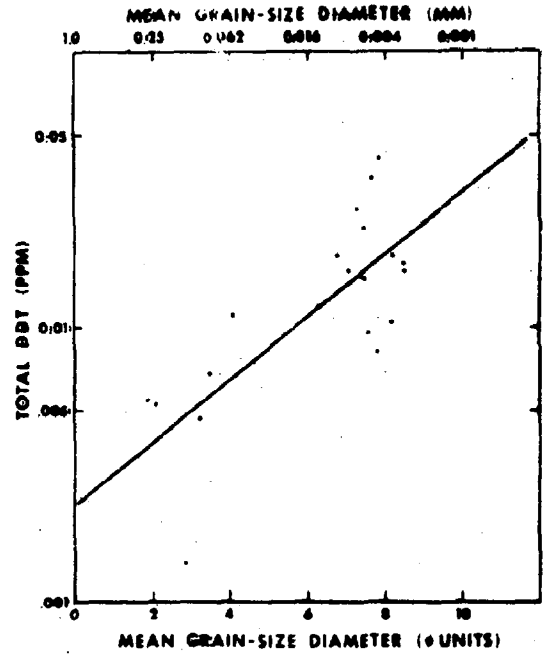


Figure 12-16 Relationship between mean-grain size of sediments and DDT concentrations for samples collected from Chester River.

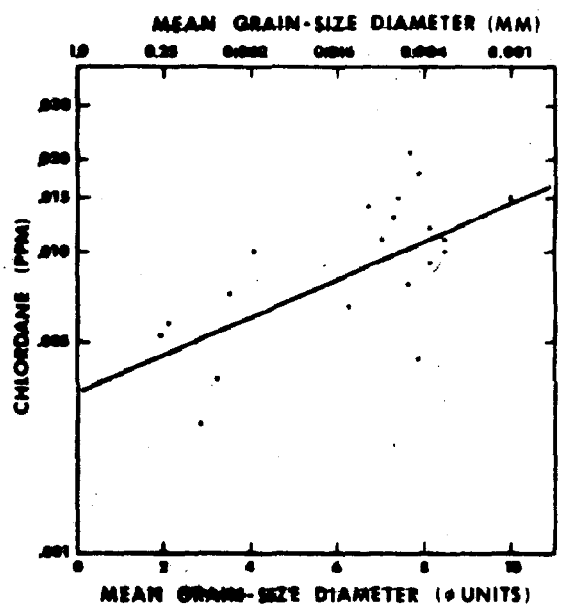


Figure 12-17 Relationship between mean-grain size of sediments and chlordane concentrations for samples collected from the Chester River.

power plants. Plants such as those located at Hog Island in the James River and at Calvert Cliffs in Calvert County, Maryland, will each be heating more than 2 billion gallons of water each day and returning it to the Bay. The flow of fresh water into the Bay on an average day is approximately 45 billion gallons. With the addition of only a few high output power plants, it can be easily seen that a major portion of the water entering the Bay will be heated to some extent.

Although the effects of temperature increases on the reproduction, spawning, migration, and life processes of many indigenous species have not been fully defined, some of the possible adverse effects of power plant operations are given in the following list: (12)

I. Intake Problems (Biological)

a. Fish may be impinged on intake screens. Impingement and/or removal of fish by high pressure water sprays and other means causes death or damage;

b. Phytoplankton, zooplankton, fish eggs and larvae entrained in cooling waters passing through the plant may be damaged or destroyed. This can occur from heat, abrasive action, turbulence, gas supersaturation, and pressure changes in the cooling system;

c. Organisms entrained through the plant or in the discharge may be killed when antifouling chemicals are used for cleaning the cooling system;

d. Fish and other organisms requiring moving water for spawning may be attracted to power plant intakes (particularly where long canals exist) and may spawn there where the drifting eggs can be lost to entrainment through the plant.

II. Discharge Problems (Biological)

a. Fish movements are restricted or prohibited by thermal barriers;

b. Fish resident in, or entering, thermal plumes may be killed by gas embolism;

c. Fish may be killed in or near a thermal discharge by reverse thermal shock. Plant shutdown, or sudden natural anomolies can cause temperatures to decrease rapidly in the plume areas, especially during winter;

d. Fish may be killed by sudden increases of temperature, depending on acclimation temperature, maximum temperature and period of exposure;

e. Species of fish (particularly the young) may be more susceptible to predation if stunned by heat exposure, or if physically damaged or subjected to changes in gas pressures;

f. Predatory fishes in heated discharges may experience additional advantage over prey species because of increased metabolic activity;

g. Sex products may fail to develop in adult fish resident in or near a thermal discharge;

h. Ripe adult fish may fail to spawn when attracted to a plume where they remain exposed to temperatures greater than natural;

i. Fish eggs may fail to hatch or larvae may be deformed when gravid females are exposed to higher than desirable temperatures;

j. Fish eggs or larvae may be damaged or destroyed by shock of temperature change from sinking plume movements during winter or from plumes impacting the bottom in spawning sites;

k. Young organisms resulting from early spawning of parents residing in heated effluent or hatched early because of accelerated incubation may not find in-phase food supplies available or may be unable as larvae to sustain a position in the current of the heated plume and would be pushed out into unheated areas where they perish;

l. Jet discharge currents from thermal plants may interfere with movements of larvae and small fishes. This may prevent their reaching required or favored nursery habitat and prevent establishment of year classes in some areas;

m. Fish resident in heated effluents may lose weight in winter apparently because rate of metabolism is high and food supply is low;

n. Aquatic insects having an emergent stage may enter the atmosphere early as a result of artificial heating of the water and may emerge into cold water where they are lost because of exposure, because food items are not in phase, or because normal egg laying conditions do not exist;

o. Endocrine system of fish or other organisms may function or develop improperly when exposed to abnormal temperatures. This may occur with young salmon exposed to high temperatures which cause them to become unable to make the transition (smoltification) from fresh to salt water;

p. Fish may be barred from use of favored or required zones by excessive temperatures;

q. Disease incidence may increase when fish or food chain organisms are exposed to warmer waters;

r. Fish and other organisms residing in thermal effluents may be affected by synergistic interaction of physical and chemical stresses, pollutants such as pesticides or other toxic materials;

s. Organisms may increase uptake of pesticides and heavy metals at higher temperatures;

t. Increased water temperatures from thermal discharge may stimulate algal growth and may cause a shift in species composition favoring less desirable green and blue-green algae;

u. Thermal discharge may stress biosystems and cause shifts in community structure or species diversity. Although the total biomass generally may not change substantially, desirable species frequently may be replaced by less desirable organisms or species not involved directly in the food chain;

v. Thermal discharge may affect the natural balance of the bacteria-algae relationship, favoring bacterial. This in turn could reduce oxygen levels by increasing the amount of decomposed materials;

w. Teredos (wood boring molluscs) or other undesirable marine forms intolerant of low salinities may invade areas when salinities increase in estuarine areas as a result of pumping;

x. Larval forms of marine invertebrates may develop at a metabolic rate which would reduce the survivability of individuals during settling or maturation;

y. Rooted aquatic plants, including kelp, may be damaged or destroyed by excess temperatures, velocities, scour or turbidity;

z. Benthic organisms may be damaged or destroyed by chlorine or other biocides contained in sinking plumes which flow along the bottom in the winter;

aa. Biological communities under stress from thermal discharge may not be able to reestablish themselves if eliminated from an area.

III. Physical Problems Which Could Affect Habitat

a. Intake or discharge structures, including dikes or dredged channels, may prevent the normal circulation of water or bar migration of organisms;

b. Discharge plumes may interfere with sediment transport along the shore and affect the deposition of sand and sediments in the discharge or nearby areas, resulting in shore erosion or beach starvation;

c. Natural temperature regimes and distribution patterns of a water body may be disrupted and destroyed by circulation of large volumes during pumping of cooling water;

d. Freshwater inflow to estuaries may be exhausted by withdrawals for power plant cooling which are subsequently discharged to the open ocean or another drainage system. The reverse may occur when saline waters are taken into the plant and discharged into freshwater zones;

e. Normal salinity distributions within estuarine areas may be altered by currents and mixing resulting from cooling water pumping with a resultant destruction of key habitat for shrimp or other organisms;

f. Clean water areas may be contaminated by introduction or redistribution of polluted waters to an area;

g. The release of phosphorous from bottom sediments may occur at an accelerated rate under anaerobic conditions at higher temperatures.

The existence of some of these problems has been documented while others are considered a potential threat to aquatic resources. The degree to which a particular condition will impact the biota or environment will vary with every individual situation depending upon the volume of water being discharged and its thermal and chemical makeup. Although the water requirements for power plants may be alleviated somewhat by the use of cooling towers, which reduce the volume of heated effluent, other problems may be magnified by the processes involved. When cooling towers are used, ten to twenty percent or more of the cooling waters are evaporated causing a concentration of the various chemicals used in the plant operation, thus presenting a chronic source of water pollution. The Atomic Energy Commission report entitled "Toxicity of Power Plant Chemicals to Aquatic Life"(13) states that the composition of power plant discharges depend on such factors as intake water quality, additives used for pre-operational cleaning, additives used for preserving the structural strength of cooling tower components, and additives used for control of corrosion, scaling and biological growths. In addition, reactions may take place between the various compounds or between the chemicals and the cooling or receiving waters thus exacerbating the situation.

In recognition of the regional, national, and international importance of Chesapeake Bay fish and wildlife resources, every conceivable effort to minimize adverse environmental impacts from power production must be made. Those involved with the design and location of power plants (Figure 12-18) should take into consideration all possible effects on the aquatic environment and its biota as well as the need for electrical power.

Currently, there are 25 power generation facilities in operation in the tidal waters of Maryland and Virginia. Twenty-four of the plants are fossil-fueled, either coal, oil or gas turbine. Only two plants, the Surry facility on the James River, and the Calvert Cliffs plant in Southern Maryland are nuclear powered. At least four more nuclear plants are in the planning stages or are under active construction. Two of the nuclear plants in the active planning stage, Douglas Point on the Potomac River and an unnamed site west of Chesapeake City on the C and D Canal are located in the primary striped bass spawning grounds of Chesapeake Bay (Figure 12-19). A third nuclear plant, Summit, is in the planning stages. Although this plant is located in Delaware, it is also potentially sited on the C and D Canal approximately 5 miles east of the Chesapeake City site and within the aforementioned striped bass spawning grounds of the Upper Bay.

The total generation capacity of on line, tidal power plants in Maryland and Virginia is 14,470 M.W. The generation capacity of the new facilities proposed within the next 10 years, including the Summit nuclear plant adjacent to Maryland in the C and D Canal, is 24,999 M.W., an increase of approximately 175 percent over existing generation capability. (Unpublished data from Martin Marietta Corp.)

Petroleum

Records of reported oil spills in the Chesapeake Bay area are compiled and maintained by the Environmental Protection Branch of the Fifth Coast Guard District in Portsmouth, Virginia. Until early 1972, very few incidents were being reported from areas outside of the Portsmouth, Norfolk, Hampton Roads region. Since that time procedures have been modified such that spills which occur throughout the Bay Area are being reported in increasing numbers. In April of 1973, the Coast Guard began a helicopter surveillance program which permits rapid identification of oil pollution problems and has greatly increased the number of reported spills. A large portion of these incidents consist of a few gallons of petroleum product which produces a sheen on the water with another large portion consisting of spills involving 50 to 500 gallons. About 1.5 percent of the spills occurring on the Bay are considered major, consisting of quantities greater than 1000 gallons ranging up to the 250,000 gallons which was released when an oil barge sank near the mouth of the Potomac River in 1976.

The total effect of these spills on the aquatic environment is not completely understood. Oil and its products vary in toxicity to aquatic organisms with the more refined products generally being more toxic; however, the crude oils may contain slow acting compounds which could interfere with the life processes of the affected

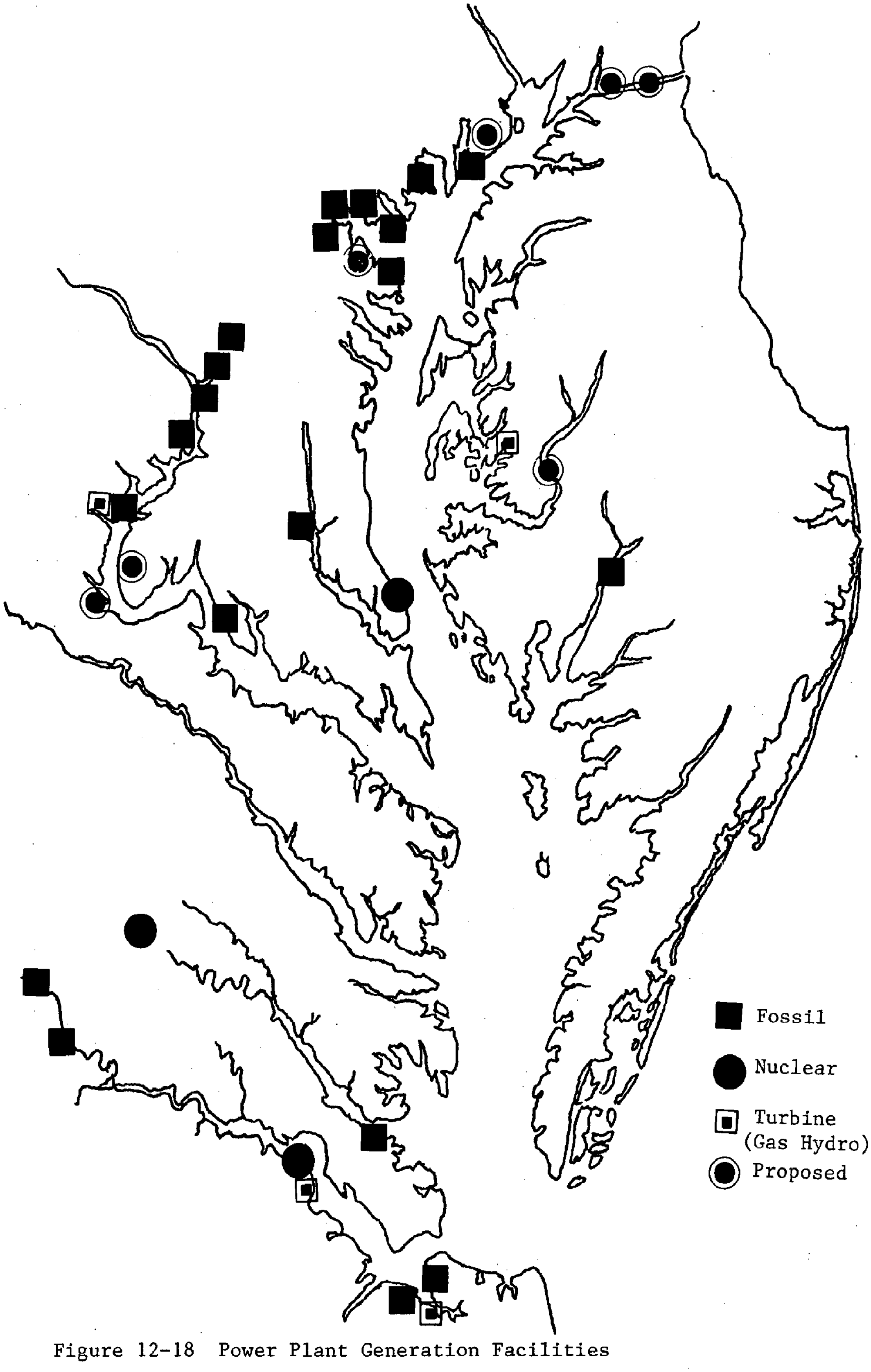


Figure 12-18 Power Plant Generation Facilities

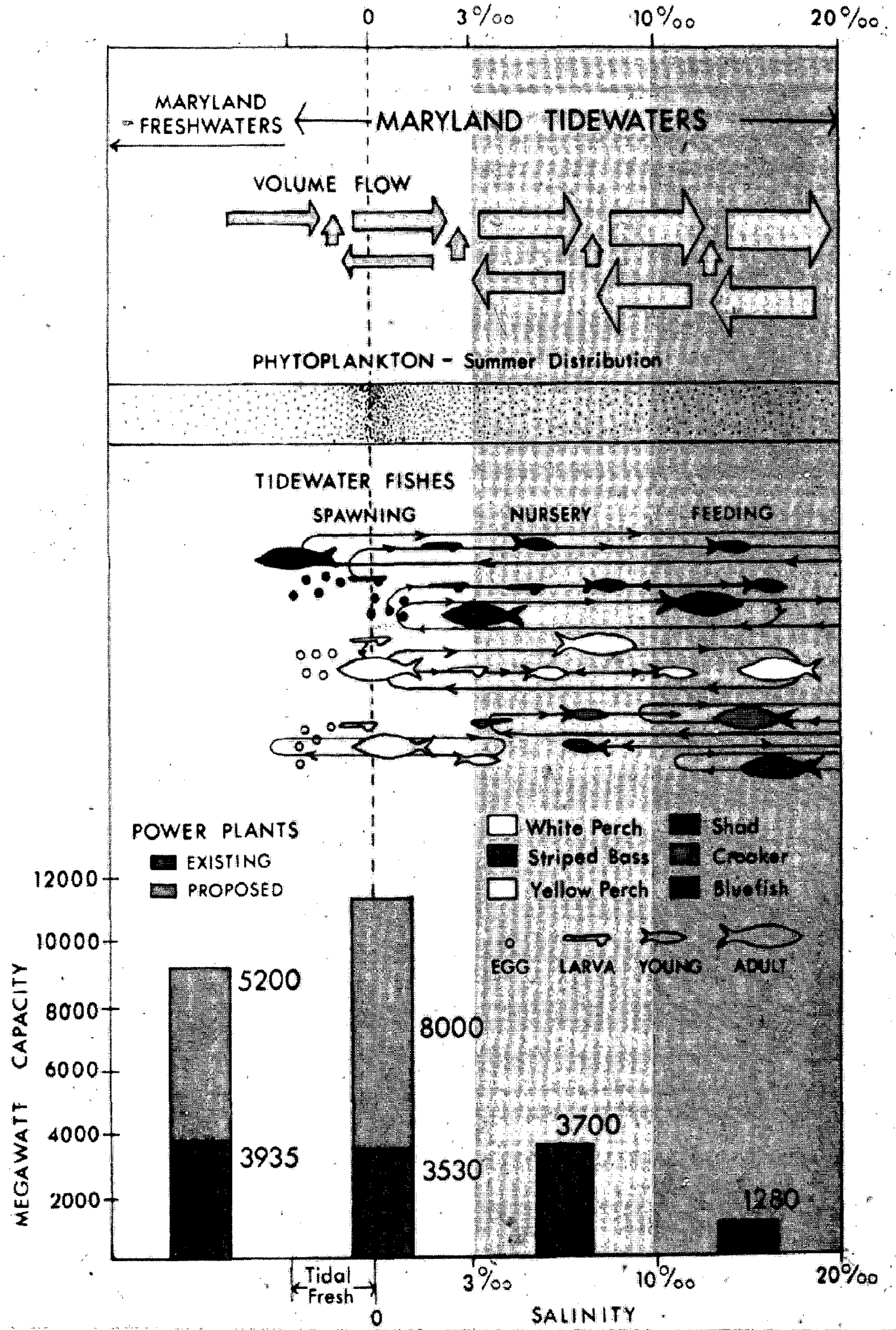


Figure 12-19 Spawning Areas and Distribution of Power Generation Facilities - Provided by Maryland Power Plant Siting Program

organisms. The more visible effect of oil pollution is the destruction it causes when large quantities reach a shoreline area. In such a case many of the animals which live or feed in the littoral zone become covered with the oil and suffocate or injest the oil and are poisoned. In the Chesapeake Bay region, there is much concern about the presently occurring and potential losses of waterfowl due to oil pollution problems.

The waterfowl which winter in the Chesapeake constitute a major portion of those using the Atlantic flyway and include large percentages of the total populations of species such as canvasback and redhead which have been removed from hunting status because of declining populations. In addition to the numerous species of duck, about one half of the North American populations of whistling swans and several hundred thousand Canada geese winter in the Bay area. Detrimental effects on these waterfowl populations have already occurred due to oil pollution and will probably continue to occur in the future. As many as 5000 birds have been killed on a single occasion in the Bay and other spills have caused the death of many thousands more. The birds which are most susceptible to oil pollution are the diving ducks which include redhead, canvasback, scaup, ringneck, goldeneye, bufflehead, ruddy ducks, and the sea ducks. Because of the flocking nature of these birds, a single spill which occurs in a feeding or resting area can have a devastating effect on a population, especially if that population is already reduced in numbers and is under other environmental stresses such as reduced breeding habitat or decreased reproductive rate due to pesticide ingestion.

In order to provide a comparison of the principal wintering areas for waterfowl and the areas where documented oil spills have occurred, two maps have been prepared. The first of these maps (Figure 12-20) shows the average concentrations of diving ducks in the Bay taken from five years of mid-winter waterfowl survey data of the U. S. Fish and Wildlife Service. The second, (Figure 12-21) is a compilation of the oil spills reported to the U. S. Coast Guard Environmental Protection Branch during the one-year period from July 1972 through June 1973. It is readily apparent from the oil spill records the majority of incidents occur in the Baltimore Harbor and Hampton Roads complexes, while the major diving duck wintering area (about 30 percent of the Chesapeake Bay total) is located in the lower Potomac River. It should also be noted that several spills associated with an existing oil storage facility have occurred in the lower Potomac region and on one occasion an estimated 2000 birds were killed. This area has recently been proposed as the site for a 100,000 barrel per day refinery which would undoubtedly increase the volume of shipping and the probability of a spill occurring. A review of the Coast Guard records indicates that the vast majority of the accidental oil spills occur during loading and unloading operations. Since oil and waterfowl as well as numerous aquatic organisms including shellfish and finfish, are obviously

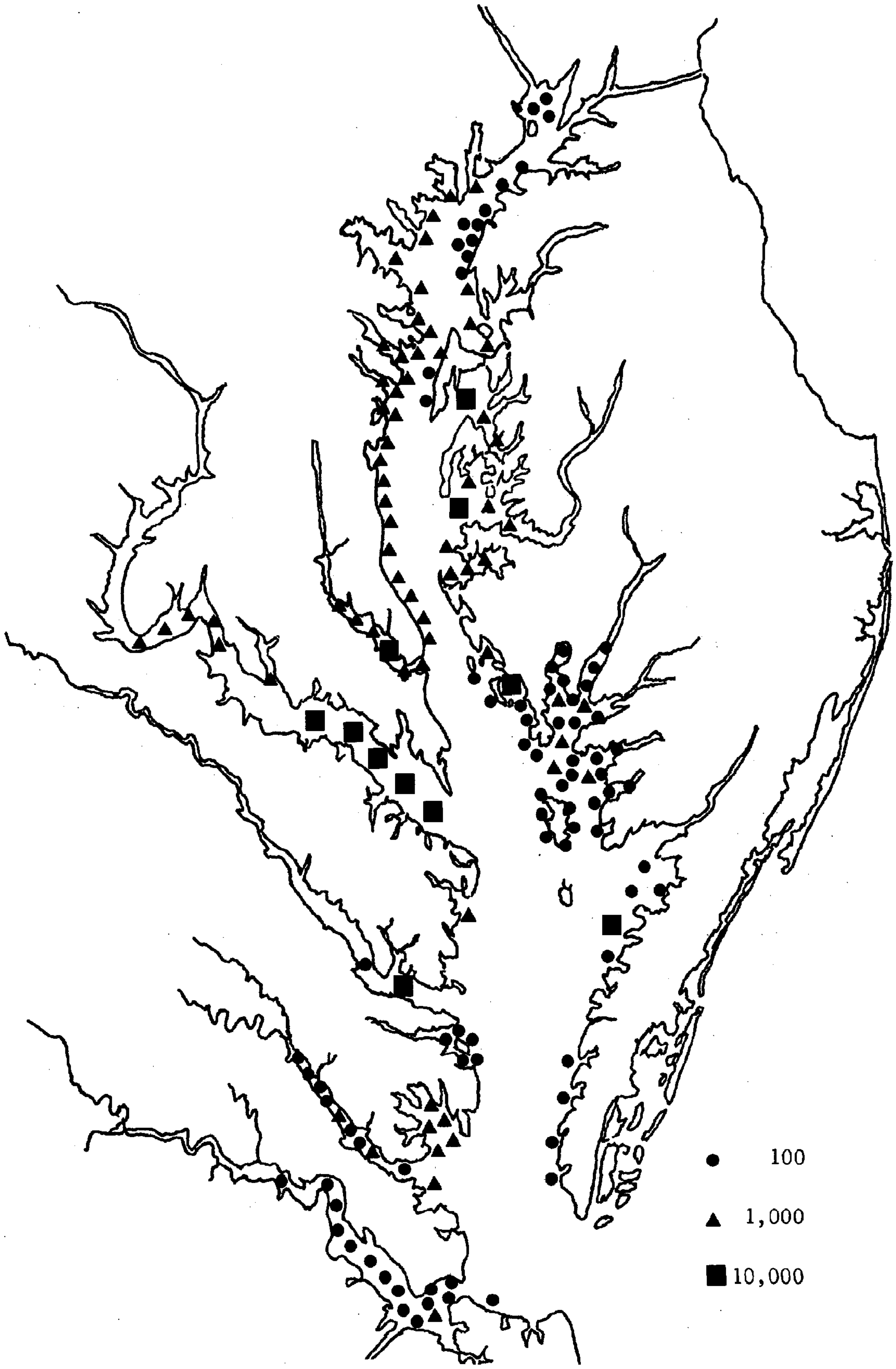


Figure 12-20 Concentrations of Diving Ducks in the Bay and Tributaries - Averaged Mid-Winter Waterfowl Survey

Figure 12-21 Distribution of Oil Spills in Chesapeake Bay
Reported Oil Spills July 1972 to June 1973

not compatible, persons involved with the establishment of facilities for handling petroleum products should make every effort to locate these facilities in areas which are not of primary ecological importance and the facilities which are presently in operation should utilize the available technology to reduce the incidence of damage from oil pollution.

Recently, plans for offshore drilling operations along the eastern coast have been proposed and it is not unreasonable to assume that if the demand for petroleum products is great enough, pressures for the development of refineries and related operations within the Bay will occur. Such developments, under the pressures of demand for high production, could have drastic effects on the Bay system. It will, therefore, be the responsibility of all concerned agencies to bear the burden of regulating such development.

Physical Changes

Aside from the previously mentioned parameters which cause chemical changes in the aquatic environment, additional degradation in the water quality may be brought about by physical changes which add sediments to, remove water from or alter the flow characteristics of the estuarine system. Although many physical changes are occurring naturally, the rate and nature of these changes are greatly affected by the activities of man through his development and utilization of both terrestrial and aquatic resources. These alterations may cause significant changes in the aquatic habitat thus reducing utilization by some species which were previously sustained. Some of these physical changes, their causes and potential effects are discussed in the following paragraphs.

Sedimentation - Sedimentation has a profound impact on the biological productivity of the Bay and on its usefulness to man as a recreational resource, and as a transport mechanism for industrial products produced in or used by industries sited in the eastern United States. Annually, millions of dollars are spent by private and public agencies in order to maintain navigable waterways. It has been estimated (Bulletin 12, The Sediments of Chesapeake Bay)[14] that the average rate of sedimentation over the past 10,000 years has been approximately 6,115,000 cubic yards per year. It is not known to what degree man's activities have increased this sedimentation rate although it is believed to be substantial. Without question, the rate of sedimentation has increased in localized areas as a result of urbanization, agriculture, waterfront development and dredging. Although little quantification exists to document fin and shellfish losses due to sedimentation, there is general agreement that losses do occur. Deposits of loose sediment only 1-2 mm thick make surfaces unsuitable for attachment of oyster spat[15] while deposition of heavy silt loads may kill adult oysters.[16] Sedimentation may also result in the reduction of species diversity in benthic communities with a resultant impact on dependent species. Fish species with demersal eggs such as the economically important winter flounder may also be adversely impacted by sediment deposition on their spawning grounds whether caused naturally or by the acts of man through channel dredging and spoil deposition. Some other possible detrimental effects of suspended sediments and spoil deposition on the aquatic resources are given in Table 12-21.

TABLE 12-21
POSSIBLE DETRIMENTAL EFFECTS OF SUSPENDED AND DEPOSITED SEDIMENTS

Suspended Sediments

1. Reduction of euphotic zone;
2. Interference with successful hatching of eggs, larval development;
3. Carries organic matter to the bottom where decomposition products may be formed;
4. Reduction of feeding activities in benthic organisms;
5. Decreased rate of temperature change in the aquatic environments;
6. Resuspended sediment may exert oxygen demand;
7. Resuspended sediments may release nutrients at high levels;
8. Resuspended sediments may release heavy metals and other toxins.

Deposited Spoils

1. Smother benthic organisms;
2. Change in sediment size may alter population type;
3. Cover spawning areas;
4. Bulk density is reduced making resuspension by wind-wave action easier;
5. Spread as a semi-liquid mass over areas larger than spoil site;
6. Thin layers of silt may prevent attachment of oyster spat.

The majority of the sediments entering the Bay are derived from the Susquehanna River and the Western Shore tributary complex. Another source of sediment is shoreline erosion which causes the loss of about 460 acres each year within the Bay and its tidal tributaries. Figure 12-22(17) documents the shoreline erosion which has occurred on the north end of Kent Island since 1846. Other regions of the Bay have had similar changes in shoreline configuration due to erosion and deposition. The volume of sediment entering the Bay from eroding shoreline is dependent upon the area from which it is eroded.

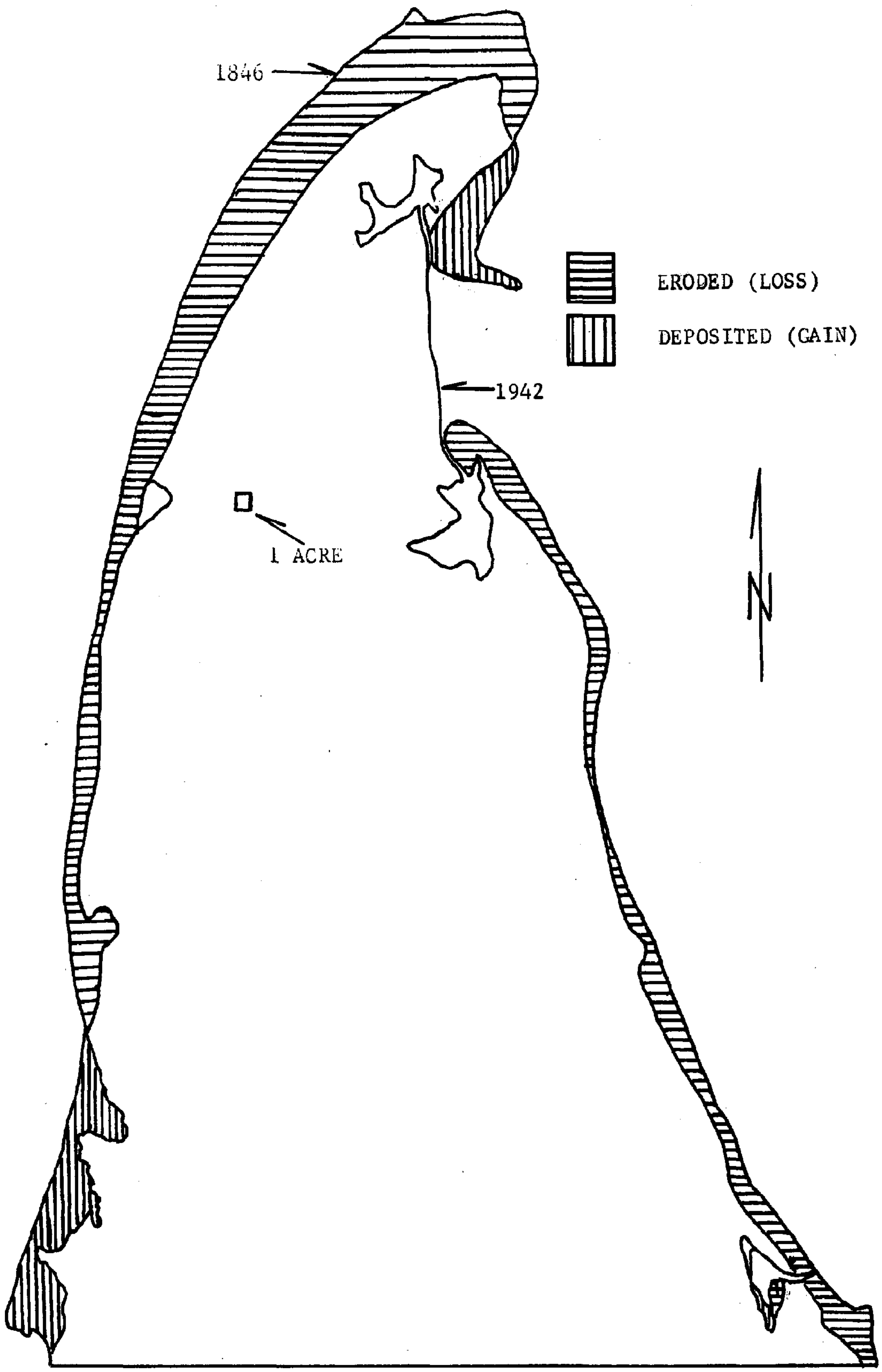


Figure 12-22 Kent Island Erosion Rate (17)

For example, a one-foot recession of the shore at the Calvert Cliffs formation would cause the deposition of a much greater volume than would a one-foot recession of the shore in a tidal marsh. If the eroding shoreline averaged only one foot high, the volume of sediment entering the Bay each year would amount to 3/4 million cubic yards. Sediments also enter the Bay to a lesser degree from the eastern shore tributaries and by the upstream flow of high salinity waters at the mouth of the Bay carrying marine-derived sediments.

Increases in land development and other activities of man are expected to cause an increase in the volumes of sediment entering the Bay during the next several decades (Figure 12-23). These quantities indicate only those sediments derived from runoff into the tributaries of the Bay and do not include the sediments derived from eroding shorelines and marine sources, thus are less than the quantities previously indicated.

Erosion and sediment are naturally occurring conditions which may have a detrimental effect upon the fish and wildlife resources of the Bay. The degree to which these resources are impacted is determined by the extent of the affected area, the duration of its instability and the ability of the affected biota to reestablish.

During an event such as Hurricane Agnes in June of 1972, great quantities of sediment were deposited in the upper reaches of the Chesapeake Bay; however, because such large depositions are not a regular occurrence much of the biota of that region has been able to reestablish itself. In a situation where a shallow bay bottom is adjacent to an eroding shoreline, the continuing shifting of the sediments may not allow the establishment of a self-maintaining community.

In addition to those physical impacts associated with sedimentation, there exists also the possibility that sediments act to affect the chemical environment in specific cases. It has been shown that sediment particles adsorb and absorb trace metals, halogenated hydrocarbons and other pollutants in inverse proportion to particle size.(17) It is therefore readily apparent that those sediments which have the greatest probability of movement through natural means such as extreme climatic phenomena or through man-induced movement such as dredging, have the greatest potential impact on the environment. The consequences of such mobility is an increased availability of deleterious substances to the biota, particularly filter feeding organisms such as soft clams, hard clams, oysters, and other molluscs. In instances where sediments have been polluted to a dangerous level such as in Baltimore Harbor or Norfolk Harbor, the impact of their movement into relatively unpolluted areas where healthy populations of estuarine organisms exist could be extreme and disasterous. It is therefore imperative that harbor managers and regulatory agencies be fully cognizant of the conditions existing within sediments prior to undertaking activities which would disturb or result in transport of such sediments to unaffected regions of the Bay. With such knowledge it is incumbent upon those individuals and agencies

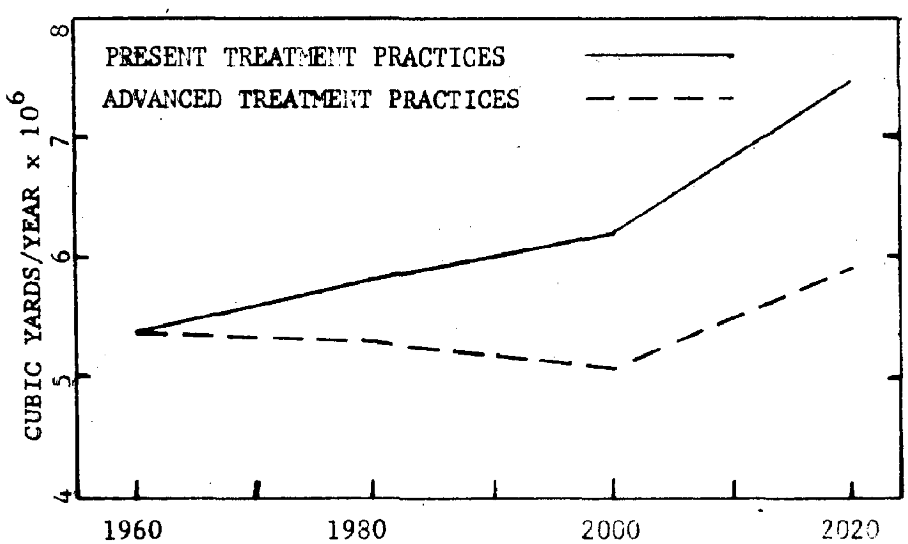


FIGURE 12-23 MAN-DERIVED SEDIMENTS ENTERING CHESAPEAKE BAY(3)

responsible to undertake only those actions that clearly will not affect the public's fish and wildlife resources and to develop alternatives to proposed actions that would result in damage.

Shipping and Navigation - The Chesapeake Bay provides access to two of the major sea ports of the country as well as numerous smaller shipping facilities. The total commerce on the Chesapeake Bay in 1970 was 148 million tons. Baltimore Harbor and the Newport News-Norfolk Harbor complex accounted for more than 122 million tons. These figures are increasing annually with an accompanying increase in the tonage shipped and the associated facilities. The activities associated with and necessitated by the shipping industry often cause changes in the fish and wildlife habitat, including total destruction in some areas.

Overboard disposal of sewage and waste has increased in recent years primarily due to the increase in pleasure craft. The occurrence of concentrations of recreational craft in small boat marinas brings about a situation similar to an untreated sewage discharge from a small town. The Water Quality Improvement Act of 1970 deals with the control of sewage discharges from vessels into the navigable waters of the United States. However, until disposal facilities are available and regulations can be enforced, these discharges will continue to be a problem.

Wakes and turbulence created by ships and pleasure craft magnify the problem of erosion in the Bay. Shoreline erosion which is caused naturally by wind-induced waves, tidal action and currents has been increased by wakes from commercial and pleasure craft which are present on the Bay in greater numbers each year. Turbulence from wakes is especially noticeable in some tributaries where pleasure craft occur in high concentrations during the summer months. In these shallow tributaries the turbulence caused by prop wash and wave action can cause a resuspension of fine-grained sediments resulting in increased turbidity and deposition at other locations which may reduce productivity and damage shellfish beds.

Programs which are oriented primarily at improving navigable waters and increasing access and use of these waters may contribute to the destruction of fish and wildlife and their habitat. Most navigation projects include dredging and the associated disposal of spoil material. These projects always have a detrimental effect on some segment of the fish and wildlife resources of the Bay, with the degree of impact varying with the area of operation. In every dredging operation some benthic organisms will be destroyed. If the depth is not changed, the dredged area may be repopulated by a community similar to the one removed. However, if the substrate composition is changed or the area is dredged to a depth beyond that normally inhabited by the species removed, rehabitation by other species may occur. During a dredging operation, sediments are resuspended producing varying degrees of turbidity which interfere with the life processes of planktonic plants and animals by reducing the availability of light and/or oxygen.(18) In the process of opening new channels or deepening existing ones, changes occur in the physical and chemical properties of the habitat.(19, 20) Deeper channels allow upstream intrusion of higher salinity waters than might naturally exist. Currents may be increased in the dredged area affecting the drainage and flow patterns of adjacent regions. The consequences of these changes may include the introduction of parasites, displacement of species with a low tolerance for salt, lowering of water level in marsh areas and an increase in the suspended sediment load due to higher current velocities. There are undoubtedly other consequences, some of which may have little adverse effect and others which may be beneficial to some segment of the fish and wildlife populations.

The dredging and maintaining of channels produces large quantities of spoil material which present a disposal problem. These spoils are dumped into natural or dug basins or onto shore areas. When the spoils are dumped into a deep-water disposal area, there is an immediate loss of the benthic organisms which are covered, including shellfish and other invertebrates which are food for fish. Spoils which are dumped into open water cannot be readily contained.(18) The actions of currents and tides carry some of the materials to adjacent areas where there is potential destruction of more habitat by siltation. When these spoils have been dredged from polluted areas, toxic materials may be released at the dump site. If the spoil material is located where it might be disturbed by wind-formed waves or wakes from ships, then it is probable that some portion of the spoil material will continue to be resuspended for some time following its disposal. This resuspension increases turbidity which decreases primary productivity and the presence of suspended material in addition to the normal load, increases the stresses of the biota of the area.

Extensive navigation projects such as the Chesapeake and Delaware Canal present problems which are the subject of much study and debate as to their effect upon the physical and biological parameters involved. Mathematical and model studies on the flow through the Canal[21] (from "Enlargement of the Chesapeake and Delaware Canal Hydraulic and Mathematical Model Investigation") have indicated that the increased dimensions from 27' deep to 35' deep and 250' wide to 450' wide, will cause an increase of 2.5 to 3.2 times the present net flow (about one billion gal/day from west to east). At the same time, tidal elevations in the Elk River downstream to Turkey Point are expected to show an increase when conditions favor a substantial westward flow. What will be the long range consequences of this type of project? Some researchers feel that the water flow through the canal will cause an upstream intrusion of higher salinity waters resulting in a change in the biotic community. The extent of this intrusion and the resulting change of biota can not be determined with any degree of accuracy at the present time. In addition to the upstream intrusion in the Chesapeake, there may be an increase in flow of Delaware Bay water from east to west during certain tidal cycles causing an increase of salinity in areas of the Elk River.

Some of the possible effects on the biotic community which may occur due to the changes in flow through the C and D Canal include the following:

1. Striped bass eggs which occur in the western segment of the canal in high concentration during certain times of the year might be carried into the Delaware estuary in a time period shorter than their incubation period.[19]

2. Shear forces created by the increased flow and by large ships might destroy many eggs and larvae.

3. Distribution of the brackish water clam, Rangia cuneata, which is a major food source for overwintering waterfowl, might be affected by a slight change in salinity since it is already inhabiting a marginal part of its geographical range.

4. Salinity regime changes might also affect large mouthed bass and other fresh water fish populations which do not spawn at salinities greater than 3.5 parts per thousand.

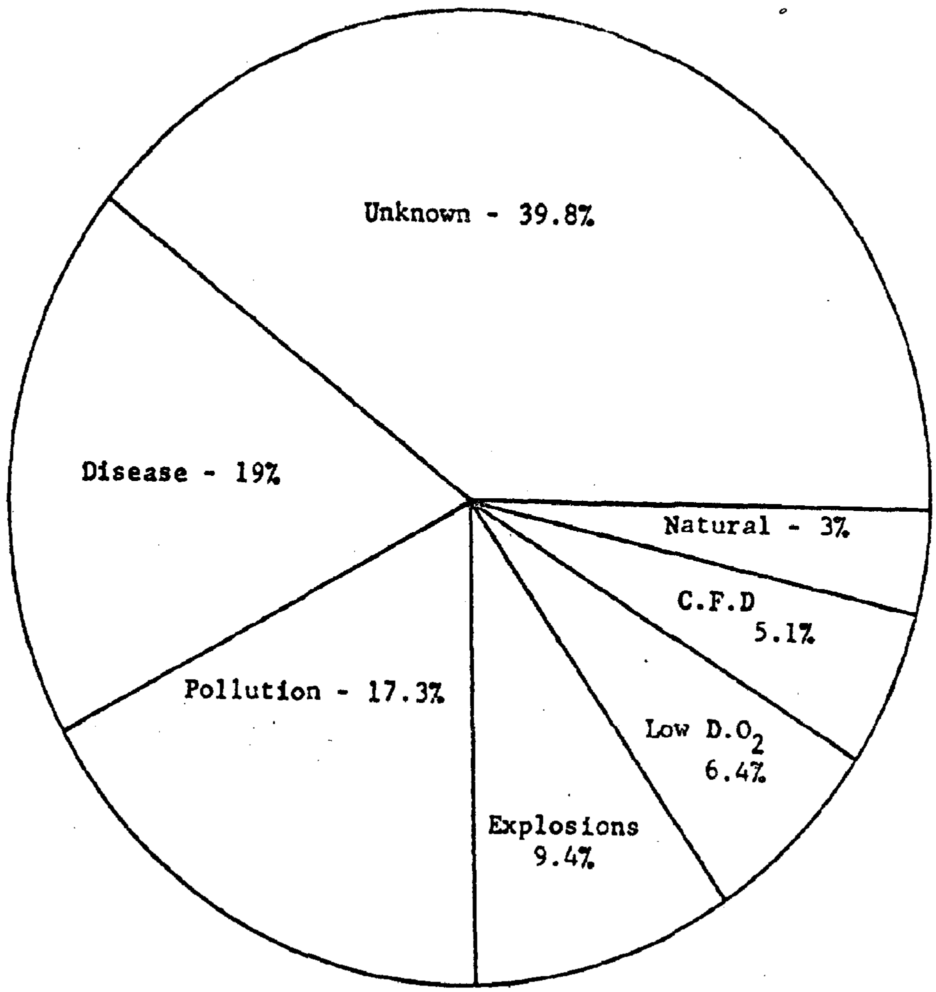
Mining - The majority of the mineral resources which are produced in the Chesapeake Bay region are non-metalic types including building stone, sand, gravel and shell.[1] The process of finding, exposing, and extracting these minerals, induce physical, chemical and biological changes.[22] Some of these changes are confined to the mining site while others are far-reaching. The most evident change is the physical alterations of a claim site in a terrestrial habitat. When an area is to be mined, the overburden is removed and placed in spoil banks, thus causing a destruction of habitat not only at the immediate mining site but also in some adjoining area. Loss of habitat also occurs due to road construction, slides, waste disposal and flooding. The aquatic habitat is affected by large quantities of silt and sediment, diversion or loss of a permanent stream flow and changes in the bottom characteristics. Sand and gravel are a major product of mining in the coastal plains and large areas of the Piedmont plateau. These resources are mined not only from open pits but also by dredging in river beds which may remove spawning gravels and increase the silt load downstream, destroying aquatic flora and fauna. Chemical alterations affecting the soil and water also occur due to mining activities. Water passing through and over mine workings or spoils, leaches minerals, which are carried into the aquatic environment. At the same time, toxic spoil areas are left which will not support plant or animal life. These conditions often occur in areas of production of sandstone, mica, feldspar, and asbestos, all of which are found in varying quantities in the Chesapeake Bay region. Because of the complete changes which occur in the habitat at the mining site, the indigenous species can no longer survive. The removal of food, nesting and escape cover makes an area useless as long as that condition presists. Nesting and breeding of birds and animals may be disturbed by human activities in the vicinity and migration or travel routes of some species may be disrupted.

FINFISH AND SHELLFISH MORTALITIES

The impact of the problems discussed in this section on the fish and wildlife resources of the Bay is often readily observable in the form of massive fin and shellfish mortalities. Annually, millions of fish, crabs, clams, and oysters die as the result of changes in their chemical and physical environment. Certainly not all mortalities can be directly attributed to man's activities, however, as Figure 12-24 illustrates, approximately 38.2 percent of Chesapeake Bay finfish kills are directly or indirectly related to man while another 39.8 percent have an unknown cause. It is possible that many of these kills resulted from man induced alterations.

Finfish

Each year many fish kills are reported to fish and wildlife agencies throughout the United States. This section summarizes existing data on fish kills occurring in Chesapeake Bay and its tributaries. The source of data on reported fish kills, as shown in Figure 12-24 and Attachment A, was provided by the Maryland State Fisheries Administration and the Virginia State Water Control Board. Additional data on fish kills may be obtained from these agencies.



C.F.D. = commercial fisheries discards.

FIGURE 12-24 PERCENTAGE OF PROBABLE CAUSES OF FINFISH KILLS OCCURRING IN CHESAPEAKE BAY

The Bay is arbitrarily divided into three major regions: upper, middle, and lower Bay (Plates 12-1, 12-2, 12-3). The upper Bay boundary lines are from Holland Point to Blackwalnut Point. The upper Bay is then divided into areas A, B, and C.

Area A is bounded to the north from Sandy Point to Turkey Point to the outfall of Pearce Creek. Its southern boundary line is from Robins Point to the north side of Fairlee Creek. Area B extends from the southern boundary of Area A to the Chesapeake Bay Bridge. Area C then is from the Bay Bridge to the southern boundary of the upper Bay, which is from Holland Point to Blackwalnut Point.

The middle Bay is also divided into areas A, B. and C. Boundary A extends from Holland Point to a line drawn from Long Beach on the Western Shore to Oyster Cove on the Eastern Shore. Area B reaches south to a line drawn from Point No Point to the mouth of the Honga River. Area C extends to the southern boundary of the middle region, which is the Maryland-Virginia State line. However, the Pocomoke River is considered part of the lower Bay.

The lower Bay is similarly divided into areas A, B, and C. Area A extends from the northern boundary of the lower Bay region to Windmill Point on the Western Shore to Milby Point on the Eastern Shore. Area B is bounded on the south by a line extending from Tue Point on the west to Cape Charles City on the east. Area C extends southward to a line drawn from Cape Henry to Fisherman's Island.

Tributaries of the Bay are separated from the Bay proper by arbitrarily drawing a line across the mouth of each river. Kills which occurred in more than one area were recorded for the different areas involved, but were only considered as one kill when the total number of kills were tallied.

Many massive fish kills involving a large percentage of white perch and a small percentage of striped bass occurred in 1963. The cause of those large mortalities was not known at that time. Subsequently, a bacterium of the genus Pasteurella is now believed to have caused the epizottic. An epizootic is defined as a disease attacking large numbers of animals simultaneously. Thus, all 1963 kills which appear to have been caused by the bacterium are included in the disease category.

The number of kills reported from 1954 to 1972 totaled 393. Of this total, 346 kills were reported in Maryland while 102 were reported for Virginia. It should be noted that data for Virginia was only available from 1960 to 1972. Kills which occurred as a result of explosive testing by the Navy were considered independently of other kills in the specific data (Table 12-22).

Table 12-22 also lists the various areas of Chesapeake Bay in which fish kills were reported. It is interesting to note that nearly 40 percent ot the total kills occurred in four areas; Patapsco River, Upper Bay Area B, Potomac River and the James River, which are all areas considered to be at least partially polluted. An increased rate of reported fish kills is evident in these areas. However, due to their proximity to major cities, care must be taken before arriving at any conclusions.

Table 12-23 indicates the species composition in kills and the number of times each species occurred in the kills. The species most commonly involved was the white perch (Morone americana), occurring

TABLE 12-22
FREQUENCY OF FISH KILLS BY AREA (1954-1972)

Bay Area	Location	No. of Kills
Upper Chesapeake	Patapsco River, Md.	51
Upper Chesapeake	Area B	40
Middle Chesapeake	Potomac River, Md.	35
Middle Chesapeake	Potomac River, VA	34
Lower Chesapeake	James River, VA	27
Upper Chesapeake	Area C	26
Upper Chesapeake	South River, Md.	20
Upper Chesapeake	Susquehanna Flats	20
Upper Chesapeake	Magothy River, Md.	18
Middle Chesapeake	Barren Island - Navy Explosions	17
Upper Chesapeake	Area A	13
Upper Chesapeake	Eastern Bay and Miles River	13
Upper Chesapeake	Severn River	13
Middle Chesapeake	Choptank River	12
Middle Chesapeake	Potomac River - Navy Explosions	11
Middle Chesapeake	Wicomico River	11
Upper Chesapeake	West and Rhode Rivers	10
Middle Chesapeake	Patuxent River	09
Upper Chesapeake	Back River, Md.	07
Upper Chesapeake	Gunpowder River	07
Middle Chesapeake	Patuxent River - Navy Explosions	07
Upper Chesapeake	Chester River	06
Upper Chesapeake	Middle River, Md.	05
Middle Chesapeake	Area A	04
Lower Chesapeake	Elizabeth River, Va.	04
Lower Chesapeake	Rappahannock River, Va.	04
Upper Chesapeake	Sassafras River	03
Middle Chesapeake	Area B	03
Middle Chesapeake	Nanticoke River	03
Upper Chesapeake	Wye River	02
Lower Chesapeake	Area A	02
Lower Chesapeake	Area C	02
Upper Chesapeake	Fairlee Creek	01
Middle Chesapeake	Middle Bay Area A	01
Middle Chesapeake	Fishing Bay	01
Middle Chesapeake	Honga Bay	01
Middle Chesapeake	Manokin River	01
Lower Chesapeake	Appomattox River, Va.	01
Lower Chesapeake	Lynnhaven Bay	01
Lower Chesapeake	Great Wicomico River	01
Lower Chesapeake	York River	01

TABLE 12-23
SPECIES RANKED BY OCCURRENCE OF KILLS

	Chesapeake Bay No. and percent of Bay Total	Maryland No. and percent of State Total	Virginia No. and percent of State Total
White perch *Morone americana*	192 - 49	183 - 53	8 - 17
Menhaden *Brevoortia tyrannus*	123 - 31	115 - 33	8 - 17
Striped bass *Morone saxatilis*	81 - 21	80 - 23	1 - 2
Yellow perch *Perca flavescens*	59 - 15	57 - 16	1 - 2
Catfish *Ictaluridae*	52 - 13	36 - 9	16 - 33
Eels *Anguilla rostrata*	50 - 13	43 - 12	7 - 15
Alewives *Alosa pseudoharengus*	41 - 10	39 - 11	2 - 4
Species unknown	27 - 7	19 - 5	8 - 17
Herring other than Alewives	27 - 7	20 - 6	7 - 15
Carp *Cyprinus carpio*	24 - 6	19 - 5	5 - 10
Sunfish	25 - 6	20 - 6	5 - 10
Pumpkinseed *Lepomis gibbosus*	23 - 6	23 - 7	0 - 0
Spot *Leiostomus xanthurus*	18 - 5	16 - 5	2 - 4
Oyster toadfish *Opsanus tau*	17 - 4	15 - 4	2 - 4
Hogchoker *Trinectes maculatus*	15 - 4	14 - 4	1 - 2
Largemouth Bass *Micropterus salmoides*	12 - 3	8 - 2	3 - 6
Gizzard Shad *Dorosoma cepedianum*	11 - 3	10 - 3	1 - 2
American Shad *Alosa sapidissima*	10 - 3	7 - 2	3 - 6
Minnows	10 - 3	10 - 3	0
Bluegill *Lepomis macrochirus*	9 - 2	4 - 1	4 - 8
Brown Bullheads *Ictalurus nebulosus*	9 - 2	8 - 2	1 - 2
Anchovies *Anchoa sp.*	8 - 2	8 - 2	0 - 0
Silversides *Mendia sp.*	8 - 2	8 - 2	0
Weakfish *Cynoscion regalis*	8 - 2	8 - 2	0
Bluefish *Pomatomus saltatrix*	4 - 1	2 - 1	2 - 4
Crappie *Pomoxis annularis*	4 - 1	4 - 1	0
Filefish *Balistidae*	4 - 1	3 - 1	1 - 2
Killifish *Cyprinodontidae*	4 - 1	4 - 1	0
Pickerel *Esox sp.*	3 - 1	3 - 1	0

TABLE 12-23 Cont'd
SPECIES RANKED BY OCCURRENCE OF KILLS

	Chesapeake Bay No. and percent of Bay Total	Maryland No. and percent of State Total	Virginia No. and percent of State Total
Chain Pickerel *Esox niger*	3 - 1	3 - 1	0
Harvestfish *Peprilus alepidotus*	3 - 1	3 - 1	0
Johnny darter *Etheostoma nigrum*	3 - 1	3 - 1	0
Madtom *Noturus sp.*	3 - 1	3 - 1	0
Shad	3 - 1	3 - 1	0
Spottail shiner *Notropis hudsonius*	3 - 1	3 - 1	0
White sucker *Catostomus commersoni*	3 - 1	3 - 1	0
Bullheads *Ictalurus sp.*	2 - 1	2 - 1	0
Channel catfish *Ictalurus punctatus*	2 - 1	1 - 1	1 - 2
Golden shiner *Notemigonus*	2 - 1	1 - 1	1 - 2
Hickory shad *Alosa mediocris*	2 - 1	1 - 1	1 - 2
Mummichog *Fundulus heteroclitus*	2 - 1	2 - 1	0
Naked goby *Gobiosoma bosci*	2 - 1	2 - 1	0
White catfish *Ictalurus catus*	2 - 1	2 - 1	0
Banded Killifish *Fundulus diaphanus*	1 - 1	0	1 - 2
Bay Anchovy *Anchoa mitchilli*	1 - 1	0	1 - 2
Bigeye shiner *Notropis boops*	1 - 1	1 - 1	0
Black drum *Pogonias cromis*	1 - 1	1 - 1	0
Blacknose dace *Rhinichthys atratulus*	1 - 1	1 - 1	0
Blueback Herring *Alosa aestivalis*	1 - 1	0	1 - 2
Carp sucker *Carpiodes sp.*	1 - 1	1 - 1	0
Clupeidae	1 - 1	1 - 1	0
Common shiner *Notropis cornutus*	1 - 1	1 - 1	0
Chubs Cyprinidae	1 - 1	1 - 1	0
Goldfish *Carassius auratus*	1 - 1	1 - 1	0
Hardhead *Micropogon undulatus*	1 - 1	1 - 1	0
Lamprey petromyzontidae	1 - 1	0	1 - 2
Longnose dace *Notropis longirostris*	1 - 1	1 - 1	0

TABLE 12-23 Cont'd
SPECIES RANKED BY OCCURRENCE OF KILLS

	Chesapeake Bay No. and percent of Bay Total	Maryland No. and percent of State Total	Virginia No. and percent of State Total
Needlefish Belonidae	1 - 1	1 - 1	0
Perch	1 - 1	0	1 - 2
Pipefish Syngnathidae	1 - 1	1 - 1	0
Northern Puffer Sphoeroides maculatus	1 - 1	0	1 - 2
Redbreast sunfish Lepomis auritus	1 - 1	1 - 1	0
Redside dace Clinostomus elongatus	1 - 1	1 - 1	0
River Herring	1 - 1	1 - 1	0
Satinfish shiner Notropis analostanus	1 - 1	1 - 1	0
Searobin Prionotus sp.	1 - 1	1 - 1	0
Silver Hake Merluccius bilinearis	1 - 1	1 - 1	0
Shiners	1 - 1	1 - 1	0
Spotted trout Cynoscion nebulosus	1 - 1	1 - 1	0
Star Butterfish Peprilus sp.	1 - 1	1 - 1	0
Stickleback Gasterosteidae	1 - 1	1 - 1	0
Stick ray Dasyatidae	1 - 1	1 - 1	0
Striped Blenny Chasmodes bosquianus	1 - 1	1 - 1	0
Summer flounder Paralichtys dentatus	1 - 1	1 - 1	0
Variegated minnow Cyprinodon variegatus	1 - 1	1 - 1	0
Winter flounder Pseudopleuronectes americanus	1 - 1	1 - 1	0
Yellow bullhead Ictalurus natalis	1 - 1	1 - 1	0

in 49 percent of the reports. The reason for its high occurrence is probably because this species is one of the most abundant fish in the Bay throughout the year.

Menhaden (Brevoortia tyrannus) occurred in 31 percent of the reported kills. Menhaden kills are often massive and involve millions of fish. Menhaden probably have the largest number of individuals dying each year. However, better methods of estimating the number of fish killed must be used before reaching any conclusions. The cause of the annual massive mortalities of menhaden is not known. Many investigators have suggested that overwintering stress, industrial wastes, and embolisms caused by high oxygen saturation levels are probable causes of mortality. Low DO levels are also a suspected cause.

Many of the moribund menhaden are observed near the surface swimming in circles. Fish showing this symptom are referred to as spinners. The whirling or spinning is not believed to be a specific characteristic as many fish die without the spinning symptom, however, the disease which causes their death is commonly known as the spinning or whirling disease.

During the past few years, Gymnodinium splendens, an estuarine algal species, has been a suspected causual agent involved in annual mortalities. However, no conclusive evidence has been found to substantiate this hypothesis. Dead menhaden have been found in areas of Gymnodinium splendens blooms and in areas without blooms.

If one looks at Figure 12-24 it becomes apparent that the causes of most fish mortalities occurring in Chesapeake Bay are not known. Disease and pollution are the main reasons put forth for fish kills. It again should be noted that all 1963 fish kills which appeared to have been caused by the Pasteurella bacterium have been included in the disease category.

Pollution can have sublethal effects on organisms and lower their resistance to disease. Also, pollution can increase the rate of eutrophication, thus causing phytoplankton blooms which may create low dissolved oxygen levels. When comparing the different causes of fish mortalities one must keep in mind that these are only very generalized categories. In most instances when fish kills are reported, it is usually too late to make a definite determination as to the exact factor involved in the mortality.

Approximately 87 percent of the fish kills occurred during the warmer months of May, June, July, August, and September (Figure 12-25) The highest incidence of kills occurred during the months of July and August. Meyers (1967), found similar findings in his study of fish mortalities occurring in Maryland waters. However, he reported that approximately 80 percent of the mortalities observed occurred during the months of June and July.

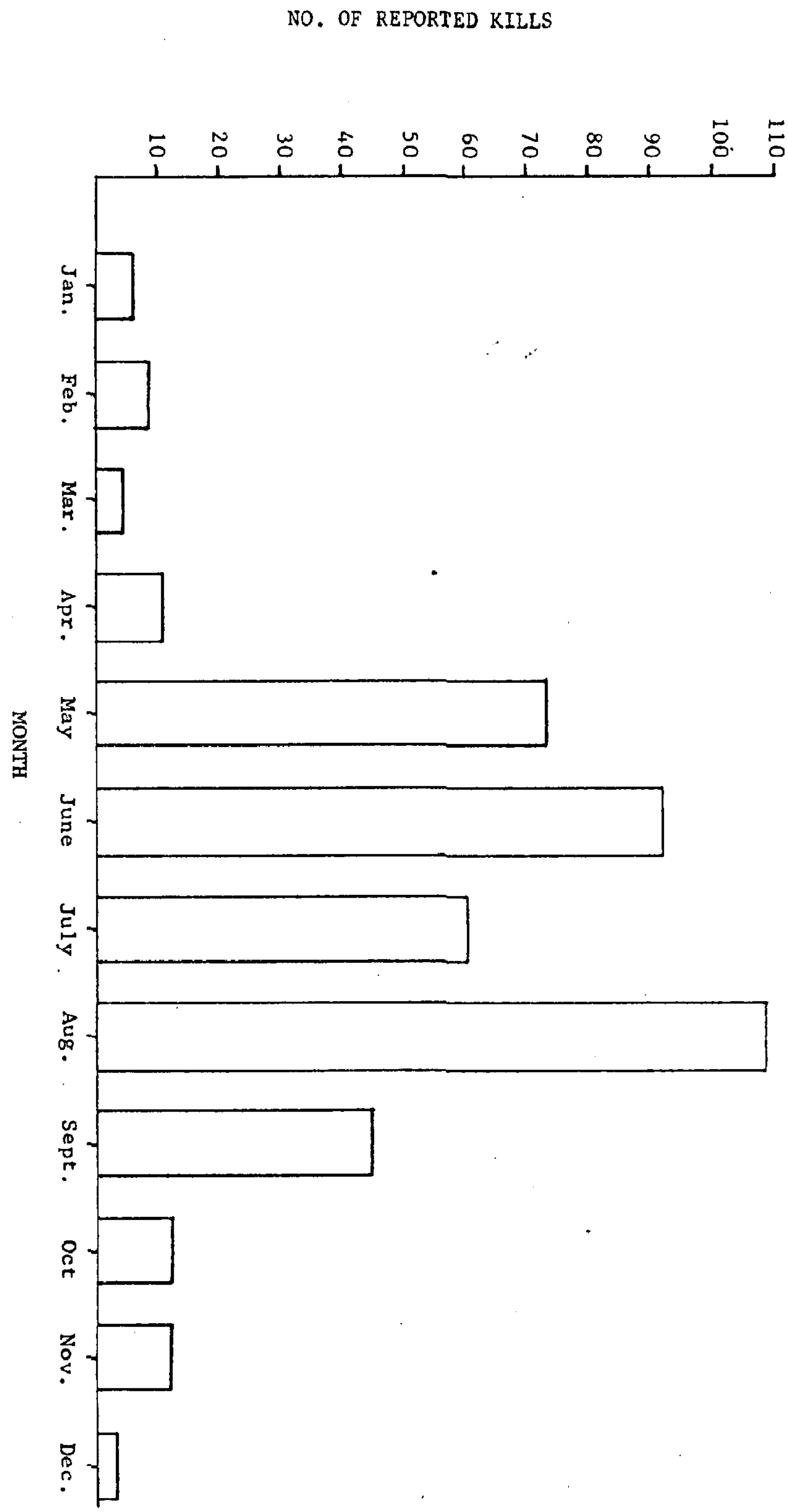


FIGURE 12-25 Monthly Distribution of Fish Kills Reported for Chesapeake Bay (Md. & Va.) for the Years 1954-1972 (23)

The most commonly occurring species of fish involved in mortalities were white perch, menhaden and striped bass.

In summary, fish mortalities are more prevalent during the warmer months of the year. Disease and pollution may be major causes of fish mortalities occurring in Chesapeake Bay. However, more intensive research must be done before any definite conclusions can be reached.

Shellfish

Shellfish mortalities records for Chesapeake Bay are generally scarce, and those that do exist are quite sketchy, however, occasionally kills of major importance have been documented for commercially important species. These species include the American oyster, the blue crab and the soft-shell clam. The causes and occurrence of major mortalities will be discussed for each species.

Oysters: Documentation of oyster mortalities is more complete than that for other shellfish. Table 12-24 summarizes the oyster mortality data for the last 95 years. (22)

Until 1950, the major cause of mortality was prolonged salinity depression resulting from fresh water inundation. Five parts per thousand (ppt.) is the lower salinity tolerance limit for oyster survival. Oysters can withstand lower salinities in an inactive state for short periods of time, but death will eventually follow if the proper salinity is not restored. Survival time decreases as water temperature increases. (24) Flooding is accompanied by secondary adverse environmental stresses, namely siltation and oxygen depletion, which contribute to mortality.

The flooding may be localized to a particular river system, or may be extensive, as results from hurricanes. Flooding of the Susquehanna River, which has been responsible for six known major oyster mortalities, effects a considerably larger area than most river systems. The distribution and percentages of deaths in Upper Bay resulting from the 1945 flooding of the Susquehanna, as shown in Figure 12-26, is illustrative of the extensive area this river system affects.

In 1950, the first major mortality caused by *Dermocystidium marinum* (=*Labyrinthomyxa marina*) occurred in the Rappahannock River. This infectious fungus became the principal cause of oyster mortalities in the more saline areas of Chesapeake Bay for the next several years. First to be attacked are the motile blood cells, or leucocytes, which spread the disease to all organs of the infected animal. (25) Scavenging fish and invertebrates that feed on dead or dying infected animals serve as effective vectors transmitting the disease throughout the oyster population. (26)

TABLE 12-24

MAJOR OYSTER MORTALITIES OF CHESAPEAKE BAY

Season	Year	Apparent Cause	Killed	Principal Areas Effected
Spring	1889	Extensive Flooding	Extensive	Rappahannock R.
------	1908-9	Flooding of Susquehanna River	55-62%	Upper Bay
------	1915	*Ulva* suffocation	------	Chesapeake Bay
------	1916	Flooding of Susquehanna River	Approx. 100%	Upper Bay
------	1928	Flooding of Susquehanna River	80%	Upper Bay
Summer	1930	**Nematopsis*, low DO, siltation	Extensive	Mobjack Bay
------	1932	Boring sponges	------	Little Choptank R.
------	1936	Flooding of Susquehanna River	Extensive	Upper Bay
------	1936	Low salinity	------	Potomac R.
------	1943	Flooding of Susquehanna River	97%	Upper Bay
------	1945	Flooding of Susquehanna River	16-92%	Upper Bay
Spring	1948	Low salinity	33%	James R.
Spring	1949	Low salinity	33%	James R.
Summer	1949	High salinity, low DO, high temp.	60%	Rappahannock R.
Summer	1950	*Dermocystidium* (=Dermo)	Extensive	Rappahannock R.

* Nematopsis, a gregarine protozoan; DO = dissolved oxygen

TABLE 12-24

MAJOR OYSTER MORTALITIES OF CHESAPEAKE BAY - cont'd

Season	Year	Apparent Cause	Killed	Principal Areas Effected
Summer	1954	Dermo and hurricanes	Extensive	Chesapeake Bay
Summer	1955	Hurricanes	------	Chesapeake Bay
Summer	1958	Low salinities	90%	James R.
Summer	1959	Dermo and MSX	30-50%	Mobjack Bay, Egg Harbour, New Point Comfort, James R. York R., Rappahannock R.
Summer	1961	MSX	------	Pocomoke Sound, Tangier Sound
Summer	1961	MSX	40-50%	James R.
		MSX	80%	Mobjack Bay
Summer	1964	MSX	------	Particularly heavy in James R.
Summer	1965	MSX	------	Particularly heavy in York & Rappahannock R.
Summer	1972	Hurricane Agnes	10%	James R.
			2%	York R.
			50%	Rappahannock R.
			70%	Potomac R.
			75%	north of Swan Point

TABLE 12-24

MAJOR OYSTERTER MORTALITIES OF CHESAPEAKE BAY - cont'd

Season	Year	Apparent Cause	Killed	Principal Areas Effected
Summer	1972	Hurricane Agnes	10%	main part of Chesapeake Bay
			Spat 100%	Great Wicomico
			Spat 100%	Piankatank R.
			Light spat set	James R.

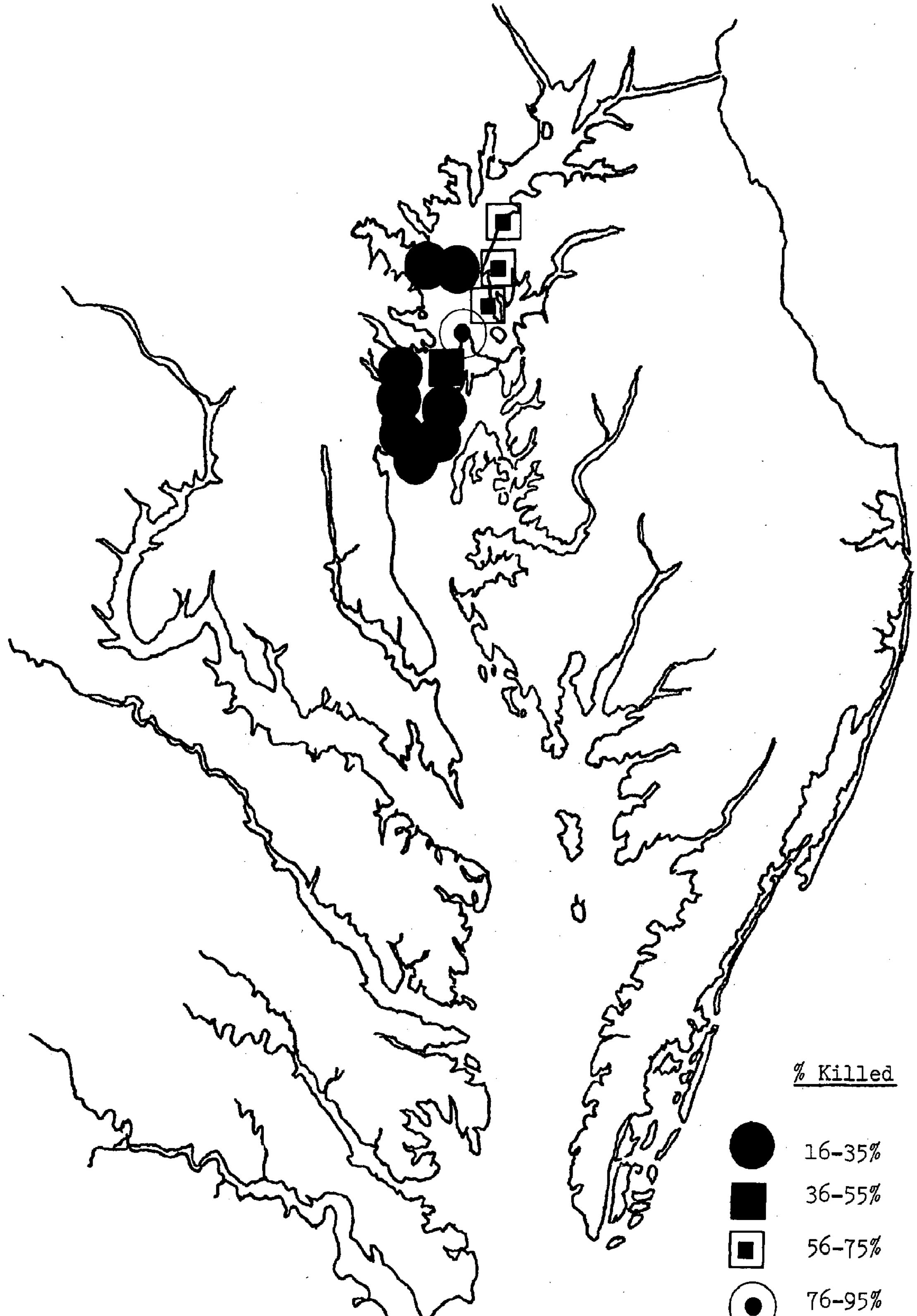


Figure 12-26 Distribution and Percentages of Oysters Killed in Upper Bay Following the Susquehanna Flood (1945) (27)

The distribution of Dermocystidium roughly follows the 15 ppt. isohaline and the 15°C isothermal. At lower salinities and temperatures growth is inhibited. (25)

In 1959, there began a series of epizootics (i.e. a disease attacking large numbers of animals simultaneously) which was caused by another pathogen, Minchinia nelsoni, or more commonly referred to as MSX. The distribution of this highly infectious protozoan disease, like that of Dermocystidium, roughly follows the 15 ppt. isohaline. (28) During drought years, both Dermocystidium and MSX are able to extend their ranges as salt water intrudes further up into the Bay and its rivers. Figures 12-27 and 12-28 illustrate the distributions of Dermocystidium and MSX, respectively.

Because no effective controls have been found for either Dermocystidium or MSX, large areas of oyster bottoms are no longer suitable for oyster production in lower Chesapeake Bay. (29) There is evidence, however, that through the process of natural selection, genetic resistance to these diseases is developing in oyster populations. (30, 31)

A recently discovered bacterial disease, bacillary necrosis, is a cause of extensive larval mortalities under hatchery conditions. Because summer temperatures favor both oyster spawning and bacterial proliferation it is possible that this disease limits natural recruitment. (32) Similar bacterial flora have been found in high concentrations in areas of Chesapeake Bay suffering with enzootics (a disease attacking animals in a restricted geographic area) as compared to disease free areas. (33)

Predation by oyster drills is considered a significant cause of oyster mortality in subtidal waters. It has been estimated that these gastropods are responsible for a 20-40 percent loss of seed planted in subtidal areas during May and June. (34) Both drill species, Urosalpinx cinerea and Eupleura caudata, are limited in their distribution by salinity. Their range is roughly restricted to the 15 ppt. isohaline or higher salinities. (28)

The flat worm, Stylochus sp., crabs, birds, and a variety of other organisms are minor causes of oyster mortality. For a more detailed discussion of these organisms the reader is referred to The American Oyster by Paul S. Galtsoff. (15)

Blue Crabs: Historically, major blue crab mortalities were reported as "winter kills" (Table 12-25), as reflected by the large number of dead crabs taken during the winter dredge fishery. (36) The extensiveness of winter kills depend not only on the severity of the winter, but also upon the condition of the young crabs in the fall. (37) If the crabs are in a poor, weakened condition, the mortality rate will be higher.

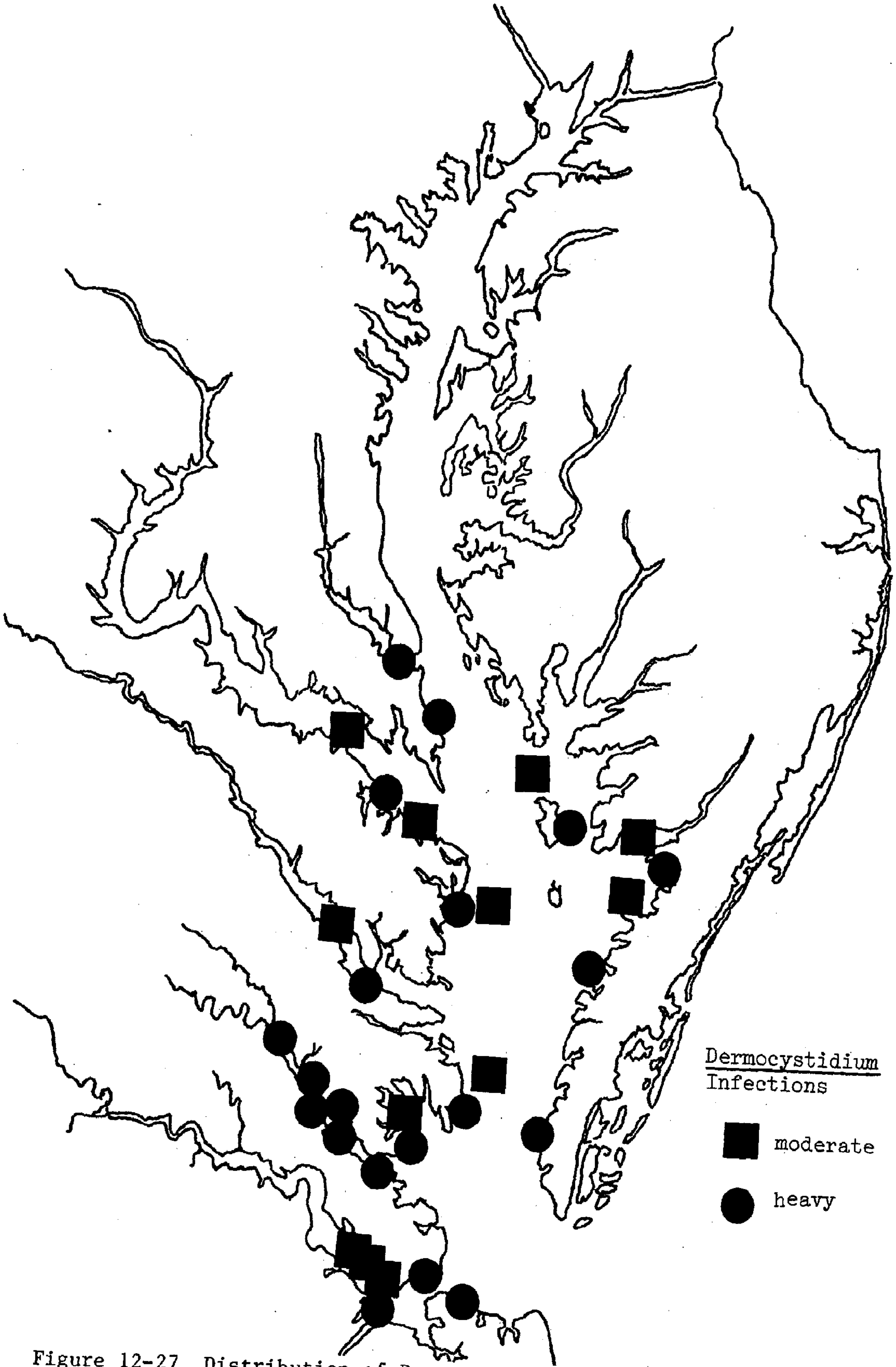


Figure 12-27 Distribution of Dermocystidium in Chesapeake Bay in 1954 (25)

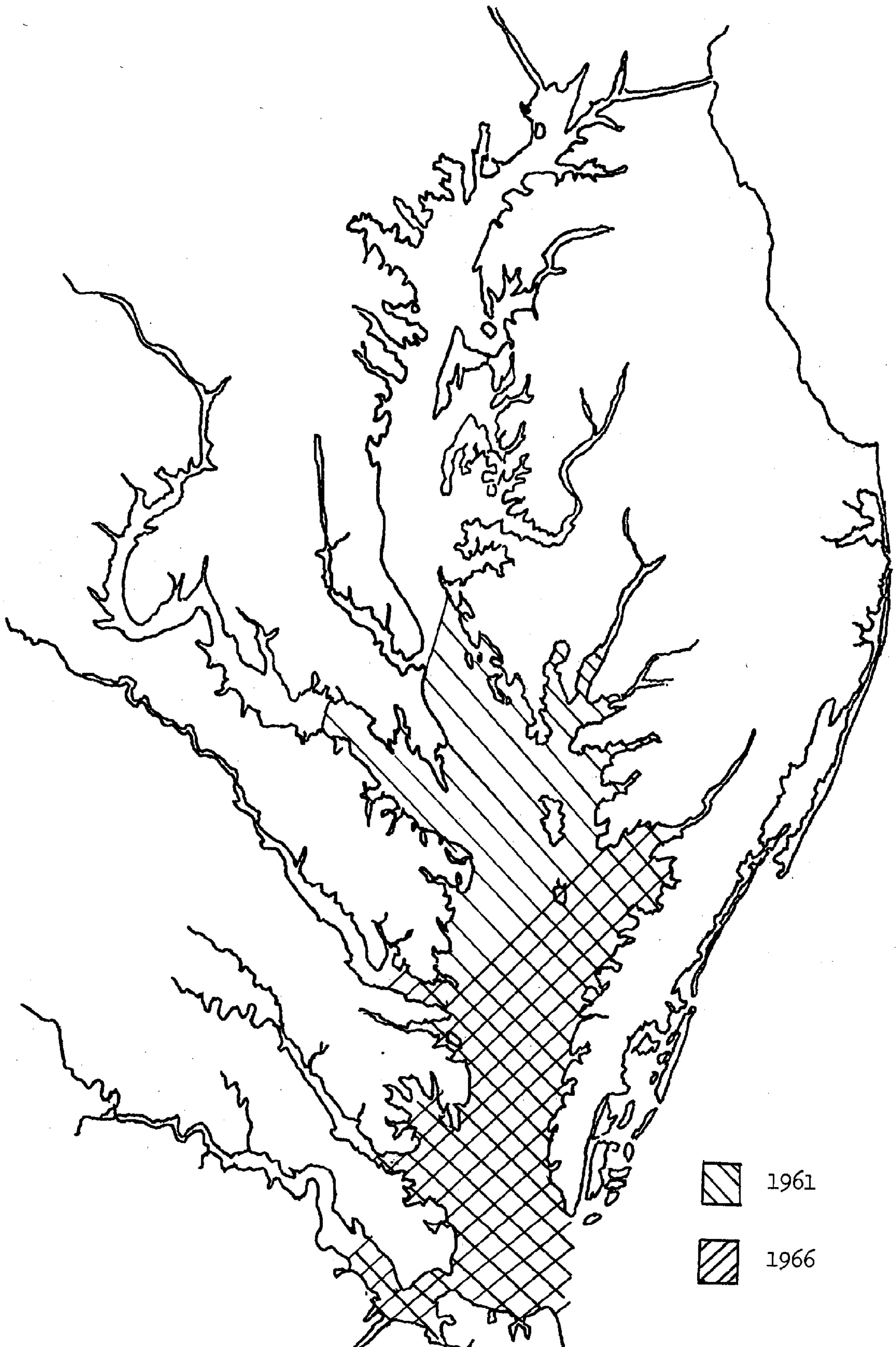


Figure 12-28 Distribution of MSX in Chesapeake Bay in 1961 and in 1966 (35)

Table 12-25

MAJOR BLUE CRAB MORTALITIES

Season	Year	Apparent Cause	Killed	Principal Area Effected
Winter	1902	Winter Kill	Extensive	Lower Chesapeake Bay
Winter	1918	Winter Kill	Extensive	Lower Chesapeake Bay
May - Aug.	1919	Fresh water inundation	Extensive	Lower Chesapeake Bay
May - Aug.	1924	Fresh water inundation	Extensive	Lower Chesapeake Bay
------	1938	Holding in shedding floats	7 Million	Chesapeake Bay
May - Aug.	1940	Fresh water inundation and winter kill	Extensive	Lower Chesapeake Bay
------	1942	Fresh water inundation	Extensive	Lower Chesapeake Bay
Summer	1951-3	*High temp. and 02 depletion	Unknown	Localized areas in fishing gear
Summer	1961	Red tide toxins	Unknown	Lower York River
Summer	1963	High temp. and 02 depletion	Unknown	Rappahannock River
August	1963	Unknown	"A lot"	Magothy River (Deep Creek)
Sept.	1965	DO depletion (decaying *Ulva*)	500	Eastern Bay
Aug - Sept.	1966	DO depletion (enrichment and high temp.)	Few	Severn River

* Temp = temperature; DO = Dissolved Oxygen

Table 12-25

MAJOR BLUE CRAB MORTALITIES (cont'd)

Season	Year	Apparent Cause	Killed	Principal Area Effected
Sept.	1966	Excessive heat (steam electric station discharge canal)	40,000	Patuxent River
June	1967	DO depletion	Unknown	South River
August	1967	DO depletion (steel plant (acid discharge)	1,000	Patapsco River (Jones Creek)
Sept.	1967	Excessive heat (steam electric station discharge canal)	10	Patuxent River
	1968	*Nosema* infection	Unknown	Pocomoke Sound
May	1968	Industrial effluent	Few	Patapsco River
Sept. - Oct.	1968	DO depletion from pollution	Hundreds	Rappahannock River (Mill Creek)
August	1969	DO depletion	150-200 bushels	Miles River (St. Michael's Harbor)
August	1969	DO depletion (sewage overflow)	Hundreds	Patapsco River (Bear Creek)
August	1969	DO depletion	5,000	Miles River (St. Michael's Harbor)
July	1970	Pesticides	10,000 to 30,000	Nassawadox Creek
August	1970	DO depletion	6	Potomac River
July	1971	Sedimentation from dredging operation	unknown	Chesconessox Creek

Table 12-25

MAJOR BLUE CRAB MORTALITIES (cont'd)

Season	Year	Apparent Cause	Killed	Principal Area Effected
July	1971	Unknown	Extensive	Patapsco River (Jones Creek)
August	1971	Unknown	Many	Patapsco River (Jones Creek)
August	1971	DO depletion caused by algal bloom (*Gymnodinium* sp.)	1,000	Patapsco River (Bodkin Creek)
September	1971	DO depletion caused by algal bloom	Few	Severn River (Spa Creek)
May	1972	Unknown	Few	Plum Point
June	1972	High cyanide levels (Steel plant effluent)	Unknown	Patapsco River (Sparrows Point)
June	1972	Hurricane Agnes - excessive sedimentation	Unknown	Baltimore City
August	1972	DO depletion caused by algae bloom	Unknown	Honga River (Fishing Creek)
August	1972	"Red tide" toxins and DO depletion	Unknown	Potomac River
September	1972	DO depletion	34	Corsica River
September	1972	DO depletion, high hydrogen sulphide levels	350	Magothy River

High river flows are another environmental factor associated with crab mortalities, but the impact is largely reflected in the larval rather than the adult populations. Because surface waters are generally more likely to show greater salinity fluctuations than bottom waters, the planktonic larval stages are more susceptible to salinity dilution than adults. Higher salinities are necessary for successful hatching and larval development. (38,39) Salinities of 18-29 ppt. are considered optimal for maximum hatching and survival. (38)

Because the blue crab spawning ground is at the mouth of Chesapeake Bay, the James River is the major source of fresh water affecting the spawning area. (36) Pearson (1948) (36) correlated the river flow of the James River with the survival of carb larvae for a fifteen year period (1930-1944). He found that the two years of maximum discharge for the James River (1940-1942) correlated well with the years of lowest annual larval survival.

A purely historical, but at one time a highly significant, cause of blue crab mortalities was holding "non-peeler" or "green" crabs in shedding impoundments. In 1938, an estimated seven million crabs were killed as a result of this practice. (40) This cause of mortality has been largely eliminated through management regulations. Occasionally, abnormal fishing gear oriented mortalities may occur, but the effects are generally localized and temporary. High temperature and oxygen depletion are the apparent causes for these deaths. (41)

Owning to their high degree of mobility, adult blue crabs are capable of escaping from localized short-term adverse environmental conditions. Blue crabs can also withstand depressed dissolved oxygen concentrations to as low as 2 ppm before suffocation ensues. The attributes enabled these animals to escape many of the detrimental effects of Hurricane Anges.(16)

Although the blue crab is subject to a number of diseases, none appear to present frequent significant problems in Chesapeake Bay. For example, even the "gray crab disease", which has been held responsible for epizootics of the seaside of Delmarva peninsula and other areas of the southeast Atlantic (42, 43), apparently exists at a very low level of incidence in Chesapeake Bay. Caused by the protozoan, *Paramoeba perniciosa*, gray crab disease first effects the blood cells of the haemolymph, or body fluid, which spread the infection to muscle and connective tissues.(42) Other infectious diseases responsible for blue crab mortalities are caused by the protozoan, *Nosema*, and the fungus, *Lagenidium callinectes*. *Nosema* causes muscle deterioration in infected animals.(44) *Lagenidium*, which attacks the female's egg mass or "sponge", may cause a maximum of 25% mortality in a given brood.(45)

Hard Clams and Soft-shell Clams: No information has been unearthed concerning mass hard clam mortalities. Of the diseases to which this species is subject, none are known to have approached epizootic proportions. (46) Predation, a major cause of mortality, most severely effects young clams because their shells are more readily broken or penetrated. Crabs (including blue crabs), whelks, and moon snails are among the principal predators.

It appears, too, that hard clams are resistant to environmental devastation. For example, following Hurricane Agnes, clams sampled from public bars in the James River showed little mortality, although specimens in shoal areas (less than 20 feet in depth) were physiologically weak. (16) The substantial losses of hard clams suffered on private bars of the York River were primarily animals purchased in a weakened condition after Agnes from the Hampton Roads area of the James River. (16)

The soft-clam, a northern species, exists at the southern end of its range in Chesapeake Bay. When water temperatures increase during the summer months, these animals are subject to thermal stress. If tolerance limits are exceeded, which is a common occurrence, mortalities will result. (16)

Since 1965 in the Potomac River and 1970 in the Patuxent River and Eastern Bay, repeated soft-shell clam mortalities have occurred which apparently are not associated with thermal stress. (47) Existing evidence indicates that chlorinated hydrocarbons and possibly polychlorinated biphenyls are responsible for these die-offs. (47)

Of all shellfish species, soft-shelled clam populations appeared to have been most severely impacted by Hurricane Agnes with mortalities approaching 100 percent in many areas. Besides the increased bacterial levels and decreased salinity concentrations resulting directly from the storm, high water temperatures also contributed to high mortality rate. (16)

CONFLICTS

Management of the resources of the Chesapeake Bay and its tributaries is the responsibility of several organizations including the Federal government, the states of Maryland, Delaware, and Virginia and the Potomac River Fisheries Commission. (48,49,50,51) The variation in laws promulgated by these organizations regarding the utilization of species which occur in or have an effect upon the resources in more than one political area, have presented and continue to present conflicts in the management practices and utilization of these resources.

Although there is often considerable variation in the trapping and hunting regulation for fur bearers, big game and upland game species, there is little conflict between the states or regions within a state since these species do not generally travel significant distances from one region to another. However, regulations governing the utilization of migratory species do cause some conflicts to arise. In the case of migratory birds, the basic regulations regarding bag limits and the number of days a species may be hunted during a season are set by Federal regulation; (52,53) however, the actual dates for the opening of a season are determined by the states under the guidelines set forth by the Federal regulations. In this instance, the conflict which arises is that the hunters of a state which has a later opening date often feel that they will have a decreased chance for success since the species sought has been previously hunted in a neighboring state and may be "gun shy."

Regulations regarding the fisheries resources of the Bay and its tributaries are set forth by agencies of the states of Maryland, Delaware, and Virginia, and by the Potomac River Fisheries Commission. Those agencies most directly concerned with the resources of the Bay are the Fisheries Administration of the Maryland Department of Natural Resources, the Virginia Marine Resources Commission and the Potomac River Fisheries Commission. Thus, there are essentially three separate organizations which determine the regulations for utilization of resources which are, in part, common to all of the regions. One of the most obvious of the resources common to several areas are certain anadromous fish species which are utilized not only in the Bay area, but in the ocean and along the eastern coast as well. The effect of a management practice on these species may occur not only in the concerned region but in others which may be far removed. For example, concentrated offshore fishing efforts for herring have greatly reduced the spawning runs which take place in the Bay each spring. It is because of these far reaching effects that a controversy may arise with regard to the effect on the resources in one area by management practices in another area.

A number of management practices have resulted in controversy between citizens and organizations from the states of Maryland and Virginia. The watermen of these states who derive their livelihood from the resources of the Bay feel that any practice which gives the residents of a neighboring state a greater opportunity to utilize a resource may, at the same time, be causing a reduction in their catches. Crabbing regulations have been cited as an example of this type of controversial mangement practice. Virginia allows the dredging of wintering crabs which are buried in the Bay bottom while Maryland has no such provision. Therefore, some Marylanders feel that this dredging depletes the supply of crabs which would be available to them the following season.

Many of the conflicts regarding resource use which occurred between the states of Maryland and Virginia prior to 1958, centered around the management and utilization of the resources of the Potomac River which is owned by Maryland but forms the border for a large portion of Virginia and is the source of livelihood for many Virginians. In 1958, the Potomac River Compact was drafted, establishing the Potomac River Fisheries Commission which enacts regulations regarding the licensing and taking of finfish and shellfish from the waters of the Potomac River. This compact provides for resource management practices common to residents of two states; however, at the same time, it introduces a third set of regulations to the Bay region, which in some cases differ from those of either Maryland or Virginia. Thus, even though some conflicts have been resolved by the initiation of a common regulating agency, there exists a potential for additional disparity of regulations within the larger region.

Aside from the problems which occur due to variations in regulations promulgated by divergent agencies within the overall study area, conflicts also arise within a given management area due to the diverse needs and desires of those who utilize the resources within that area. The resource managers are confronted with the problem of trying to develop programs which will conserve or enhance the resources and at the same time satisfy the needs or desires of these dissimilar special interest groups. Whenever an action is taken which satisfies one need, it is not unlikely that a conflict with the needs of another group will manifest itself. Some of the conflicts which have occurred previously and will probably continue to occur are discussed in the following paragraphs.

One of the most apparent conflicts which often arises is between commercial and non-commercial users of the resources. The commercial faction includes the watermen who gain their livelihood directly from the resources of the Bay as well as the industries which develop the periphery and reduce the productive capability of surrounding area. The non-commercial user often feels that since the fish and wildlife which inhabit and utilize the waters of the Bay are a public resource, no individual or corporation should be granted the right to remove or destroy for his own commercial gain that which is the common property of all citizens. The commercial interest may at the same time feel that since their catch or product is being utilized by a large segment of the community, they should be allowed to utilize the resources in a manner which provides the greatest possible production of their particular commodity. The reasoning used by each of these factions has some degree of validity; however, in order to provide for the combined needs of the community neither of these can be considered to the exclusion of the other.

With the increases in population, per capita income and available leisure time in the recent past, there has been an increased demand for development around the shores of the Bay and its tributaries. In some areas of this shoreline, productive wetlands which are essential to the aquatic community are being altered in order to provide for the development of housing and recreation facilities. The loss of these wetlands to development in turn, reduces the productivity of the area and ultimately the yield to the sport or commercial fisherman. Thus, the demand for waterfront homes and recreational facilities is causing a loss of the resource which originated the demand.

Traditionally, the Bay and its tributaries have been used as a recepticle for the waste from waste treatment plants, industries and the shipping trade which has developed to supply these industries. These uses often present a conflict with the production of natural resources in a manner which is more direct than that of shoreline development. That is, these activities may have a direct detrimental effect on the higher species which are of both sport and commercial importance. A more detailed discussion of the effects of these uses is in the Problems section of this report.

Aside from the conflicts which arise due to various types of development, numerous conflicts also arise due to the diverse recreational interests of resource users. These diverse interests create a continuing controversy between hunters and non-hunters, farmers and hunters, fishermen and waterskiers, powerboaters and sailors and other groups seeking to use the resource to meet their own specific demands.

These conflicts originate for reasons which are just as numerous as the uses of the Bay's resources. As examples of the types of problems confronting the resource managers of the Bay region, some of these conflicts are discussed below.

Hunting is not only a major form of recreation in the Bay region but is considered by many, especially in the less urbanized areas, to be a traditional way of life. Yet, in recent years, numerous individuals and organizations have spoken out in vehement opposition to any type of hunting. Some opposition comes from individuals and organizations dedicated to the preservation of all life and some comes from those who feel that hunting interfers with their chosen form of recreation, including hiking, nature photography or bird watching as well as others. At the same time, the hunters may be opposed to the issuance of permits to farmers to kill deer which are destroying crops because to the hunter this action reduces his chances of success. Many farmers have also found that hunting rights can be sold to provide the income of an additional crop; thus, the wealthy hunting clubs gain access while many individuals are excluded from prime hunting areas, especially for waterfowl which are abundant around the shores of the Bay. Thus, it can be seen that there is a complex interaction between several groups within the Bay area regarding the utilization of the wildlife resources.

A similar situation exists with the aquatic resources. Not only is there a conflict between sport and commercial interests but also between sport fishermen and those using the resource for other types of recreation such as waterskiing and other boating activities, between the sailboaters and powerboaters and between any number of other groups with diversified needs.

In all probability, any person using the resources of the Bay area to satisfy his own needs, surely feels that some other uses are detrimental to his goal and at the same time, his use is probably considered to be less important by some other individual or group of individuals. The question is posed then, who has the right to use the resources and to what degree can this use be allowed to affect the uses desired by others? There can, of course, be no simple answer to this question. Management of resources has traditionally been carried out through the enforcement of various legislation, which at times have favored development and industry and have at other times been modified to inhibit the growth of these same factions. The existing body of laws and the variations in their enforcement and interpreations further compound the problems confronting the resource managers and in some cases impede the progress toward stabilization of environmental factors.

MANAGEMENT RESPONSIBILITIES

Management of the Bay resources, including fish and wildlife and their habitat, is the responsibility of various branches of the Federal, State, and local governments. Agencies of the Federal government which have managing, regulatory, or permitting authority for actions which may affect the fish and wildlife resources of the Bay, include the U. S. Army Corps of Engineers, the U. S. Environmental Protection Agency, the National Marine Fisheries Service of the U. S. Department of Commerce, the Atomic Energy Commission, the Federal Power Commission, the Soil Conservation Service of the Department of Agriculture and the Divisions of Refuges, Law Enforcement and Ecological Services of the U. S. Fish and Wildlife Service of the U. S. Department of the Interior. Among the Federal agencies, there is a great deal of interaction. The Federal agencies which have the authority to issue permits or perform work in any stream or other body of water are required to consult with the U. S. Fish and Wildlife Service and the State agency which exercises administration over the resources of the project area. This requirement is delineated in the Fish and Wildlife Coordination Act of 1958. Further coordination occurs between permitting or licensing agencies such as the Corps of Engineers, Nuclear Regulatory Commission, Federal Power Commission, Environmental Protection Agency and National Marine Fisheries Service. The purpose of the consultation and coordination procedures of these agencies is to minimize the impact of federally controlled projects and to conserve or develop and improve the fish and wildlife resources of the project area. Aside from the regulation of development through permitting and licensing procedures, other Federal agencies are involved in the protection and development of resources through law enforcement, refuge management and research programs. The U.S. Fish and Wildlife Service, Division of Law Enforcement, is responsible for the enforcement of Federal regulations regarding migratory birds, rare and endangered species, marine mammals, and interstate transportation and importation of various species from foreign countries. The Division of Refuges manages 11 refuges within the Study Area primarily for migratory birds. Research programs are carried out by the Fisheries and Wildlife Research Units, the National Marine Fisheries Service, and the Patuxent Wildlife Research Center as well as by State agencies, universities and colleges which receive funding from the Division of Federal Aid through the Dingell-Johnson and Pittman-Robinson programs for approved fisheries and wildlife research projects.

Also at the Federal level, the Coastal Zone Management Act of 1972 has been implemented with a view toward more effective protection and use of the land and water resources of the coastal zone. Many of the provisions of the Act relate both directly and indirectly to fish and wildlife resources. The states of Maryland, Delaware, and Virginia are actively pursuing the development of coastal zone management plans under this program.

The major portion of the Study Area is located in the states of Maryland and Virginia, and the management responsibilities of these two states are administered by various agencies of the respective state governments. The Maryland Department of Natural Resources is composed of subordinate units which have various degrees of responsibility regarding the resources of the State. Included are the Fisheries and Wildlife Administrations, the Natural Resources Police Force, the Water Resources Administration and membership units of the Susquehanna River Basin Commission and Potomac River Fisheries Commission. It is the function of these agencies of the Maryland Department of Natural Resources to provide research information regarding fish and wildlife resources, enforce state laws and to provide the administration of policies for preservation, maintenance and replenishment of fish and wildlife resources. Among these agencies, many programs are administered for the betterment of fish and wildlife resources. For example, the Fisheries Administration is involved in oyster and clam management, fish population surveys, and anadromous fish spawning studies. The Wildlife Administration has programs directed toward management of waterfowl populations and propagation of the types of rooted aquatic plants preferred by waterfowl.

The fish and wildlife resources of the portion of Virginia located within the Study Area are managed by the Virginia Commission of Game and Inland Fisheries and the Virginia Marine Resources Commission. The Commission of Game and Inland Fisheries is responsible for management of wildlife areas for upland game and waterfowl, fish hatcheries and various projects for the enhancement of game species and inland fish species in the Study Area as well as enforcement of laws regarding upland game and inland fish species. The fishery resources of the tidewater areas of Virginia are managed by the Virginia Marine Resources Commission which regulated the uses and enforces the legislation regarding tidewater species of Virginia.

The Virginia Institute of Marine Science is a separate facility which was organized to conduct studies and investigations on various phases of commercial and sport fisheries and to provide information which will aid in the conservation, development and replenishment of the fishery resources of tidewater Virginia. State Programs within the Study Area include the maintenance of wildlife management areas, four in Delaware, 32 in Maryland, and eight in Virginia. Other projects include fish hatcheries, forests, parks, and numerous boat ramps maintained by State, county, and local governments. A summary of the Federal and State public facilities and management areas is included in Table 12-26.

In order to regulate and maintain the commercial fisheries in the Potomac River, the states of Maryland and Virginia drafted the Potomac River Compact of 1958 which provides regulations for licensing and taking of finfish and shellfish from the Potomac River by residents of either state. The Compact also provides for the taxation of oyster catch in order to supply funding necessary for transplanting and reseeding of oyster beds. The provisions and regulations of the Potomac River Compact and of the Potomac River Fisheries Commission are enforced by officers and inspectors from Maryland and Virginia.

Resource management by the local levels of government generally consists of zoning regulations and occasional refuges or sanctuaries. Because of pressures to develop or utilize the resources by individuals or corporations, local regulations are not traditionally oriented toward the preservation of fish and wildlife resources and thus the responsibility for these resources is generally that of higher governmental units. It should also be noted that private interests have definite influences on fish and wildlife through their deliberate management and preservation of land for wildlife. Private foundations, conservation groups, corporations, and hunt clubs are examples.

TABLE 12-26
SUMMARY OF PUBLIC FACILITIES AND MANAGEMENT AREAS(1)

Study Area	Federal Installation Wildlife Management	Fish Hatcheries	Boat Ramps	Impds. 5 acres or more	Water Acres	State Wild-life Mgt. Areas or Refuges	Total Acres	Federal Refuges	Total Acres
Chesapeake[1] Bay Area	12	1	117	17	12,949	33	98,180	10	52,739
James River Basin	2	1	5	2	3,700	2	2,885	1	2,199
Rappahannock-York River Basin	4	1	15	0	0	2	3,197	0	0
Potomac River Basin	5	0	8	2	241	7	8,153	1	2,516
Total Study Area	23	3	145	21	16,890	44	112,415	12	57,454
State Totals									
Delaware	1	0	6	6	510	4	11,820	0	0
Maryland	6	1	94	12	12,462	32	78,167	6	37,178
Virginia	16	2	45	3	3,918	8	22,428	6	20,276

1 Bay proper excluding all tributaries

CHAPTER III

FUTURE FISH AND WILDLIFE NEEDS

Chesapeake Bay has for centuries been the source of both food and recreation for people living in a large area of the Eastern United States. Associated with the increasing population of the Region has been an expansion of the exploitation of the resources of the Bay. Both commercial and sport fishing sectors in the Bay are contributing to the demand for aquatic resources. Also, a significant demand exists within the Bay Area for the utilization of wildlife resources through both consumptive (hunting and trapping) and nonconsumptive (bird watching, nature photography, and nature walking) uses. This chapter contains projections of both the demand and supply of consumptive and nonconsumptive fish and wildlife resources. It should be noted that because of the many variables within both nature and society which influence the supply and demand of these resources, the projections included in this report are intended to serve as a guide for the identification of future problems and conflicts based on the specific assumptions made in this analysis.

FUTURE DEMANDS AND SUPPLIES OF FISHERY RESOURCES

The information contained in this section is a compendium of the report prepared by Richard J. Marasco, entitled "An Analysis of Future Demands, Supplies, Prices and Needs for Fishery Resources of the Chesapeake Bay." Although much of the mechanics involved in the projections has been omitted, the pertinent information which was obtained is included herein. Anyone interested in the details of the methodology involved in determining the supply and demand functions should refer to the report by Marasco.

Base data necessary to make the projections included in this section were obtained from maximum sustainable yields supplied by the National Marine Fisheries Service, recreational utilizations projections provided by the U. S. Fish and Wildlife Service, and population and income projections from the U. S. Department of Commerce (OBERS).

ASSUMPTIONS

Many uncertainties combine to make future estimates of fisheries supply and demand difficult. Among these are management actions that may occur to enhance the resource and increase the supply; improved water quality which may improve fish reproductive rates and survival chances; market fluctuations and societal preferences for particular seafoods; and improved data such as sportfishing effort and harvest information. Thus, prior to the development of the demand and supply projections, several assumptions were made in order to restrict the variability of the factors and yet provide valid results.

The following assumptions were used in the development of the forecasts:

1. Total cost of harvesting varies with effort in such a way that the relative cost is proportional to relative effort.

2. Fisheries closely approximate the situation that exists under conditions of perfect competition, increasing costs, and free access to the resource. That is, production is increased up to the point where price equals average cost.

3. There is no change in the existing degree of fishery management.

4. Factors which affect both demand and supply remain fixed with respect to time.

5. Factors influencing commercial fishing pressure are the same as those factors affecting sport fishing pressure. (The validity of this assumption and its effect on the projections of species important to both sport and commerical fishermen is discussed in the sensitivity analysis sub-section).

The fourth of the above assumptions was considered to be very restrictive. Tastes and preferences while evolving slowly may vary with respect to time. Changes in tastes and preferences result in parametric changes in the demand equation. Technological and stock changes are capable of producing change on the supply side. To determine the effect of changes in both supply and demand, a sensitivity analysis was performed for one species, oysters.

In order to fully understand the relationship between the supply of and demand for the fisheries resources of the Bay, several factors must be considered. Since these resources are subject to several environmental stresses and losses from predation, including harvesting by man, population levels may fluctuate considerably. In calculating the supply of a species a generalized growth pattern was used. This pattern indicates a natural population will increase in biomass at an increasing rate for a given time, as shown in Figure 12-29. The increased rate is less as the population approaches a stable level. This growth pattern is dependent upon a stable set of environmental conditions.

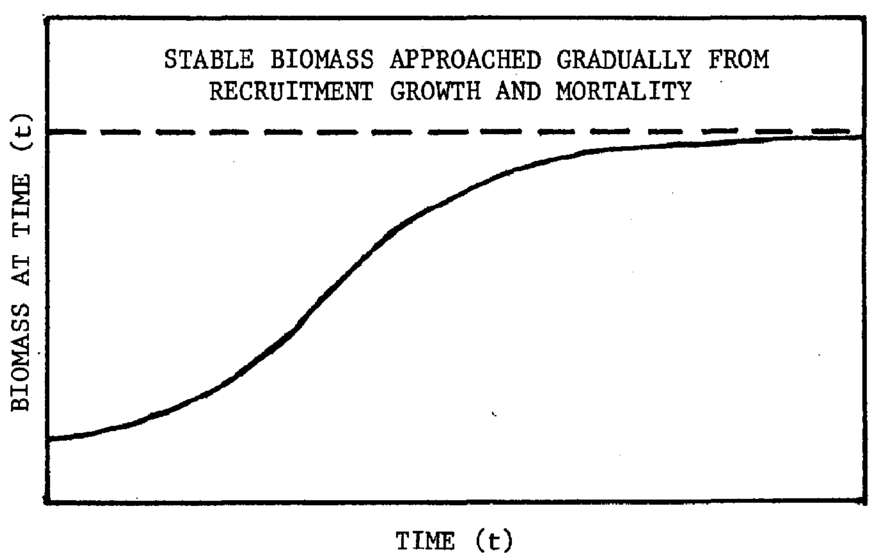


FIGURE 12-29: GROWTH OF FISH POPULATION WITHOUT FISHING

The introduction of a fishery into this system results in a reduction in the increase of stock which is occurring at a given population level. If the yield to the fishery is less than the natural rate of increase, the population will continue to increase, although at a slower rate. If the yield to the fishery is greater than the natural increase, the population will decrease. When the yield is equal to the natural rate of increase, the population remains unchanged.

The relationships between the maximum sustainable yield, fishing effort and the known yield of a given species during the base period, can be used to project the supply of a species and to determine the point at which overfishing will occur.

With the introduction of price as a determining factor in the consumption of a good, a demand equation was formulated which when combined with the previously mentioned supply relations was used to project the future trends in fish supplies, consumption, and prices.

The following procedures were employed in making economic projections of the demand and supply for each finfish and shellfish species considered:

1. For each species, the commercial demand equation was evaluated at an initial price equal to 1 percent of the base year nominal price, the projected values of both the consumer price index and level of income for year "t". OBERS income projections were used (U. S. Water Resources Council).

2. The projected consumption of fish landed commercially was added to the recreation consumption developed by the Bureau of Sport Fisheries and Wildlife to determine the total demand for any year "t".

3. The supply equation was then evaluated at the same initial price and consumer price index used to evaluate demand.

4. The projected total demand and supply were compared. Since a consumption excess was forced in the first iteration, the initial price was incremented by 25 percent of the base year nominal price (dp). Production and consumption were then recalculated for the new price. Upon comparing consumption and production, the price was incremented by an additional "dp" if demand exceeded supply. This incremental procedure was forced to continue until production exceeded consumption. Once production exceeds consumption, "dp" was set equal to 1/10 of the current "dp". The new "dp" was then added to the price that was used in the previous iteration. This iterative procedure continued until the equilibrium solution was located.

5. Recreational data utilized for these projections were derived from information in the 1970 Salt Water Angling Survey (published by the Department of Commerce, NOAA), National Hunting and Fishing Surveys, OBERS population data and projections, and personal communications with representatives of the state fisheries agencies. A compilation of this data was used to determine the annual catch weight by species per angler and the projected increases in anglers over the study period. These calculations assumed a constant percentage of the population would be anglers.

PROJECTED DEMANDS AND SUPPLIES

Utilization of the aquatic resources by commercial and sport fishing interests has been projected for several species of finfish and shellfish which are commonly sought in the waters of Chesapeake Bay.* For each species included in these projections, the probable quantity which will be harvested by commercial and recreational users, the percent of the maximum sustainable yield which this quantity represents, and the probable future price for the species, are given in a tabular form. These projections are not intended to be mathematical certainties, but represent best judgments as to the most probable outcome with current information. The figures for maximum sustainable yield, for example, as shown in Table 12-27, should be considered as estimates at best since there are too many variables which influence populations to allow definitive statements concerning the MSY's. Also, there are admitted inadequacies in the recreational catch information included in the Angling Survey prepared by the National Marine Fisheries Service.

In order to understand the effect of the fishery upon the resource, knowledge of the ability of the fish species to recover its losses and maintain a stable population is of utmost importance. The estimates of maximum sustainable yield which were used in these projections (Table 12-27) reflect the probably limits of the commercial harvest for given species within Chesapeake Bay under the present management programs. Figure 12-30 illustrates the typical relationship between supply and demand within a fishery. The term "supply" refers to the commercial harvest only, and represents the demand that will be expected in each of the goal years as a function of price. The phenomenon of excess demand is shown for the years 2000 and 2020 where the demand curves do not intersect the supply curve. In these cases, sufficient supplies cannot be had at any price since the maximum sustainable yield has been exceeded. Increased harvesting beyond the MSY results in an eventual decline in the fish population due to overharvesting. Brief comments on the life cycle and utilization of each species are included in the discussions.

---

*It should be noted that the bluefish, which has become important in recent years, was not included in this analysis.

TABLE 12-27
ESTIMATES OF THE MAXIMUM SUSTAINABLE COMMERCIAL YIELD FOR SELECTED SPECIES HARVESTED IN CHESAPEAKE BAY*

SPECIES	MSY/YEAR (POUNDS)
Striped bass	6,000,000
White perch	3,000,000
Sea trout (Weakfish)	2,000,000
Spot	3,000,000
Flounder (mostly fluke)	3,000,000
Scup	6,000,000
Sea bass	4,000,000
Catfish-bullheads	2,500,000
Eel	1,500,000
Yellow perch	250,000
Alewife	25,000,000
Menhaden	300,000,000
Shad	4,000,000
Blue crab (hard and soft)	65,000,000
Oyster	30,000,000
Soft clam	6,000,000

*These estimates were obtained from Bob Lippson, Biological Laboratory, National Marine Fisheries Service, Oxford, Maryland.

BLUE CRAB - Callinectes sapidus

Blue crabs are an important shellfish species to both commercial and recreational fishermen. Hard crabs account for the major portion of the total poundage of crabs landed in Maryland and Virginia. In addition, there is an intensive fishery for soft-shell crabs.

The life of the blue crab begins near the mouth of the Bay from June to October. In its larval stages, the crab is moved into the Bay by tidal currents. After several molts, the zoeae larvae transforms into a megalopae which is able to swim and crawl along the bottom. These megalopae move into the upper estuary and tributary areas where they become recognizable as small crabs. During their development into adults, the crabs shed several times and provide the soft crabs of high market and recreational value. As adults, the male crabs generally remain in the northern portion of the Bay and the low salinity areas of the tributaries, while the females migrate back to the mouth of the Bay where spawning takes place.

Because of the lack of data regarding the actual numbers of crabs landed by sportsmen, the projections were limited to the commercial crab fishery. The recreational crab catch is estimated by some sources to be as great as the commercial catch.

Since 1947, crab landings have exhibited cyclical fluctuations. Forecasted landings for 1980 were found to correspond with the harvest that was taken at approximately the midpoint of the 1959-1967 cyclical period. Excess demands of greater than 5 million pounds were forecasted for both 2000 and 2020. Figure 12-30 illustrates the phenomenon that give rise to excess demand. As indicated in the diagram, the demand curves for both 2000 and 2020 do not intersect the supply curve. The end product of the lack of intersection is a

---

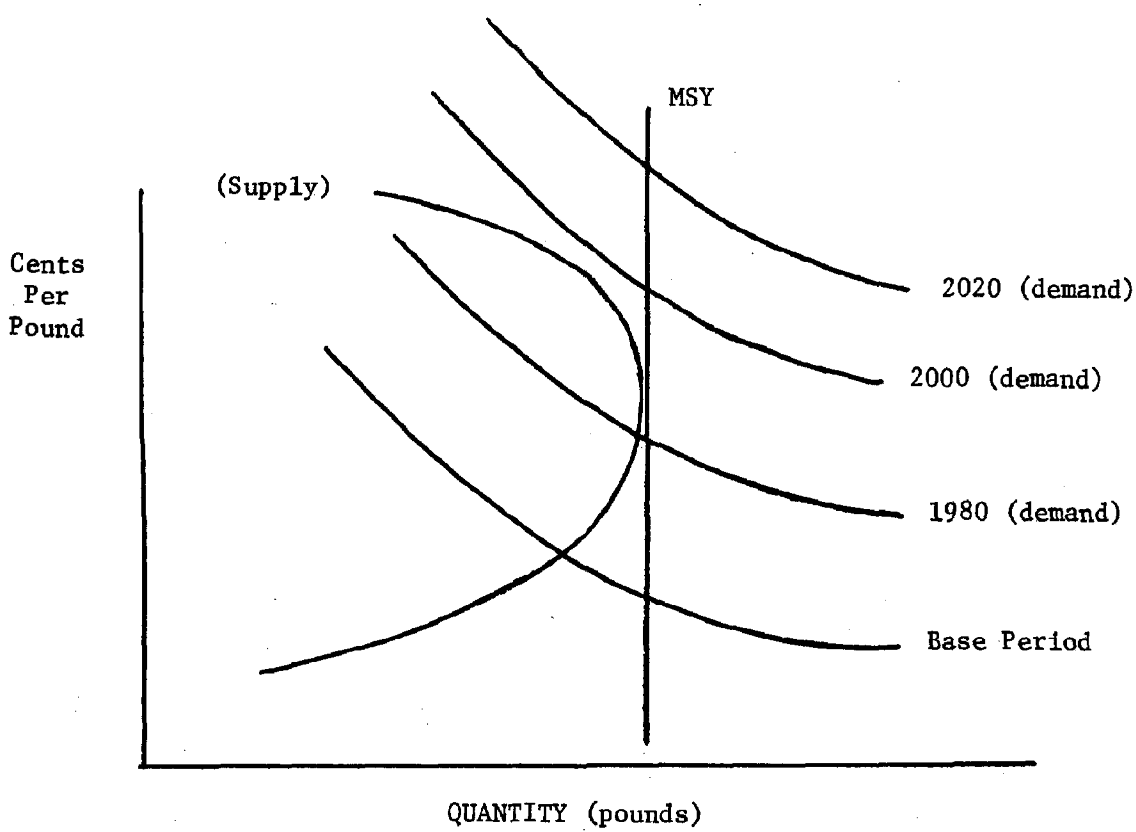


FIGURE 12-30: DEMAND AND SUPPLY FUNCTIONS 1980-2020

market shortage. Theoretically, this would indicate rapid extinction of the resource. It is, however, sufficient to say that overfishing will occur after 1980 given the parameters and projections used in the model. Table 12-28 shows projections for blue crabs for 2000 and 2020. These projections were developed by assuming that the peaks and valleys that characterized the 1959-67 period hold true for the future.

TABLE 12-28

Blue Crab Projections

Year	Commercial Quantity (100,000 lbs.)	Percent of MSYa	Price (¢/lb.)
Base Period	613.731	94	10.52
1980	649.344	99	16.91
2000	680.000b	>100	36.54
2020	780.000b	>100	65.75

a. MSY = 650.0

b. Developed by assuming that the cyclical movements in quantity landed exhibited between 1959-67 hold into the future.

OYSTERS - Crassostrea virginica

The oyster is distributed in the Chesapeake Bay from near the mouth of the Bay to its head waters. Until the early 1960's, commercial oyster landings exhibited a significant downward trend. However, with the advent of the oyster seeding program in Maryland, the trend has been reversed. Major factors limiting the present distribution of oysters in the Bay area are the availability of suitable substrate for setting and the presence of predators and disease in some areas. Spawning occurs from June to October when the water temperature reaches 20°C. Oysters can survive in waters ranging in salinity from 7 ppt. to 35 ppt. and are susceptible to massive die offs due to extensive periods of low salinities such as those which occurred following hurricane Agnes in 1972.

Projections of the future oyster harvest indicate that commercial landings will continue to increase through the year 2020. However, the forecasts obtained indicate that the maximum sustained yield will be exceeded prior to the year 2020. As shown in Table 12-29 the small quantity change and large price changes between the 2000 and 2020 projections indicate that the MSY will be exceeded some time between the two years.

Oyster populations can be augmented by culturing practices. Supply augmentation in the Chesapeake Bay beyond certain levels could counter future demand increases, thus resulting in prices lower than those forecasted.

Table 12-29

Oyster Projections

Year	Commercial Quantity (1,000,000 lbs.)	Percent of MSYa	Price (¢/lbs.)
Base period	23.74	79	60.16
1980	26.13	87	76.94
2000	29.47	98	112.41
2020	29.49	98	176.99

a. MSY = 30.0

SOFT CLAMS - *Mya arenaria*

Soft shell clams are widely distributed throughout the Bay and its tributaries. They generally occur in the tributary areas with a salinity range of 5 ppt. to 20 ppt. and a depth of less than 20 feet in sand or sandy mud bottoms. Spawning occurs at two times during the year, from early May to mid-June, and from late August to early December. Mya are susceptible to summer mortalities due to increased water temperatures and to extremely low salinities such as those which occurred following hurricane Agnes.

Landings data available revealed that during the base period 1967-68, 90 percent of the maximum sustainable yield was harvested. Projections made (Table 12-30) indicated that 96 percent of MSY would be captured in 1980 and 99 percent in 2000. Landings were predicted to exceed MSY by the year 2020.

Table 12-30

Soft Clam Projections

Year	Commercial Quantity (10,000 lbs.)	Percent of MSYa	Price (¢/lb.)
Base period	541.245	90	32.20
1980	576.391	96	47.82
2000	599.513	99	71.81
2020	568.138	95	109.62

a. MSY = 600.000

MENHADEN - Brovoortia tyrannus

Menhaden are found in the Chesapeake Bay throughout the year. Although they are considered to be oceanic spawners, menhaden eggs are often found in the upper Bay. This may be due to the upstream movement of deep waters which transport the eggs. The larvae enter the Bay from October to April. In the late spring and early summer the juveniles become concentrated in the tidal streams of the marshes in the upper Bay and tributaries. Later in the summer, the young menhaden form schools and begin to move back downstream. It is this schooling nature of these fish, which occurs throughout their life cycle, that makes them susceptible to the commercial fishing techniques employed to capture them. Because of the movement that takes place between the Chesapeake Bay and the ocean, it was deemed necessary to consider menhaden from a regional rather than a Bay only perspective. Therefore, menhaden landings for North Carolina, the New England, Middle Atlantic and Chesapeake Bay states were used to develop the projections that appear in Table 12-31. Since 1967, Chesapeake Bay landings have accounted for 54 percent of the menhaden landed in the states listed. Using this information, an indication of the status of the Chesapeake Bay menhaden fishery in the years 1980, 2000, and 2020 can be obtained. Forecasts indicated that menhaden landings will increase through 2000 (relative to the base period landings). Revealed also was that the maximum sustainable yield would be exceeded prior to 2020.

Table 12-31

Menhaden Projections

Year	Commercial Quantity (100,000,000 lbs.)	Percent of MSYa	Price (¢/lb.)
Base Year	4.4979	90	1.70
1980	4.5583	91	2.05
2000	4.9682	99	3.01
2020	4.9510	99	4.36

a. MSY = 500,000,000 lbs. Taken from Schaaf, William E. and G. R. Huntsman, "Effects of Fishing on the Atlantic Menhaden Stock: 1955-1969", Transactions of the American Fisheries Society, 191(2): 290-297.

ALEWIFE - Alosa pseudoharengus

The alewife is found throughout the Bay and its tributaries. They are anadromous, spawning from early March to early May in fresh water and remain in the brackish water nursery ground until October or November when they move to the deeper Bay waters or the Ocean.

Alewife landings have shown a significant uptrend since the early 1950's. Projections (Table 12-32) indicate that alewife landings will increase through 2000 and then decrease slightly in the year 2020. It was also revealed that the maximum sustainable yield will probably be exceeded sometime between the years 2000 and 2020.

Table 12-32

Alewife Projections

Year	Commercial Quantity (100,000 lbs.)	Percent of MSYa	Price (¢/lb.)
Base Period	211.103	84	2.10
1980	232.820	92	2.77
2000	249.803	99	4.38
2020	227.48	91	7.37

a. MSY = 250.0

SPOT - Leiostomus xanthurus

Spot enter the Chesapeake Bay to feed during months when the water is warm. As cold water approaches they return to the sea and by winter most have returned. The young spawned in oceanic waters use the shallows of the low salinity regions of the Bay as nursery grounds and may remain in the Bay until December. In general, the smaller specimens are found in lower salinity waters and the larger ones in the lower reaches of the Bay.

Commercial landings of spot were found to exhibit large year to year fluctuations between 1952 and 1970. The base period total harvest of spot was found to be 96 percent of the maximum sustainable yield. Due to the large recreational catch projections and the assumption that recreational demand, would be satisfied before commercial demand, no solutions were possible for 1980, 2000, and 2020. This resulted because the demand and supply curves did not intersect. It was evident from the projections that recreational pressures will play a critical role in determining the future state of spot. Demands for the years 1980, 2000, and 2020 were found to exceed supply by 1.0, 8.5 and 19.2 million pounds, respectively. Quantity and price forecasts for 1980 that appear in Table 12-33 were developed based on the same procedure that was used to make similar projections for white perch. Because of the excess of recreational catch over the estimated MSY, forecasts were not developed for 2000 and 2020.

Table 12-33

Spot Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreation Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	141.930	96	113.000	28.930	11.02
1980	147.193	100	139.000	8.193	46.89
2000	-b	-b	187.000	-b	-b
2020	-b	-b	245.000	-b	-b

a. MSY = 147.193

b. No solution was possible due to the lack of intersection of the demand and supply curves. This result followed due to the assumption that recreational demand would be satisfied before commercial demand The solution for 1980 was developed by assuming that the maximum sustainable yield would be harvested with recreational demand satisfied first and the remainder constituting the commercial catch.

STRIPED BASS - Morone saxatilis

The striped bass is probably the most sought after fish in the Bay by both commercial and sport fishermen. Although they are anadromous, they are found in some area of the Bay throughout the year. Spawning takes place in numerous tributaries of the Bay from April to mid-June, in waters with salinities less than 1.5 ppt. Juveniles move into the shallow inshore areas of the upper tributary nursery areas. As they grow, they gradually move downstream where they form schools in the Bays and rivers during their first summer. During the winter months some of the larger bass migrate northward along the Atlantic coast while many remain in the deep holes of the Bay and lower rivers.

Evidence indicates that 96 percent of the maximum sustainable yield was harvested during 1970, (Table 12-34). By 1980, the total harvest of striped bass was predicted to be 99 percent of the maximum sustainable yield. Because of the larger projected recreational demand and the assumption that recreational demand would be satisfied before commercial demand, no solutions were possible for 2000, and 2020. It was evident from the projections made that the maximum sustainable yield will be surpassed before the year 2000. Social demands were indicated to exceed supply by approximately 3.4 and 8.4 million pounds for the years 2000 and 2020, respectively. Quantity and price forecasts for 2000 and 2020 that appear in Table 12-34 were developed based on the same procedure that was used to make similar projections for white perch.

Table 12 -34

Striped Bass Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreation Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	111.590	96	54.000	57.590	21.55
1980	115.373	99	65.000	50.373	34.58
2000	115.800b	100	87.000	28.8	95.00
2020	115.8b	100	114.000	1.8	230.00

a. MSY = 115.800
b. No solution was possible due to the lack of intersection of the supply and demand curves. This result followed due to the assumption that recreational demand would be satisfied before commercial demand. The solutions for 2000 and 2020 were developed by assuming that maximum sustainable yield would be harvested with recreational demand satisfied first and the remainder constituting the commercial catch.

WHITE PERCH - *Morone americana*

White perch are distributed throughout the Chesapeake Bay. They are considered to be semi-anadromous, moving from brackish water to fresher waters in April and May to spawn. The young remain during their first summer in the shallow slightly brackish areas of the tributaries, then, as the waters turn cooler, they migrate to the deeper areas of the Bay and its tributaries. To date, white perch have been of greater importance to the recreational fishermen than to their commercial counterparts. As revealed by the results that appear in Table 12-35, recreational catch represented 73 percent of the total quantity harvested during 1970. Projections indicate that 76 percent of the maximum sustainable yield will be harvested by 1980.

The model did not provide solutions for 2000 and 2020 because of the lack of intersection of the demand and supply curves. Illustrated in Figure 12-31 is a situation where demand and supply do not intersect. This result was due to the assumption that recreation represented the highest priority and best use of the resource. The quantities and prices that appear in Table 12-35 were developed based on the assumption that the maximum sustainable yield would be harvested with recreation demand satisfied first with the remainder constituting the commercial harvest.

It was evident from the projections that recreational pressure will be the critical determinant of the future state of the Chesapeake white perch population. By the year 2020 recreational catch alone was determined to be 99 percent of the maximum sustainable yield. Social demands for the years 2000 and 2020 were indicated by the model to exceed supply by approximately 350 thousand and 4.5 million pounds, respectively. The minimum distance between the demand and supply curves was used as the measure of excess demand.

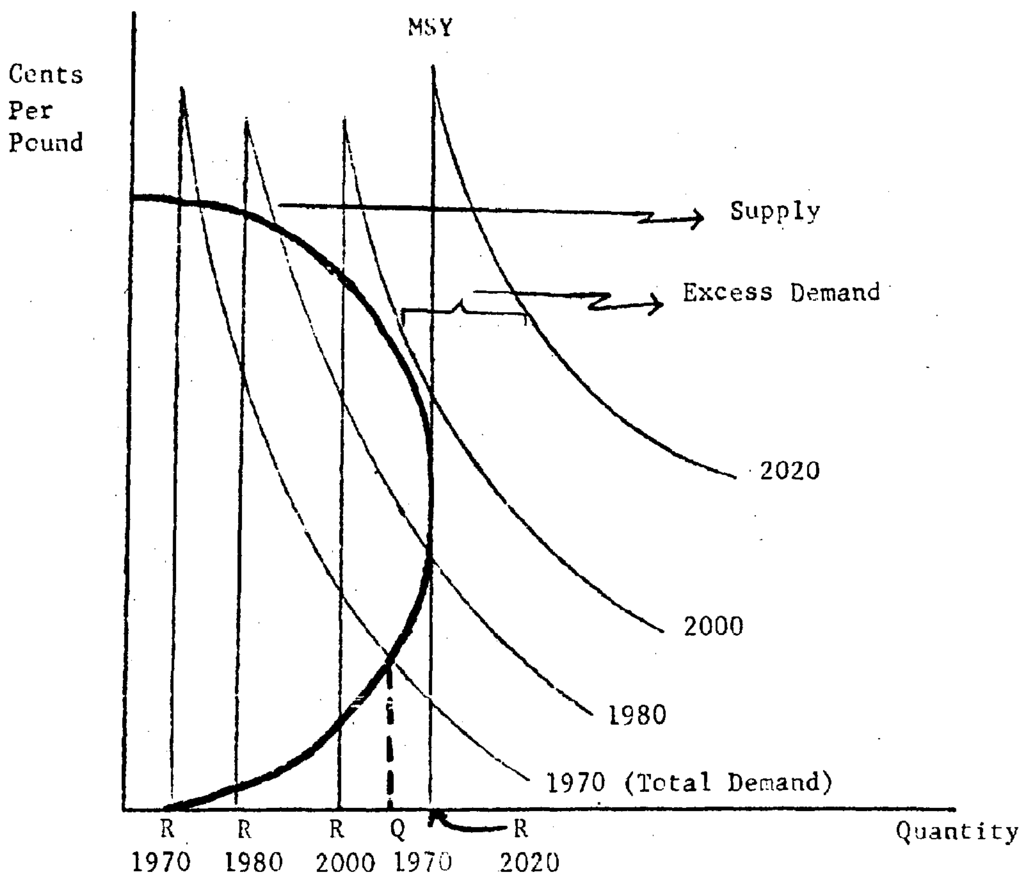


Figure 12-31 Demand and Supply Functions for Species Subject to Both Commercial and Recreational Use (R = Recreation Catch; Q = Total Demand)

Table 12-35

White perch projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreation Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	72.254	64	53.000	19.254	15.71
1980	86.017	76	63.000	23.017	23.09
2000	112.5b	100	85.000	27.5	200.00
2020	112.5b	100	111.000	1.5	500.00

a. MSY = 112.5

b. No solution was possible due to the lack of intersection of the demand and supply curves. This result followed due to the assumption that recreational demand would be satisfied before commercial demand. Solutions were developed by assuming that the maximum sustainable yield would be harvested with recreation demand satisfied first and the remainder constituting the commercial catch.

SHAD - *Alosa sapidissima*

Shad, a member of the herring family, is an anadromous fish. That is, they leave the ocean and swim upstream to fresh water to spawn in the late winter and early spring months. In the Chesapeake Bay Area, shad have been subject to both commercial and recreational use. Since the roe of the female is a prized delicacy, the major commercial and sport fishing effort is expended toward these individuals prior to and during their spawning run in the spring.

During 1970, commercial landings were only slightly larger than the recreational catch. Collectively, commercial and recreational harvests represented 93 percent of MSY. This percentage was projected to increase to 99 percent by 1980. As indicated in Table 12-36, the estimated recreation catch was sufficiently large to prevent the intersection of the demand and supply curves for 2000 and 2020. This indicated that social demand would exceed supply by 860 thousand and 3.7 million pounds in 2000 and 2020, respectively. Quantity and price forecasts for 2000 and 2020 that appear in Table 12-36 were developed based on the same procedure that was used to make similar projections for white perch.

Table 12-36

Shad Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreational Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	71.196	93	33.90	37.269	8.85
1980	75.994	99	43.00	32.994	13.70
2000	76.384b	100	59.00	17.384	27.54
2020	76.384b	100	76.00	.384	300.00

a. MSY = 76.384

b. No solution was possible due to the lack of intersection of the demand and supply curves. This result followed due to the assumption that recreational demand would be satisfied before commercial demand. Solutions were developed by assuming that the maximum sustainable yield would be harvested with recreation demand satisfied first and the remainder constituting the commercial catch.

WEAKFISH - *Cynoscion regalis*

Weakfish abundance in the Chesapeake Bay has tended to fluctuate from year to year. These fish spawn at sea and use the shallow estuarine waters as a nursery. The spawning period is from April through August and the juveniles move into the Bay in the early summer. Adults feed in the lower Bay during the summer and are occasionally found as far north as Annapolis and the Chesapeake Bay bridge.

It was determined that the total quantity harvested by both commercial and recreational fishermen represented 81 percent of the maximum sustainable yield in the base period. Projected 1980 total harvest was determined to be 93 percent of MSY. Recreational demand for the years 2000 and 2020 were sufficiently large to make it impossible to obtain a solution. This result being due to the assumption that recreational demand would be satisfied before commercial demand. Social demand was determined to exceed supply by approximately 890,000 and 3,809,000 pounds in 2000 and 2020, respectively. Price-quantity forecasts that appear in Table 12-37 were developed by using the same procedure that was used to make similar projections for white perch.

Table 12-37

Weakfish Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreation Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	51.743	81	35.5	16.243	10.66
1980	59.571	93	44.0	15.571	17.03
2000	63.710b	100	59.0	4.71	102.00
2020	-b	-b	78.0	-b	-b

a. MSY = 63.710

b. No solution was possible due to the lack of intersection of the demand and supply curves. This result followed due to the assumption that recreational demand would be satisfied before commercial demand. The solution for 2000 was developed by assuming that the maximum sustainable yield would be harvested with recreation demand satisfied first and the remainder constituting the commercial catch.

FLOUNDER - *Paralicthys dentatus* - Summer flounder - *Pseudopleuronectes americanus* - winter flounder

Since very little information was available to differentiate the data for the two species of flounder found in the Bay, one projection was made to include both species. Winter flounder are found in the Bay only during the winter months when they ascend to the lower reaches of many of the tributaries to spawn. This species is a cold water fish and cannot tolerate the high summer temperatures of the Bay. The summer flounder spawn in the ocean in the fall and use the low salinity areas of the Bay as a nursery during the winter, spring and summer. In the lower Bay this species is sought by numerous sportsmen.

Since 1950, the commercial harvest of flounder has not been characterized by either a significant increasing or decreasing trend. The 1970 harvest, both recreational and commercial, was determined to be 89 percent of the maximum sustainable yield. Projections made indicated that 97 percent of the MSY would be harvested by 1980. Forecasts obtained for 2000 indicated that overfishing would take place by the turn of the century; that is, maximum sustainable yield of the fishery would be surpassed.

No projections were possible for 2020 due to the lack of intersection of the demand and supply curves. This phenomenon was a by-product of the assumption that recreational use represented the highest and best use of the resource. Social demand for the year 2020 was determined to exceed supply by approximately 1.5 million pounds.

Price-quantity forecasts that appear in Table 12-38 were developed by using the same procedure that was used to make similar projections for white perch.

Table 12-38

Flounder Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreational Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	45.750	89	19.000	26.750	26.77
1980	49.788	97	23.000	26.788	35.94
2000	47.729	93	31.000	16.729	75.80
2020	51.300b	100	40.000	11.300	150.00

a. MSY = 51.300

b. No solution was possible due to the lack of intersection of the demand and supply curves. This result followed due to the assumption that recreational demand would be satisfied before commercial demand. The solution for 2020 was developed by assuming that the maximum sustainable yield would be harvested with recreation demand satisfied first and the remainder constituting the commercial catch.

<u>CATFISH</u> - <u>Ictalurus catus</u> - White catfish
<u>Ictalurus nebulosus</u> - Brown bullhead
<u>Ictalurus punctalus</u> - Channel catfish
<u>Ictalurus natalis</u> - Yellow bullhead

All of the above species of catfish are found primarily in the upper tributaries of the Bay. The channel catfish and white catfish can tolerate salinities near 5-6 ppt. and the brown bullhead salinities of approximately 2-3 ppt. The yellow bullhead is found in the fresh waters of the major tributaries. When taken as a commercial or sport catch these species are not usually separated but all considered as catfish. Records indicate that from 1952 to 1970 commercial landings of catfish have been declining; however, it should be noted that interest in the commercial exploitation of these species has recently been renewed. It was determined that 1970 commercial and recreational harvests accounted for 54 percent of the maximum sustainable yield. Projections made indicated that by year 2020, 96 percent of the maximum sustainable yield would be harvested. This result indicated that the species would be capable of withstanding fishing intensities in excess of those predicted (Table 12-39).

Table 12-39

Catfish Projections

Year	Total Quantity (10,000 lbs.)	Percent of MSYa	Recreation Quantity (10,000 lbs.)	Commercial Quantity (10,000 lbs.)	Price (¢/lb.)
Base Period	243.960	54	110.000	113.960	14.47
1980	298.328	65	130.000	168.328	17.90
2000	369.263	81	180.000	189.263	25.58
2020	438.553	96	230.000	208.553	40.70

a. MSY = 455.000

SCUP - Stenotomus chrysops

Scup are found in the Bay primarily in the spring, summer and fall, They are of minor importance to the sport or commercial fishery in the Bay; however, they have a significant fishery in the nearby offshore regions and landings in Bay region ports total about two million pounds per year.

Projections may reveal increases in the commercial landings of scup through the year 2020. Increases in recreational catch were also indicated. As revealed in Table 12-40, the scup fishery was found to be capable of withstanding a significant increase in fishing intensity without adverse effects results.

Table 12-40

Scup Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreation Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	22.810	35	2.000	20.810	17.44
1980	25.897	39	2.000	23.897	21.42
2000	34.319	52	3.000	31.319	27.15
2020	42.998	65	4.000	38.998	35.07

a. MSY = 65.766

<u>SEA BASS</u> - <u>Centropristes striatus</u>

The sport and commercial fisheries for sea bass in Chesapeake Bay is located in the lower reaches, predominantly from the Patuxent River and Tangier Sound southward. Spawning of this species occurs off the coast in the late spring. The majority of this species caught in the Bay are small individuals weighing less than one half pound with larger individuals being taken from oceanic waters.

Projections made indicated that the commercial sea bass fishery will grow through 2020. Slight increases were indicated in recreational catch. As revealed in Table 12-41, the sea bass fishery was found to be capable of withstanding a significant increase in fishing intensity without adverse effects resulting.

Table 12-41

Sea Bass Projections

Year	Total Quantity (100,000 lbs.)	Percent of MSYa	Recreation Quantity (100,000 lbs.)	Commercial Quantity (100,000 lbs.)	Price (¢/lb.)
Base Period	20.840	42	4.0	16.840	22.68
1980	24.736	50	5.0	19.736	27.48
2000	31.302	60	6.0	25.302	34.67
2020	39.118	80	8.0	31.118	49.45

a. MSY = 49.200

AMERICAN EEL - Anguilla rostrata

American eel are located throughout the Bay and its tributaries. They are catadromous, spawning in the open ocean and ascending the bays and tributaries where they spend several years until they mature and return to the sea to spawn. Until recently the major commercial utilization of eel was as bait for trotline crabbers. not generally used as a food fish in this region; however, in Europe and Asia they are considered gourmet fare and recently Chesapeake Bay markets have developed to supply those regions.

Commercial landings of eel decreased from 1952 through the early 1960's, then staged a recovery and increased through 1970. Because of the large projected total demand, the supply and demand curves did not intersect. Therefore, no solution was obtained. Social demands were indicated to exceed supply by approximately 127,600 and 390,600 pounds, respectively, for 2000 and 2020. Forecasts that appear in Table 12-42 were developed by using the same procedure that was used to project quantities and prices for white perch (for 2000 and 2020).

Table 12-42

Eel Projections

Year	Total Quantity (1,000 lbs.)	Percent of MSYa	Recreation Quantity (1,000 lbs.)	Commercial Quantity (1,000 lbs.)	Price (¢/1b.)
Base Period	1692.000	99	200.000	1492.900	20.10
1980	1665.985	98	200.000	1465.985	28.95
2000	1695.000b	100	300.000	1395.000b	50.94b
2020	1695.000b	100	400.000	1295.000b	111.00b

a. MSY = 1695.000

b. No solution was possible due to the lack of intersection of the supply and demand curves. This result followed because of the assumption that recreation demand would be satisfied before commercial demand. The solution for 2000 and 2020 were developed by assuming that the maximum sustainable yield would be harvested with recreational demand satisfied first and the remainder constituting the commercial catch.

YELLOW PERCH - *Perca flavescens*

Yellow perch are found primarily in the fresh waters of lakes and streams; however, they are also well adapted to the low salinities of the tributaries surrounding the Bay. Their distribution in the Bay region includes nearly all of rivers and streams with salinities less than about 7-8 ppt. This species spawns in fresh water in April and May through its range in Chesapeake Bay. During the spring spawning season yellow perch congregate in several areas of the upper tributaries where they are sought by numerous sport fishermen, who provide the major utilization of this species.

This finfish species is considered to be underutilized. During 1970 the total quantity harvested was found to represent 44 percent of the maximum sustainable yield. By the year 2020 total quantity harvested was projected to represent 92 percent of the maximum sustainable yield. Major expansion was predicted by both recreational and commercial segments of the fishery (Table 12-43).

Table 12-43

Yellow Perch Projections

Year	Total Quantity (10,000 lbs.)	Percent of MSYa	Recreation Quantity (10,000 lbs.)	Commercial Quantity (10,000 lbs.)	Price (¢/lb.)
Base Period	151.050	44	140.000	11.050	13.14
1980	183.163	53	170.000	13.163	18.99
2000	247.772	73	230.000	17.772	47.36
2020	313.108	92	290.000	23.108	132.95

a. MSY = 341.5

FUTURE NEEDS FOR IMPORTANT CHESAPEAKE BAY FISH SPECIES, PRODUCTS AND INDUSTRIES

In light of the projections made in the preceding section, the following questions were asked: 1) will future supplies of finfish and shellfish be sufficient to meet demand; 2) will the projected quantities dictate a significant change in the future size of the harvesting section; and 3) will the forecasted landings require a contraction or expansion in the processing sector? The lack of information made an appraisal of the impact of projected recreation demand upon employment in the associated industrial complex infeasible at this time. However, it was concluded that the projected recreation demands appeared capable of generating a significant employment effect. The magnitude of this effect appeared sufficient to counter any negative employment effect indicated in the commercial sector.

FUTURE DEMAND AND SUPPLY COMPARISONS

The results of the empirical analysis revealed that supplies were sufficient to meet the demand for alewife, menhaden, soft-shell clams, oysters, yellow perch, sea bass, scup, and catfish. While supply was found to be capable of satisfying demand for alewife, menhaden, and soft-clams, overfishing was indicated; that is, exploitation would be taking place in the right hand portion of the yield-effort curve such that increased effort causes decreased yield. Excess demands were indicated for blue crab, white perch, shad, flounder, spot, weakfish, striped bass and eel. Where excess demands were indicated, recreational pressures were found to be as intense and in some cases more intense than commercial use of the species. In light of current legislative trends, it was concluded that for those finfish species where excess demands were indicated, recreation use would receive priority.

FUTURE REQUIREMENTS - THE HARVESTING SECTOR

The decrease in commercial landings indicated for a majority of the finfish species for which projections were made was interpreted as revealing a contraction in the finfish segment of the harvesting sector. While increases in commercial landings of some finfish species were revealed, most notably yellow perch, catfish, sea bass, and alewife, the even larger reduction in the level of fishing effort associated with the predicted contraction in the other finfish fisheries was considered sufficient to meet the needs of the expanding fisheries.

Of the projections made for the three shellfish species, the predicted increases in oyster landings was the only result considered to be of significance in relation to the probable effect upon the harvesting sector. The predicted landings increases cannot be interpreted as implying a needed expansion in the harvesting component of the oyster industry. Of critical importance is the present capacity of the oyster fishery and the degree to which it is utilized. Currently, in Maryland, each licensed oysterman is limited to a catch of 25 bushels per day. Assuming two persons per rig, the catch limit would be 50 bushels. Experience was indicated that various rigs are capable of harvesting two or three times this quantity. In light of this evidence, it was concluded that the present capacity of the harvesting sector of the oyster industry would be sufficient to meet future demands.

FUTURE REQUIREMENTS - THE PROCESSING SECTOR

As indicated in Table 12-44, the majority of processors located in the Bay Area have been engaged in the processing of clams, oysters and/or crabs. A small group of processors have been involved with finfish with the production of industrial fish products occupying an important position. Recent trends were found to indicate a decrease in the number of processors in all the categories listed in Table 12-44. While the number of plants has been declining, the average annual employment per plant was found to have increased between 1966 and 1970, (Table 12-45 and 12-46).Employment in the Maryland-Virginia seafood wholesaling and processing industries between 1939 and 1970 is summarized in Table 12-47. As indicated by these data, total employment in these two segments of the seafood industry has exhibited an upward trend over time.

Due to data limitations, precise projection of number of wholesaling and processing establishments and employment in these two segments of the fishing industry was not attempted. Of the species for which projections were made, it was determined that alewife, menhaden, oyster, crabs, and clams forecasts would dictate the future of the processing sector. Projections made appeared, at a minimum, to be capable of supporting a processing sector of current size and degree of utilization. The inability of processors to attract young shuckers and the age of current shuckers could serve to constrain processing activities. However, it is likely that sometime in the near future mechanical devices will replace these employees or at least perform a portion of their duties.

FISHERIES SENSITIVITY ANALYSIS

The purpose of this section is to provide a discussion of the factors affecting the validity of the fisheries projections. These factors include the assumptions which have been made in order to provide the projections and the methods and parameters incorporated into the projections.

The assumption was made that the percent of the commercial maximum sustainable yield (MSY) which is harvested is directly proportioned to the percent of the recreational MSY which is harvested. This implies that the factors which influence the recreational catch are the same as those affecting the commercial catch. However, the factors which influence the commercial and recreational fishing pressures are not the same. For example, the commercial fishing pressure on a species may be related to the dockside value, the availability and value of other species and other similar factors. Sport fishing effort for the same species may be regulated by weather conditions, available leisure time, desirability of the species as a game fish, cost and availability

Table 12-44

NUMBER OF SEAFOOD PROCESSING PLANTS BY TYPE AND COUNTY, 1970(1)

State, Region, County	Total Number of Firms	Fresh, Frozen, Cooked, and/or Prepared Crab-meat	Oysters	Clams	Specialties[2]	Canning[3]	Curing[4]	Industrial[5]
MARYLAND:								
Lower Eastern Shore:								
Dorchester	22	16	6	0	1	0	0	3
Somerset	27	18	13	0	1	0	0	0
Wicomico	4	0	4	1	0	1	0	0
Worcester	0	0	0	0	0	0	0	0
Upper Eastern Shore:								
Caroline	0	0	0	0	0	0	0	0
Kent	3	1	2	1	0	0	1	0
Queen Annes	13	2	9	9	0	0	0	0
Talbot	13	1	7	9	1	0	0	0
Lower Western Shore:								
Anne Arundel	3	1	2	0	0	0	0	0
Calvert	2	0	2	0	0	0	0	0
Prince Georges	0	0	0	0	0	0	0	0
St. Marys	6	0	4	2	0	0	0	0
Upper Western Shore:								
Baltimore	3	0	1	0	0	1	0	1
Maryland Total:	96	39	50	22	3	2	1	4
VIRGINIA:								
Virginia Eastern Shore:								
Accomack	19	2	16	1	0	0	0	0
Northampton	11	0	10	0	0	0	0	1
Potomac and Upper Shore:								
Fairfax	0	0	0	0	0	0	0	0
King George	2	0	2	0	0	0	0	0
Lancaster	16	1	13	0	0	2	2	1

Table 12-44 cont'd

NUMBER OF SEAFOOD PROCESSING PLANTS BY TYPE AND COUNTY, 1970

State, Region, County	Total Number of Firms	Fresh, Frozen, Cooked, and/or Prepared Crab-meat	Oysters	Clams	Specialties[2]	Canning[3]	Curing[4]	Industrial[5]
Northumberland	18	2	11	0	1	1	1	3
Prince William	0	0	0	0	0	0	0	0
Richmond	2	0	2	0	0	0	0	0
Westmoreland	16	2	16	0	0	0	0	0
Central Western Shore:								
Essex	0	0	0	0	0	0	0	0
Gloucester	3	1	2	0	1	0	0	0
James City	1	0	0	0	1	0	0	0
Mathews	2	1	1	0	0	0	0	0
Middlesex	4	0	4	0	0	0	0	0
York	18	14	3	0	1	0	0	2
Lower Southern Shore:								
Isle of Wight	1	0	1	0	0	0	0	1
Nansemond	1	0	1	0	0	0	0	0
Norfolk	5	1	1	1	2	0	0	0
Princess Anne	0	0	0	0	0	0	0	0
Inland Virginia:								
Frederick	1	0	0	0	1	0	0	0
Henrico	1	1	1	0	1	0	0	0
Virginia Total:	121	26	84	2	8	3	3	8
GRAND TOTAL (Chesapeake Bay Area)	217	65	135	24	11	5	4	13

Table 12-44 cont'd.

NUMBER OF SEAFOOD PROCESSING PLANTS BY TYPE AND COUNTY, 1970

---

1 Some firms process more than one product or may deal in but not actually "process" other fish and shellfish products (e.g. in 1965, of the Bay's 257 plants there were 46 which handled and dealt with fresh and/or frozen edible finfish, species generally not indicated but believed to include mainly striped bass, scup, flounder, shad, sea bass, and croakers).

2 Other than those already accounted for under crab-meat, oysters, and clams; (includes mainly fish sticks, fish portions, and fish cakes. Also included are breaded sea scallops, breaded shrimp, steamed conches, and frozen TV dinners.

3 Mainly alewives and alewife roe, but also includes tuna, various soups, and soft clams.

4 Mainly salted and pickled alewives.

5 Mainly menhaden products (in Virginia), but also includes crab-scrap meal, oyster-shell products, and pet foods.

Source:
Compiled from:
United States Department of the Interior, WHOLESALE DEALERS IN FISHERY PRODUCTS, VIRGINIA 1969, Bureau of Commercial Fisheries, SL-12 (revised)
United States Department of the Interior, WHOLESALE DEALERS IN FISHERY PRODUCTS, MARYLAND 1969, Bureau of Commercial Fisheries, SL-10 (revised)
United States Department of Commerce, unpublished working papers of the National Marine Fishery Service.

Table 12-45

Number of seafood processing plants and employment in Maryland and Virginia by region seasonal and annual average, 1966

State and Region	Number of Plants	Employment: Seasonal average[1] Total (number)	Seasonal average[1] Per-plant (number)	Annual average[2] Total (Number)	Annual average[2] Per-plant (Number)	Seasonal annual (ratio)
Maryland:						
1. Lower Eastern Shore	57	2,578	45.2	1,776	31.2	1.45
2. Upper Eastern Shore	28	1,398	49.9	1,059	37.8	1.32
3. Western Shore	18	512	28.4	368	24.4	1.39
Sub-total Maryland	103	4,488	43.6	3,203	31.1	1.40
Virginia:						
4. Eastern Shore	29	852	29.4	488	15.4	1.90
5. Upper Western Shore	55	1,701	30.9	793	14.4	2.15
6. Middle Western Shore	39	1,216	31.2	871	22.3	1.40
7. Lower Western Shore and Inland	11	375	34.1	272	24.7	1.38
Sub-total Virginia	134	4,144	30.9	2,384	17.8	1.74
Total Chesapeake Bay Area	237	8,632	36.4	5,587	23.6	1.55

1 Calculated either as the average of those monthly totals during which processing activities actually occurred, or as the peak month for those plants processing year-round.

2 Calculated as the average of twelve monthly totals.

Table 12-46
Number of seafood processing plants and employment in Maryland and Virginia by region, seasonal and annual average, 1970

State and Region	Number of Plants	Employment: Seasonal average[1] Total	Employment: Seasonal average[1] Per-plant	Employment: Annual average[2] Total	Employment: Annual average[2] Per-plant	Employment: Seasonal annual
		(number)	(number)	(number)	(number)	(ratio)
Mayland:						
1. Lower Eastern Shore	54	2,397	44.4	1,919	35.5	1.25
2. Upper Eastern Shore	28	1,339	47.8	1,064	38.0	1.26
3. Western Shore	14	630	45.0	409	29.2	1.54
Sub-total Maryland	96	4,366	45.5	3,392	35.3	1.29
Virginia:						
4. Eastern Shore	30	958	31.9	598	19.9	1.63
5. Upper Western Shore	54	2,323	43.0	1,236	22.9	1.88
6. Middle Western Shore	28	1,189	42.5	1,033	36.9	1.15
7. Lower Western Shore and Inland	9	725	80.6	590	65.6	1.23
Sub-total Virginia	121	5,195	42.9	3,448	28.5	1.51
Total Chesapeake Bay Area	217	9,561	44.1	6,840	31.5	1.40

1 Calculated either as the average of those monthly totals during which processing activities actually occurred, or as the peak month for those plants processing year-round.

2 Calculated as the average of twelve monthly totals.

Table 12-47

Employment and Number of Employees and Seafood Wholesaling and Processing Industry, By State, 1939-1970[1]

Year	Persons engaged						Establishments		
	Average for season			Average for year					
	Maryland	Virginia	Total	Maryland	Virginia	Total	Maryland	Virginia	Total
	Number								
1939	5,828	5,647	11,475	2,654	2,158	4,812	303	234	537
1940	5,507	5,938	11,445	2,471	2,079	4,550	282	243	525
1941-52[2]	/2	/2	/2	/2	/2	/2	/2	/2	/2
1953	6,159	6,492	12,651	3,292	2,798	6,090	317	358	675
1954	6,308	6,542	12,850	3,758	3,063	6,821	301	347	648
1955	6,545	6,104	12,649	4,039	2,405	6,444	389	353	742
1956	6,387	6,288	12,675	4,120	2,329	6,449	385	348	733
1957	6,399	6,658	13,057	4,302	2,632	6,934	357	377	734
1958	6,513	6,662	13,175	4,337	2,720	7,057	304	393	697
1959	6,849	6,866	13,715	4,632	2,582	7,214	270	382	652
1960	6,687	7,123	13,810	4,271	2,726	6,997	253	378	631
1961	6,532	6,974	13,506	4,419	2,725	7,144	256	341	597
1962	6,491	6,638	13,129	4,243	3,916	8,159	239	341	580
1963	6,096	4,853	10,949	4,254	3,130	7,384	298	357	655
1964	5,042	5,242	10,284	4,385	3,069	7,545	272	350	622
1965	4,965	4,714	9,679	4,112	2,914	7,026	285	336	621
1966	5,165	5,233	10,398	3,809	3,109	6,918	283	304	587
1967	5,208	5,234	10,442	3,865	3,087	6,952	232	298	530
1968	4,919	5,417	10,336	3,878	3,522	7,400	271	310	581
1969	4,937	5,328	10,265	3,695	3,565	7,260	250	306	556
1970	4,812	5,834	10,646	3,790	4,021	7,811	205	260	465

1 The seafood "wholesaling and processing industry includes firms engaged solely in wholesale marketing (i.e., wholesale dealers and distributors) of fresh and processed seafood products but who perform no actual processing functions (packaging, freezing, preparing, canning, curing, reducing, etc.) themselves as well as seafood processors per se; thus, figures appearing in this table represent a somewhat different industry then processing itself and the data do not directly correspond to other tables and information appearing elsewhere in this bulletin which may refer to "seafood processing" in the strict sense of the word.

2 Incomplete data invalidates use during this period.

Source: USDI, Fish and Wildlife Service, Bureau of Commercial Fisheries Statistical Digests.

of boats, equipment, access, and numerous other social and economic factors. Because of the divergence of demand-causing factors, the development of a total MSY based on this assumption is not valid for many of the species considered in this analysis.

The MSY's which are based on this relationship may be either high or low depending on the following factors. If the commercial harvest is a small percentage of the commercial MSY and the recreational catch is very large in comparison, then the species under consideration may be near the limits of its true total MSY even though the total MSY which was utilized in the projection indicates underharvesting of the species. If the commercial harvest is a low percentage of the commercial MSY and the recreational catch is comparatively much smaller, then the projected MSY may be lower than the true value. The projections in this section are most accurate when the commercial catch is a large percentage of the commercial MSY and the recreational catch is similar. Given this information, the projections can be divided into three categories: those with a high projected MSY, those with a low projected MSY and those with a relatively accurate projected MSY. An analysis of the data given for each species (Table 12-48) indicates that yellow perch, white perch, and weakfish may be included in the first of these categories; sea bass and scup may be included in the second category; and shad, flounder, spot, catfish, striped bass and eel may be included in the third category. Affirmation of this theory requires that studies be initiated in order to determine the true population characteristics of the important commercial and recreational species of the Bay.

Table 12-48

VALIDITY OF PROJECTED FISHERIES DATA

	Recreational Catch (million lbs.)	Commercial Catch (million lbs.)	MSYt (million lbs.)	MSYc (million lbs.)	MSYr (million lbs.)	% MSYt
Category I (high projected MSY)						
Yellow Perch	1.40	0.11	3.42	0.25	3.16	44%
White Perch	5.30	1.93	11.25	3.00	8.25	64%
Weakfish	3.55	1.62	6.37	2.00	4.37	81%
Category II (low projected MSY)						
Sea Bass	0.40	1.68	4.92	4.00	0.92	42%
Scup (Porgy)	0.20	2.08	6.58	6.00	0.58	35%
Category III (relatively accurate projected MSY)						
Shad	3.39	3.73	7.64	4.00	3.63	93%
Flounder	1.90	2.68	5.13	3.00	2.13	89%
Spot	11.30	2.89	14.72	3.00	11.719	96%
Catfish	1.10	1.34	4.55	2.50	2.05	54%
Striped Bass	5.40	5.76	11.58	6.00	5.58	96%
Eel	0.20	1.49	1.70	1.50	0.20	99%

It was also assumed that both demand and supply parameters remain fixed with respect to time. This assumption implies that the desire for a species or product derived from a species remains constant and that no extraneous factors will be introduced which may effect an increase or decrease in the abundance of the species. This is not necessarily a valid assumption since tastes and preferences may change over a period of time and technological changes may be developed with the capability to alter species populations. Additionally, natural and man induced processes may affect population levels and reproduction rates. In order to determine the effects of variations in the demand and supply parameters on the projections, several alternative sets of forecasts were generated for oysters. The results obtained from these alternate projections indicate that the variations in the supply parameters did not produce a significant difference in the projections. However, changing demand by varying the income elasticities was found to produce significantly different projections within the context of the model used when changes occurred in the supply parameters. Details of the methodology and results of the sensitivity analysis can be found in the Marasco report. Finally, it should be reiterated that the projections presented in the preceding sections are intended to serve only as güides to identify future problem areas and are only valid within the basic assumptions made for the analysis.

FUTURE WILDLIFE DEMANDS

This section is divided into two major components: future consumptive and non-consumptive wildlife demands. The consumptive demands subsection includes projections of recreational demand for big game, small game and waterfowl as well as the combined demand for these species. The non-consumptive demand subsection presents projections for the numbers of participants and the recreational days expended for bird watching, bird and wildlife photography and nature walking.

For the purposes of this section, the Study Area is the same as that described in the Existing Conditions Report(1). This includes all of Delaware and Salem County, New Jersey.

FUTURE CONSUMPTIVE WILDLIFE DEMANDS

For viable planning in controlling and managing the supply of wildlife, reliable estimates of future demands for the wildlife resource must be determined. This section presents the results of the statistical models which were used for making the projections of consumptive recreational demand for big game, small game, waterfowl and all wildlife in the Chesapeake Bay Basin in terms of recreation days.

The following subsections describe the principal assumptions made in the demand analysis, the methodology used to project the future demands and the projected demands.

ASSUMPTIONS

The development of projections of hunter demand is complicated by many variables such as the availability of habitat due to changing land use and farming practices, societal attitudes toward hunting, and license price. To alleviate these uncertainties and to provide a basis for making the demand projections, certain basic assumptions were made.

Trends in social and moral values regarding hunting were assumed to remain constant through the study period. It was further assumed that the number of participating hunters would grow in proportion to the population as a whole. It should be noted, however, that the offspring of hunters are not necessarily hunters; therefore, the hunter population will not necessarily increase at the same rate as total population.

The primary assumption used in performing the regression analysis was the validity of applying the results in the 1955, 1960, 1965, and 1970 National Surveys of Fishing and Hunting conducted by the U.S. Department of Interior.(8) The data extracted from the surveys are the foundation of the complete demand analysis. Another assumption was that the independent parameters included in the regression equations were relevant and no major factors were excluded. The two independent variables initially used in the study were population and per capita income. However, per capita income had an inverse effect on the projected hunting effort which lead to a closer examination of this parameter. It was concluded that hunting is a cultural and family tradition which is independent of the financial status or (economic condition) of the participant. Since per capita income had no direct bearing on participation, it was not included as an independent parameter in the analysis.

License price was assumed to be an independent variable in the demand analysis. Past studies have shown that hunter demand decreases significantly with increases in license price. It should be noted, however, that some debate remains on this issue and that some models have found hunter demand to be insensitive to license price.

Two sets of hunter demand projections were generated for small game, waterfowl and all hunting, one with all future license prices fixed at the current rate and one with future license prices increasing. For big game effort the only parameter used was population. This was necessary due to the insensitivity of big game hunter effort to license price during the observation years.

The demand projections further assume that adequate hunting lands would be available to supply a recreational experience of the same quality as that found during the base years. It is understood that this does not reflect expected land use changes; however, these projections are designed to identify demands as a separate entity from supply. Further discussion is included in the Wildlife Supply and Wildlife Needs sections.

METHODOLOGY

The analytical approach used to project consumptive recreational demand for wildlife in the Chesapeake Bay Area consists of three phases. The first phase involved the collection and reduction of National Survey of Fishing and Hunting data, population data, per capita income data and license price data. The data sources and methods of reduction and interpolation are discussed in the following paragraphs. In the second phase, a multiple linear iterative regression analysis was performed to establish the relationship between hunter effort for the basic categories of hunters (big game, small game, waterfowl and all wildlife) as the dependent variable and population, license prices, and average per capita income within the study area as the independent variables.

As indicated in the discussion section on assumptions, the final regression equations did not incorporate per capita income. The third phase was the incorporation of the regression equations into a simple model that would generate the hunter effort for each set of conditions: population and license price. The tables in the following subsection were generated by this model.

National Survey Data Reduction Methodology

The figures used to arrive at the effort for each of the three types of species were taken from the five year National Surveys of Fishing and Hunting conducted by the U. S. Department of Interior. It was assumed that the figures in these reports are the best available and accurate. The only discrepancies were in the waterfowl data. Due to the differences in the classification of hunters in each of the surveys, (see note 3, page 104 of the 1970 Survey) the data in 1960, 1965 and 1970 were not compatible. Therefore, instead of using the data as reported in the surveys, interpolation was used to arrive at the adjusted national efforts for 1960 and 1965.

The approach used to arrive at the Chesapeake Bay Basin area effort was to first determine what the national average effort factor was for each species for each study year. Next, since the Study Area lies within the South Atlantic region and borders on the Middle Atlantic region, the hunting and non-hunting populations for both of these regions were used to arrive at the proportion of the population that participated in hunting in the region encompassing the Study Area. From these factors it was possible to obtain the species days per population which, when related to the Study Area population, produced the species effort in the area of study.

The information applied in the calculations of species effort is contained in Tables 12-49 thru 12-55.

The formula used to determine species effort in the Study Area was as follows:

$$\frac{\text{National Species Days}}{\text{National Hunters}} \times \frac{\text{Atlantic Area Hunters}}{\text{Atlantic Area Population}} \times$$

$$\text{Population in Study Area} = \text{Species Effort in Study Area}$$

Table 12-49

NATIONAL HUNTING
EFFORT (in thousands) (8)

	1955	1960	1965	1970
HUNTERS (NUMBER)	11,787	14,637	13,583	14,336
SMALL GAME DAYS	118,630	138,192	128,448	124,041
BIG GAME DAYS	30,834	39,190	43,845	54,536
WATERFOWL DAYS	19,959	15,158*	13,526*	25,113
ALL HUNTING DAYS	169,423	192,539	185,819	203,689

*Due to incompatibility of data, these figures were derived by interpolation

Table 12-50

NATIONAL AVERAGE EFFORT DAYS PER HUNTER (8)

	1955	1960	1965	1970
SMALL GAME	10.06	9.44	9.46	8.65
BIG GAME	2.62	2.68	3.23	3.80
WATERFOWL	1.69	1.71	1.73	1.75
ALL HUNTERS	14.37	13.15	13.68	14.21

Table 12-51

HUNTERS IN COMBINED REGIONS (8)
(in thousands)

	1955	1960	1965	1970
MIDDLE ATLANTIC	1,608	1,723	1,631	1.731
SOUTH ATLANTIC	1,449	2,045	1,900	1,904
TOTAL	3,057	3,768	3,531	3,635

Table 12-52

POPULATION IN COMBINED REGIONS (8)
(in thousands)

	1955	1960	1965	1970
MIDDLE ATLANTIC	32,256	34,270	36,122	37,153
SOUTH ATLANTIC	23,394	26,091	28,743	30,671
TOTAL	55,650	60,361	64,865	67,824

SOURCE: U. S. CENSUS

Table 12-53

NUMBER OF HUNTERS/
1,000 POPULATION, ATLANTIC AREA (8)

	1955	1960	1965	1970
POPULATION	55	62	54	54

Table 12-54

POPULATION IN STUDY AREA (8)
(in thousands)

	1955	1960	1965	1970
POPULATION	5,713	6,404	7,212	7,870

Table 12-55

CHESAPEAKE BAY DAYS HUNTING EFFORT (8)
(in thousands)

	1955	1960	1965	1970
SMALL GAME	3,161	3,784	3.684	3,676
BIG GAME	823	1,074	1,258	1,615
WATERFOWL	531	685	674	744
ALL HUNTING	4,515	5,543	5,616	6,035

Population and Per Capita Income Data Reduction Methodology

The population and per capita income data used in the aforementioned projections were originally derived from data developed by the Bureau of Economic Analysis (BEA) (formerly the Office of Business Economics of the U. S. Department of Commerce and the Economic Research Service of the U. S. Department of Agriculture (OBERS)). The Bureau of Economic Analysis further disaggregated and aggregated this data to reflect the population and per capita income projections for the Chesapeake Bay Area which is defined as "the counties or Standard Metropolitan Statistical Areas (SMSA's) which touch or have a major influence on the estuary."(1) This area encompasses six SMSA's, thirty-six non-SMSA counties and four independent cities.

> Population - Historical population data was gathered from Bureau of Census population publications. In the population projections, the Series E assumption rate (2.11 children per woman) was applied. Series E population data was used instead of Series C because computer programs were available and it was felt that Series E would provide more realistic results.
>
> Per capita income - As defined by BEA, these figures were calculated by dividing total personal income by the total population (Table 12-56).

Table 12-56

POPULATION AND
PER CAPITA INCOME FOR THE
CHESAPEAKE BAY BASIN
IN THE YEAR 2020

Area	Population		Per Capita/ Income		Total Income
15-7	841,000	x	14,800	=	12,446,800,000
17-1	2,710,200	x	13,500	=	36,587,700,000
17-2	296,890	x	13,000	=	3,859,570,000
17-3	38,200	x	13,000	=	496,600,000
17-4	223,100	x	13,000	=	2,900,300,000
18-1	6,894,100	x	15,000	=	103,411,500,000
18-2	291,460	x	12,000	=	3,497,520,000
18-3	137,650	x	12,000	=	1,651,800,000
21-1	1,158,900	x	13,700	=	15,876,930,000
21-2	99,720	x	10,700	=	1,067,004,000
22-1	403,700	x	12,400	=	5,005,880,000
22-2	872,700	x	12,000	=	10,472,400,000
22-3	174,660	x	10,600	=	1,851,396,000
	14,142,280				$199,125,400,000

$$\frac{\$199,125,400,000}{14,142,280} = \$14,080.15$$ Per capita income for study region in the year 2020

SOURCE: BEA (OBERS)

"Personal income consists of private and government wage and salary payments in cash and in kind, other labor income, farm and non-farm proprietors' income, interest, not rents, dividends, and transfer payments, less personal contributions for social insurance. It is measured before the deduction of personal income or other personal taxes."(62)

The historical and projected E series per capita income data were not available for the study area. In order to calculate these statistics two sources of data were used. The per capita income data for each SMSA and non-SMSA portion of the economic areas within the Study Areas was obtained from the 1972 E-OBERS projections. The population data of the Chesapeake Bay Basin was obtained from the U. S. Army Corps of Engineers in Baltimore. These two figures were then multiplied to produce a weighted average per capita income for the study region for each year of study.

License Price Data Reduction Methodology

In order to derive the license price variable for the regression equation, a weighted average price for small game, big game, and waterfowl hunting licenses in the Chesapeake Bay Basin was calculated for each hunter paid for his license.

Weighted average takes into account the license price, the total number of hunters that have purchased the license, and the total amount spent by all hunters for the license.

Data Sources

The Delaware, Maryland, and Virginia statistics were obtained from the Delaware Division of Fish and Wildlife, the Maryland Department of Natural Resource and the Virginia Commission of Game and Inland Fisheries, respectively. Federal waterfowl stamp statistics were obtained from the United States Department of the Interior. Other statistics used were obtained from the 1970 U. S. Fish and Wildlife Survey, the 1970 Delaware Hunter Survey, and the United states Census Bureau.

Assumptions Applied in Calculations

For Virginia, hunter statistics required for the survey area are only a fraction of the statewide totals. Therefore, for the purpose of computing a weighted average, the percentage of state population located in the survey area was computed and the percentage of hunters located in the survey area was assumed to be the same.

The 1970 U. S. Fish and Wildlife Survey documented that nationwide 83 percent and 37 percent of all hunters hunted small game and big game, respectively. Therefore, it was assumed that 83 percent of all hunters hunted small game in the three survey states. This assumption was necessary to obtain weighted average license price for all hunters of big game, small game, etc., rather than the actual cost of individual hunters.

A 1970 Delaware Hunters Survey revealed that 58 percent of the resident hunters and 14.3 percent of the non-resident hunters hunted big game in that state. These percentages were applied for Delaware during the survey years.

The big game hunter figures in Maryland for 1965 and 1970 were available; however, the figures for 1955 and 1960 were not. Therefore, the 1970 national average of 37 percent was used.

The big game hunter figures in Virginia were available for all four survey years. The Virginia Commission of Game and Inland Fisheries indicated that one-half of all people that purchased county licenses fished exclusively. Therefore, county license figures were halved for the purpose of computing a weighted average hunting license price.

To hunt waterfowl, the purchase of a Federal waterfowl stamp is required, and the number of stamps sold in each state and survey year were available, therefore, the exact number of waterfowl hunters in each state and survey year is known and no assumptions were made.

The current hunter statistics were not available for Delaware and Virginia. In order to calculate the current weighted average license price, 1970 hunter statistics were used for these states. In Maryland, a 1974 estimate of hunter statistics supplied by the Maryland Department of Natural Resources was used. The 1970 waterfowl hunter figures were used for all three states.

In order to hunt big game or waterfowl, it is necessary to purchase a state resident, state non-resident, county, or special hunting license in addition to state big game stamps and the Federal Waterfowl Stamp. For each survey year and state, the percentage of each type of these licenses sold, as compared to the total number of licenses sold, was computed. It was assumed that big game and waterfowl hunters held the same percentage of these licenses through the goal years.

As related to the Survey, the special state hunting licenses were only available in Maryland in 1970. They are the Junior State Hunting License, for age sixteen and under, at $2.50, and Senior State Hunting License, for age sixty-five and over, which are provided at no charge. In 1970, the regular Maryland State Hunting License cost $6.50.

The prediction of future license prices is not possible for any formula or past pattern of price increases. Therefore, a percentage price increase, at ten year intervals, was decided upon. The price increases in 1985 and 1995 were 20 percent and the price increase in 2005 and 2015 were 15 percent. These price increases were arbitarily selected to illustrate the effect of as yet unknown and expected price increases on license sales.

Calculations

The calculation process used to derive the weighted average license price for a small game hunting license in the survey area in 1955 (Table 12-57) is as follows:

Delaware 1955

Number of state resident hunting licenses purchased: 22,773
License Price: $2.25

Number of state non-resident hunting licenses purchased: 465
License Price: $15.50

From the 1970 U. S. Fish and Wildlife Survey 83 percent of all hunters hunted small game.

22,773 x .83 = 18,902. This is the number of state resident license holders that hunted small game.

465 x .83 = 386. This is the number of state non-resident license holders that hunted small game.

Number of Small Game Hunters	License Prices	Total Money Spent
18,902	$ 2.25	$ 42,530
386	15.50	5,983

Maryland 1955

Number of state resident hunting licenses purchased: 57,668
License Price: $5.25

Number of state non-resident hunting licenses purchased: 4,475
License Price: $20.00

Number of county hunting licenses purchased: 77,560
License Price: $1.25

57,668 x .83 = 47,864. This is the number of state resident license holders that hunted small game.

4,475 x .83 = 3,714. This is the number of state non-resident license holders that hunted small game.

77,560 x .83 = 64,375. This is the number of county license holders that hunted small game.

Number of Small Game Hunters	License Price	Total Money Spent
47,864	$ 5.25	$251,286
3,714	20.00	74,280
64,375	1.25	80,469

Virginia 1955

Population of survey area = 2,370,000
State population = 3,567,000

Percentage of state population located in survey area =

$$\frac{2,370,000}{3,567,000} = .66$$

Number of state resident hunting licenses purchased: 147,978
License Price: $3.50

147,978 x .66 = 97,665 = Number purchased in survey area.

Number of state non-resident hunting licenses purchased: 6,501
License Price: $15.75

6,501 x .66 = 4,291 = Number purchased in survey area.

Number of county hunting licenses purchased: 222,116 x .5 = 111,058. As previously mentioned, this figure is halved to remove the license holders who exclusively fished.
License Price: $1.00

111,058 x .66 = 73,298 = Number purchased for hunting purposes in survey area.

97,665 x .83 = 81,062. This is the number of state resident license holders in the survey area that hunted small game.

4,291 x .83 = 3,562. This is the number of state non-resident license holders in the survey area that hunted small game.

73,298 x .83 = 60,837. This is the number of county license holders in the survey area that hunted small game.

Number of Small Game Hunters	License Prices	Total Money Spent
81,062	$ 3.50	$283,717
3,562	15.75	56,102
60,837	1.00	60,837

Table 12-57

1955 Small Game License Price Determination

	Number of Small Game Hunters	Total Money Spent
Delaware	18,902	$ 42,530
	386	5,983
Maryland	47,864	251,286
	3,714	74,280
	64,375	80,469
Virginia	81,062	283,717
	3,562	56,102
	60,837	60,837
Totals	280,702	$855,204

Weighted average = $\frac{\$855,204}{280,702} = \$3.04$

Table 12-58 shows weighted average hunting license prices by year and type.

Projected Demands

There are no statistical formulae which foretell the future precisely; the best that one can hope to attain is a reasonable estimate to serve as a basis for planning. The statistical procedures for obtaining this reasonable estimate vary greatly depending on available information and the quality or accuracy of that information. After applying the best procedure and obtaining a projection, the statistical results must then be evaluated. Analysis rests with the judgement of the analyst and manager, based on his intimate knowledge of applicable conditions.

Effective use of any model requires two kinds of knowledge: first, knowledge about the segment of reality to which the model must correspond; and second, knowledge about the model's structure (that is,

Table 12-58

Weighted Average Hunting License Prices

Year	Small Game	Big Game	Water Fowl	All Hunters
1955	$ 3.04	$ 3.67	$ 4.86	$ 3.40
1960	3.33	4.06	6.30	3.75
1965	4.19	5.50	7.19	4.90
1970	4.85	7.68	8.53	6.20
1975	6.16	11.44	11.61	8.64
1980	6.16	11.44	11.61	8.64
1985	7.39	13.73	13.93	10.64
1990	7.39	13.73	13.93	10.64
1995	8.87	16.48	16.72	12.77
2000	8.87	16.48	16.72	12.77
2005	10.20	18.95	19.23	14.68
2010	10.20	18.95	19.23	14.68
2015	11.73	21.79	22.11	16.88
2020	11.73	21.79	22.11	16.88

its abstractions; the relationships it represents; and its assumptions, both explicit and implicit). This knowledge is usually gained by going back to the premises of the model to evaluate how closely they fit reality and to perform a comparison of the model's output with historical data. This allows a value judgement on the accuracy of the model's projections.

Because of the limitation of only four observations it is almost impossible to get a reliable regression equation even though one can obtain a close fit (relatively small standard error) with almost any form of equation. In the analysis, linear, second degree, and logarithmic equations, as well as combinations of these were tried with varying degrees of success. In the end it was necessary to impose an additional constraint, except for big game, on the problem based on knowledge external to the four observations to obtain the final linear regression equations. This constraint used was to introduce a constant equal to -10^5 in each equation in the regression analyses. This insured that the equations would behave in a manner consistent with known relationships. For big game this was not necessary because only one independent parameter was used.

The hunter demand projections revealed that increasing license prices inversely effect hunting effort with the exception of big game effort. This is to say that the historical data used for the projections depicted big game hunting as increasing at a greater rate than the population, even during periods of appreciating license prices. Since it appears that big game hunter effort is relatively insensitive to license price, the big game projection is based solely on population growth. This will reflect a more realistic demand projection. This effect of license price of big game effort is difficult to interpret. It may signify that big game hunting is a prestige or trophy activity independent of price consideration. It may be, however, that in reality, effort would decrease with price increases and the statistics of the four known years do not bear out the true big game effort and license price relationship.

The projections are presented on a consolidated graph (Figure 12-32) with the individual tables (Tables 12-59 thru 12-65) of data following. The appropriate regression equation is included with each table.

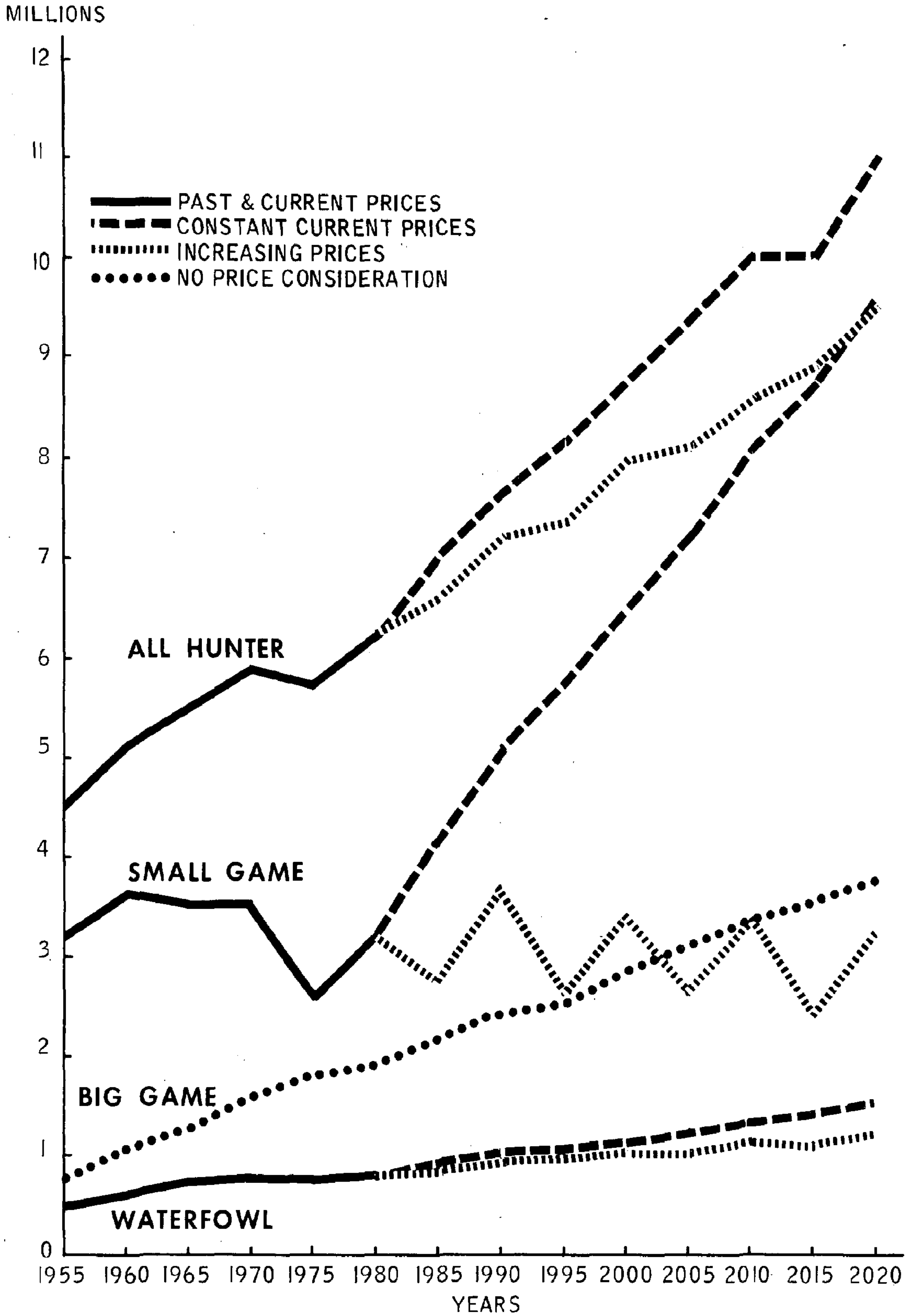


Figure 12-32 HUNTER DEMAND IN CHESAPEAKE BAY BASIN

Table 12-59

SMALL GAME EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

(Future License Price Held Constant At Current Rate)

$$\text{EFFORT} = -1.0 \times 10^5 - 1.1536 \times 10^6 \times \text{License Price} + 1.1918 \times \text{Population}$$

Year	License Price	Population	Effort
1955	3.04	5713440	3202334
1960	3.33	6464348	3762722
1965	4.19	7212290	3662023
1970	4.85	7870131	3684662
1975	6.16	8362999	2760846
1980	6.16	8858920	3351885
1985	6.16	9653048	4298327
1990	6.16	10343520	5121231
1995	6.16	10957341	5852783
2000	6.16	11579420	6594177
2005	6.16	12208021	7343343
2010	6.16	12845003	8102499
2015	6.16	13489748	8870906
2020	6.16	14142280	9648593

Table 12-60

SMALL GAME EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

(Future License Prices Increasing)

$$EFFORT = -1.0 \times 10^5 - 1.1536 \times 10^6 \times \text{License Price} + 1.1918 \times \text{Population}$$

Year	License Price	Population	Effort
1955	3.04	5713440	3202334
1960	3.33	6464348	3762722
1965	4.19	7212290	3662023
1970	4.85	7870131	3684662
1975	6.16	8362999	2760846
1980	6.16	8858920	3351885
1985	7.39	9653048	2879399
1990	7.39	10343520	3702303
1995	8.87	10957341	2726527
2000	8.87	11579420	3467921
2005	10.20	12208021	2682799
2010	10.20	12845003	3441955
2015	11.73	13489748	2445354
2020	11.73	14142280	3223041

Table 12-61

BIG GAME EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

$$\text{EFFORT} = -\ 1.2130 \times 10^{6} + 3.5298 \times 10^{-1} \times \text{Population}$$

Year	Population	Effort
1955	5713440	803730
1960	6464348	1068786
1965	7212290	1332794
1970	7870131	1564999
1975	8362999	1738971
1980	8858920	1914022
1985	9653048	2194333
1990	10343520	2438056
1995	10957341	2654722
2000	11579420	2874304
2005	12208021	3096187
2010	12845003	3321029
2015	13489748	3548611
2020	14142280	3778942

Table 12-62

WATERFOWL EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

(Future License Price Held Constant At Current Rate)

$$EFFORT = 1.0 \times 10^5 - 2.3022 \times 10^4 \times \text{License Price} + 1.3388 \times 10^{-1} \times \text{Population}$$

Year	License Price	Population	Effort
1955	4.86	5713440	553024
1960	6.30	6464348	620402
1965	7.19	7212290	700046
1970	8.53	7870131	757267
1975	11.61	8362999	752341
1980	11.61	8858920	818735
1985	11.61	9653048	925053
1990	11.61	10343520	1017493
1995	11.61	10957341	1099672
2000	11.61	11579420	1182956
2005	11.61	12208021	1267113
2010	11.61	12845003	1352392
2015	11.61	13489748	1438710
2020	11.61	14142280	1526071

Table 12-63

WATERFOWL EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

(Future License Prices Increasing)

$$\text{EFFORT} = -1.0 \times 10^5 - 2.3022 \times 10^4 \times \text{License Price} + 1.3388 \times 10^{-1} \times \text{Population}$$

Year	License Price	Population	Effort
1955	4.86	5713440	553024
1960	6.30	6464348	620402
1965	7.19	7212290	700046
1970	8.53	7870131	757267
1975	11.61	8362999	752341
1980	11.61	8858920	818735
1985	13.93	9653048	871640
1990	13.93	10343520	964080
1995	16.72	10957341	982024
2000	16.72	11579420	1065308
2005	19.23	12208021	1091678
2010	19.23	12845003	1176957
2015	22.11	13489748	1196969
2020	22.11	14142280	1284330

Table 12-64

ALL HUNTER EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

(Future License Price Held Constant At Current Rate)

EFFORT = $- 1.0 \times 10^5 - 2.0773 \times 10^5 \times$ License Price $+ 9.2943 \times 10^{-1} \times$ Population

Year	License Price	Population	Effort
1955	3.40	5713440	4503961
1960	3.75	6464348	5129171
1965	4.90	7212290	5585442
1970	6.20	7870131	5926810
1975	8.64	8362999	5878035
1980	8.64	8858920	6338959
1985	8.64	9653048	7077045
1990	8.64	10343520	7718791
1995	8.64	10957341	8289294
2000	8.64	11579420	8867473
2005	8.64	12208021	9451714
2010	8.64	12845003	10043744
2015	8.64	13489748	10642989
2020	8.64	14142280	11249472

Table 12-65

ALL HUNTER EFFORT PROJECTIONS
FOR THE CHESAPEAKE BAY BASIN STUDY REGION

(Future License Prices Increasing)

EFFORT = $1.0 \times 10^5 - 2.0773 \times 10^5 \times$ License Price $+ 9.2943 \times 10^{-1} \times$ Population

Year	License Price	Population	Effort
1955	3.40	5713440	4503961
1960	3.75	6464348	5129171
1965	4.90	7212290	5585442
1970	6.20	7870131	5926810
1975	8.64	8362999	5878035
1980	8.64	8858920	6338959
1985	10.64	9653048	6661585
1990	10.64	10343520	7303331
1995	12.77	10957341	7431369
2000	12.77	11579420	8009548
2005	14.68	12208021	8197025
2010	14.68	12845003	8789055
2015	16.88	13489748	8931294
2020	16.88	14142280	9537777

FUTURE NON-CONSUMPTIVE WILDLIFE DEMANDS

This section presents projections of the number of participants involved in bird watching, bird and wildlife photography, and "nature walking." Demand for this type of nonconsumptive recreation is projected in may days.

ASSUMPTIONS

Assumptions made to develop non-consumptive wildlife utilization projections were as follows:

1. The population growth rate projected for the Bay Study area in the Series E (OBERS) data is valid.

2. Participation factors developed in the National Hunting and Fishing Survey for the entire United States are valid for the Chesapeake Bay Area.

3. The percent increase in non-consumptive wildlife users indicated by comparing the 1965 and the 1970 survey data represents a long term stable trend applicable to the Bay Area population

4. Factors which influence the rate of increase of non-consumptive users will not change over the projection time frame.

5. It is assumed that the percent of population nine years of age or older as developed in national data in the 1970 Hunting and Fishing Survey is the same percentage in the Bay area population. This percentage, 82.64 percent, is assumed to be constant throughout the projection period.

6. That the percent of "nature walkers" in the 1970 population will remain constant through 2020.

The validity of these assumptions will be discussed in the sensitivity analysis section presented at the end of this chapter.

METHODOLOGY

Population data for the Bay Study Area was obtained by Control Data Corporation from the U. S. Army Corps of Engineers, Baltimore District, Series E (OBERS) data was utilized.

In order to apply use factors as developed in the National Hunting and Fishing Surveys it was necessary to determine the Study Area population that was nine years old or older. This was accomplished by applying a fixed percentage derived from the Hunting and Fishing Survey for the base year of 1970. This percentage was 82.64 percent. The following formula was used to estimate the number of non-consumptive wildlife users in the study areas for the base year 1970 and to project users on a five year basis through the year 2020.

N.C.U. = (P) (8.26354 x 10-1) ((7.336 x 10-2) + (1.919 x 10-3) (N))

N.C.U. = Bay area non-consumptive users 9 years of age or older

P = Projected Bay area population

8.26354 x 10-1 = Percent of U.S. population 9 years of age or older

7.336 x 10-2 = Percent of U.S. population that are non-consumptive wildlife users

1.919 x 10-3 = Percent increase in non-consumptive wildlife users nationwide per five year increment

N = Number of five year periods considered.

User days per year was then calculated by multiplying the number of users by the average number of days of participation per user as found in the National Hunting and Fishing Survey of 1970.

PROJECTED DEMANDS

As stated in the consumptive wildlife utilization section, no statistical formulae can foretell the future. This statement was made in regard to projections of a resource that is readily identifiable and about which a relative abundance of data exists. Certainly in the case of a resource activity as nebulous as non-consumptive wildlife utilization, where data is almost non existent, this statement is even more applicable. We are, as a society, only in recent years leaving a decades long period during which we regarded bird watching and its attendant activities of photography and nature walking as being reserved for knobby kneed men and women clad in shorts, bush jacket and pith helmet. Today we live in a time where each evening the average family has available for television viewing documentaries or fictional stories developed around our environment and its component organisms. This type of exposure must affect the attitudes and activities of the populace. Because of this phenomenon the fragmentary information developed in past years certainly can not accurately reflect present and future trends in non-consumptive wildlife utilization. It is believed, however, that the upsweeping curves presented in Figure 12-33 do portray future trends within an order of magnitude framework. The importance of the information presented in Table 12-64 and Figure 12-33 lies in the emphasis it places on our societal demands for a healthy environment.

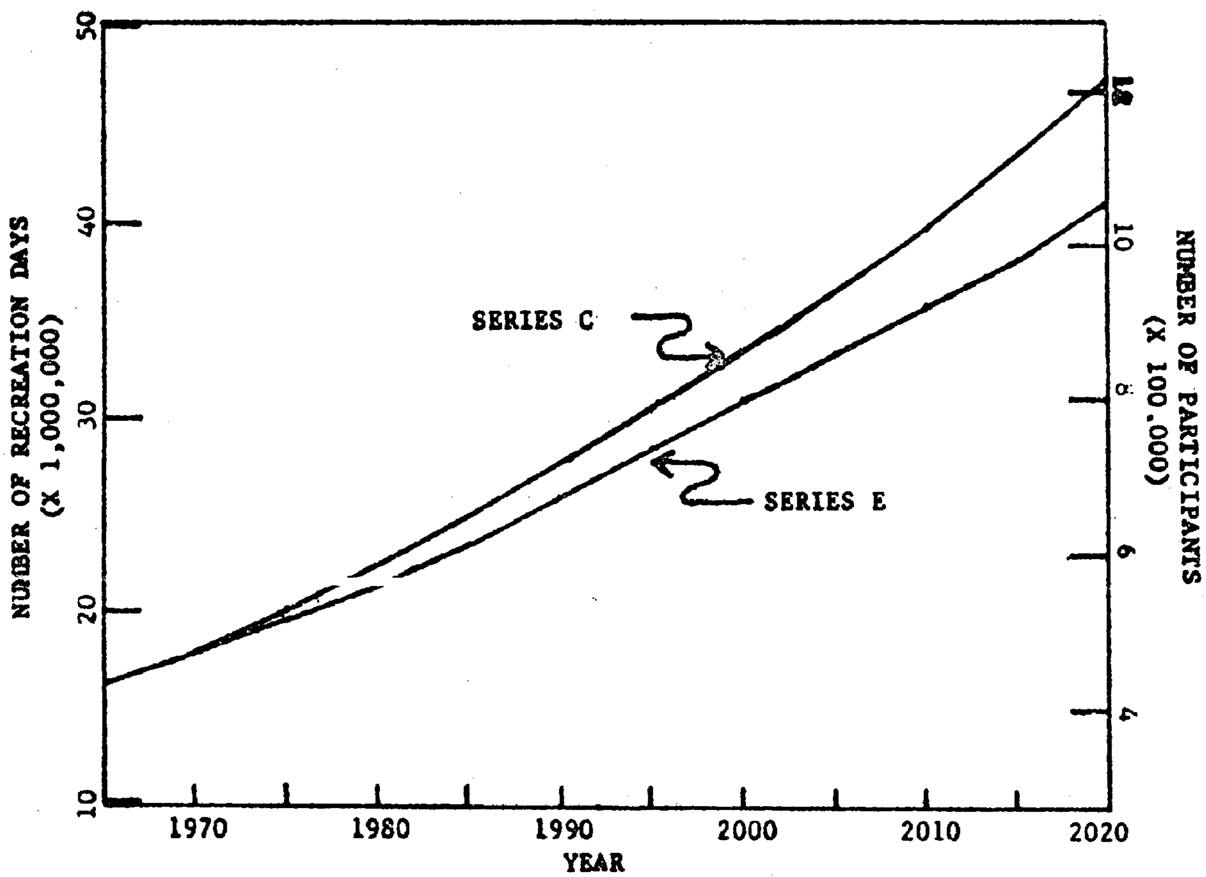


Figure 12-33 FUTURE NON-CONSUMPTIVE WILDLIFE UTILIZATION

This data should be interpreted by the resource manager as a guideline by which to evaluate the effectiveness of future planning activities, not as a goal.

Table 12-66 presents projected population, number of participants and total recreation days on a five year frequency through the year 2020. Since population is the only variable in the equation, the projection directly parallels population projection fluctuations.

These projections represent only a part of the total demand for the non-consumptive uses of fish and willdife resources. Data collected in the 1970 National Survey of Fishing and Hunting identified nature walking as a non-consumptive use. Since only one data point is available for this user type, it is not possible to identify an increasing or decreasing trend on which projections can be made. However, applying the national percentage of nature walkers to the Bay Study Area population projections, it is possible to estimate within an order of magnitude the number of nature walkers within the Study Area. This data is presented in Table 12-67

Table 12-66

Non-Consumptive Wildlife Utilization In The Chesapeake Bay Area

Year	Bay Area Population over 9 years of age, from Series E Projections (millions)	Number of Participants (millions)	Number of Recreation Days (millions)
1965	5.960	0.437	16.614
1970	6.504	0.477	18.130
1975	6.911	0.520	19.775
1980	7.321	0.564	21.448
1985	7.977	0.630	23.946
1990	8.547	0.692	26.309
1995	9.055	0.751	28.524
2000	9.569	0.812	30.871
2005	10.088	0.876	33.275
2010	10.615	0.942	35.777
2015	11.147	1.010	38.378
2020	11.687	1.081	41.078

Table 12-67

NATURE WALKERS, BAY AREA, 1970 - 2020

Year	Bay Area Population 9 and Over (millions)	Nature Walkers* (millions)	Rec Days** (millions)
1970	6.504	1.184	14.523
1980	7.321	1.332	16.348
1990	8.547	1.556	19.088
2000	9.569	1.742	21.368
2010	10.615	1.932	23.704
2020	11.687	2.127	26.098

*Based on fixed percentage of 18.2%

**Based on 12.27 days per user per year

FUTURE WILDLIFE SUPPLY

In the previous section, demands for the various sections of Bay resource users were projected utilizing available historical resource use data. The validity of these projections depends on the accuracy of the data and the validity of the assumptions made and statistical procedures applied. As discussed in the sensitivity analysis, these projections are at least valid when they are considered in terms of future trends. Of course an understanding and analysis of demand trends is of little practical value unless similar data is available for resource supplies. In order to make such projections for the various catagories of resource supplies, an adequate data base is required. At this time such data is unavailable and resource supplies can only be discussed in a qualitative fashion. In the following section, apparent trends in future resource availability will be outlined and related to projected resource utilization for specific resource sectors.

CONSUMPTIVE WILDLIFE SUPPLY

In order to accurately assess the availability of game species for hunting purposes it is not necessary nor possible to project numbers of individuals within a given species. It is necessary, however, to construct an accurate land use map for some base year and to be able to accurately project land use changes for the study time period. If this information is available, then it is possible to project the maximum amount of available habitat for the various species groups. However, this information would not accurately represent the real situation since most huntable lands in the Study Area are in private ownership and land owners are presently reluctant to allow public hunter access. There is no indication that this situation will improve in the future.

Big Game

Big game species in the Study Area include deer, wild turkey and black bear. Of these three species, deer is the only one found throughout the Study Area. Turkey are considered legal game only in two Maryland counties in the Study Area. Turkey is legal game in all Virginia study area counties. Bear is a game species only in the Isle of Wight, Nansemond, Chesapeake, and Virginia Beach areas of Virginia.

Hunting for these big game species is limited to a great extent by the land owners who may prohibit all hunting or lease their lands to a group. With the limiting of access to privately owned lands, many hunters are forced to hunt the publicly owned lands which during big game seasons may become overcrowded to the extent that the hunt is no longer a quality recreational experience.

In addition to the availability of land for hunting, another limiting factor is the quantity or accessibility of the game species sought. Some of the factors which determine the species abundance are available food and cover, severity of weather, effects of diseases and predation and hunting pressure. Because of the agricultural practices in a large portion of the Study Area, food and cover for deer are abundant and populations are at a relatively high level. Also, the tempering effects of the large water masses of the Bay tend to reduce the severity of the winters and thus the winter mortality of the animal species living in the Bay region. Disease and predation have not been a major factor in controlling populations of big game species in the Bay Area. The major cropping of deer takes place during the firearms hunting seasons with additional animals being harvested by bow or muzzle loaders during special seasons. In Maryland the bow season extends from September 15 to January 1 with a one week firearms season in late November and early December. Virginia deer seasons vary from county to county. A special bow season exists in all open counties from mid-October to mid-November. The firearms season in Virginia depends upon the county in which hunting is to occur and ranges from a one week season in Northampton County to a two month season in Chesapeake and Virginia Beach counties.

Deer are also taken by farmers who are sustaining some degree of crop damage. These animals are not always harvested for consumption and are often left to decompose in the fields. Accurate data on the numbers of deer eliminated in this fashion was not gathered for this study. Unlawful taking of deer is also a factor affecting the supply of this animal, however, data regarding the numbers harvested illegally is not readily available nor is it apt to become available.

Small Game

Small game in the Study Area includes squirrel, rabbit, quail, woodchuck, skunk, fox, raccoon, opossum, mourning dove, rail, gallinule, coot, woodcock, and jacksnipe. Because of the great diversity of food and habitat types required by these species, the availability of each species is relative to different factors. The first three of the species listed provide a major portion of the small game hunting in the Study Area and therefore the factors which induce changes in their availability will likely have the greatest effect upon small game hunting in the Bay region. The following discussion includes some of the factors which may affect the populations of these species.

The eastern gray squirrel is found in nearly all of the hardwood forest within the Study Area and rarely is found at any distance from trees. The food of this species consists of a variety of nuts, seeds, fungi, fruits and often the cambium layer beneath the bark of trees. Nesting takes place in holes in trees or in leaf nests which are built in the branches. The supply of this species is relative to the amount of hardwood forest, the available food supplies, predation and disease. Since predation and disease generally become significant only when population levels are high, they are not considered significant factors in maintaining a stable supply.

The eastern cottontail rabbit makes its home throughout the Study Area in brush or wooded areas with nearby open areas, in the edges of swamps, in weed patches and in fence rows. Their food consists of greens in summer and bark and twigs in winter. These animals are often found in gardens and orchards where they may cause considerable damage. While predation and disease may play a significant role in the reduction of extremely dense populations of rabbits, these factors are generally not a major controlling factor of populations in the Study Area. If food and cover requirements are met, adequate population levels will be maintained. In the Study Area, however, agricultural practices have resulted in the reduction of fence rows and other habitat. Rabbit populations as well as several other species which depend on these cover types have been reduced in a corresponding manner.

Within the Study Area, the bob white quail is probably the most important small game bird. These birds are found throughout the Study Area, primarily on farm lands where they feed on cultivated grains and other seeds. The major habitat requirement which must be met in order to maintain high population levels is an adequate interspersion of cover types. As is the case with rabbits, clean farming practices have significantly affected the amount and quality of habitat.

The preceding brief discussions of small game food and habitat requirements indicate that land use alternations are probably the most significant factor affecting the supplies of small game in the Study Area. The major alterations which bring about loss of habitat and decreased hunter use are the establishment of residential, industrial and commercial developments in areas which were previously farmed or wooded and the implementation of clean farming practices which reduce the cover necessary for maintaining high small game populations.

Waterfowl

Directly associated with the Bay and its resources are waterfowl populations which account for a significant portion of the recreational hunting in the Bay Area. The waterfowl species which are presently hunted include geese, baldpate, scaup, teal, mallard, black duck, wood duck, sea ducks (scoters, eiders and old squaw) and others. Because these are migratory species, their populations are determined by several factors outside of the Bay Area such as the availability of breeding habitat and food supplies in other regions. Large populations of these birds, especially Canada geese, arrive in the Bay Area each fall and remain through the winter instead of continuing to migrate farther south. Some of this concentrating characteristic is attributed to a change in food habits which has developed in the birds and the abundance of grains such as corn which remain in the fields after the harvest. While the geese seem to be thriving in the Bay Area many of the duck species have declined during recent years apparently due to loss of nesting habitat, pollution, and decreased food supplies in the Bay. One type of food of primary importance to these waterfowl is the rooted aquatic plants which grow in many of the shallow water areas of the Bay. Increased nutrient levels in the water column, in recent years, have favored the production of phytoplankton which by reducing light penetration has also reduced the growth of some rooted aquatic plants.

NON-CONSUMPTIVE WILDLIFE SUPPLY

The previous section of non-consumptive wildlife demands projected the number of recreation days which will be required to fulfill the demands of bird watchers, bird and wildlife photographers and nature walkers through the year 2020. In order to provide for these recreational days in a quality manner, certain criteria will have to be met. The primary criteria involve adequate supplies of the wildlife sought and an environmental setting which provides a quality experience for the non-consumptive resource user. The factor most affecting the future availability of these resources is the alteration of land use within the Study Area.

At the present time the amount of land and wildlife habitat which is available to the non-consumptive resource user in the Study Area, includes about 814,000 acres of public, semi-public and park lands as well as privately owned agricultural lands, woodlands, and wetlands which may or may not be accessable to the public. The total acreage of these lands amounts to an additional 11.5 million acres which provide a base for non-consumptive recreation for an unknown percentage of the users. If a constant percentage of the resources users are assumed to use these non-public areas, then future projections can be made regarding the acreage of land required to provide non-consumptive resources users with an experience of equal quality to the present recreational experience. Table 12-68 gives the projected acreages of public lands which will be required through the year 2020 to provide the present quality of recreational experience to the non-consumptive resource users.

Table 12-68

Land Required To Meet Future
Non-Consumptive Resource Demand

Year	Number of Rec Days	Acres of Public Land
1970	18,129,716	814,150
1980	21,447,903	963,518
2000	30,870,516	1,386,816
2020	41,078,152	1,845,380

These projections are based on the projected number of recreation days as presented in the non-consumptive wildlife demands section.

FUTURE WILDLIFE NEEDS AND PROBLEM AREAS

Since many of the factors which will ultimately determine the needs for wildlife in the Study Area are beyond the scope of the appendix, the discussion of wildlife needs given in this section is based on the projected trends for demand and supply and the factors which may affect either demand or supply. In general, the projections for demand indicate increases of varying magnitude with non-consumptive uses experiencing the greatest increase. Wildlife supplies will at best remain constant and will most likely decrease significantly. Supply, in this context, is not necessarily related only to the population of a species. Supply may also be determined by the numbers which are available for utilization. The accessability of the resource is probably the most important factor in satisfying the recreational demand for these resources.

CONSUMPTIVE WILDLIFE NEEDS AND PROBLEMS

The primary concern of hunters and wildlife management agencies in the Bay area is finding or supplying a place to hunt in which a quality recreation experience can be attained by the hunter along with a reasonable chance for success. At the present time, this need is being filled by several State, Federal and local public hunt areas and by private lands which may be available to hunters either through a private lease agreement or by land owner's consent on an individual basis. It is not known what percentage of hunter demand is being satisfied by public hunt areas and what percentage is satisfied on private lands. It is not possible, within the scope of this study, to ascertain the amount of private and public lands which are accessable to hunters through some mechanism (public ownership, private lease, by consent). However, if 1970 is taken as a base year and it is assumed that the demand expressed during that year was satisfied in an adequate fashion, it is possible to estimate the percent increase of accessable land that will be necessary to satisfy demand through 2020. Table 12-69 presents hunter effort and percent increase in hunter effort for ten year increments through 2020. In order to supply a recreational experience for future hunters of similar quality

Table 12-69

Projected Increases In Hunter Effort

	1980	1990	2000	2010	2020
Hunter effort* (man days)	6,338,959	7,303,331	8,009,548	8,789,055	9,537,777
% increase in hunter effort over 1970	6.9	23.2	35.1	48.2	60.9

*Hunter effort figures are those for all hunters projected with license price increasing.

as was experienced in 1970, it will be necessary to increase hunter access in direct proportion to the projected increase in hunter effort. Meeting this demand presents an interesting and difficult challange to resource managers.

If this challange is to be met, many obstacles must be overcome. A brief discussion of some of these problem areas is presented in the following sub-section.

Problems facing resource managers in their attempt to meet hunter demands can be categorized into two general types. These are land access and maintenance of an adequate supply of game.

Factors affecting hunter access are numerous and diverse. Much land has been lost to the hunter for all time due to rapid conversion of farm and wood lands to urban and suburban land uses. Conversion of wildlife habitats to other uses will continue to be a significant problem to the resource manager. During this century, in excess of 1 million acres were eliminated as potential hunting lands in Maryland alone. Access to lands also appears to be significantly affected by proximity to population centers. The nearer land is located to an urban area the less accessable the land. This is due to the reluctance of land owners to open their lands to multitudes of recreationists from the city. There is of course ample justification for this attitude. Many hunters have proven themselves inexperienced, careless and heedless of the privilege bestowed on them by the land owner. This lack of concern has often resulted in needless damages to the land owner's property. A very significant factor affecting hunter access in the Bay Area is the leasing of hunting rights on agricultural lands to private individuals and groups. This practice of course satisfies some hunter demand; however, due to the popularity of goose hunting in the Bay Area, these leases are often single purpose. The end result is limitation of fine big and small game habitat to a single purpose hunt. As hunter demand increases and access to private land decreases, the limited public hunt areas are forced to carry more of the burden and the quality of the hunt on these lands degenerates. This can only result in an increase in unsatisfied demand.

In conjunction with the reduction of private hunt lands, the wildlife manager must also be concerned with maintenance of adequate game populations on the lands that are available. On public lands obtained specifically for wildlife management purposes, habitat management practices are readily applied and given the funding necessary for implementation. These areas present no real problem to the resource managers. Public lands such as state and national forests which are increasingly being managed to supply materials to the nation's wood and paper industries present a difficult management problem. Current monotypic or single species tree farming practices virtually eliminate wildlife utilization on vast acreages of public lands. Monoculture practices combined with the rapid rotation of forest crops are in diametric opposition to good wildlife management practices. Resolution of this management problem can only come with a restructuring of national priorities.

Perhaps the most significant and probably the most difficult management problem facing wildlife managers today is the impact of modern farming concepts on wildlife habitat. Generally, the present trend in agriculture is toward large farms containing large fields. Efficient operation of modern farm machinery has resulted in the elimination of vast numbers of fence rows and much of the edge habitat along wood lot borders. Widespread usage of herbicides for weed control has eliminated much of the in-field habitat that previously supported many small game mammals and birds.

Rising land values, taxes, crop prices and operational costs make this type of highly efficient farming mandatory if the farm is to remain a viable economic venture. It is easily seen that the practices which make it feasible to maintain land for agricultural uses, also result in the distruction of important game habitat. Any solutions to the problem of game management on private lands must take this factor into account.

NON-CONSUMPTIVE WILDLIFE NEEDS AND PROBLEMS

The future non-consumptive wildlife demands section indicates that the number of participants will increase dramatically over the study period. The supply section indicates that if there is no increase of available land the result will be a continual degradation of the recreational experience. The major need of the non-consumptive wildlife participant, is not only an abundant supply of wildlife but also increased access to wildlife habitat. If non-consumptive wildlife utilization increases as projected, by the year 2020 an additional one million acres of public land or private land accessable to the public will be required to fulfill the recreational need at the 1970 level of quality.

Table 12-70 gives the projected acreages and percent increase in public lands which will be required to supply the future needs of non-consumptive wildlife users in the Bay area.

Table 12-70

Future Public Land Requirements

Year	Public Lands Needed	Percent increase over 1970 acreages
1970	814,150	0
1980	963,518	18.3
2000	1,386,816	70.3
2020	1,845,380	126.6

Acquisition of such large quantities of land for recreational purposes in a populated region such as the Chesapeake Bay Area presents many problems. The most apparent is the conflicting demand for land development. Increases in population and demands for consumer products concurrent with increases in leisure time and income, heighten this conflict. Resolution of this conflict lies with the development of land use priorities. Such priorities must incorporate resource management criteria if the societal needs for non-consumptive wildlife recreation are to be met.

Aside from the necessity of establishing additional areas for recreational utilization, the problem of maintaining the quality of the recreational experience in existing areas is apparent. For the bird watcher, wildlife photographer and nature walker, a quality experience relies upon a variety and abundance of wildlife in a natural uncrowded settling. Because of increasing population and development pressures, these qualities are being degraded in many areas. This degradation may occur as a result of activities outside the Bay Area. The loss of feeding and breeding habitat in remote regions may affect wildlife populations within the Study Area. Development of lands adjacent to recreational areas may cause overutilization, noise and the disappearance of seclusive species, all of which reduces the desirability of the area. A combination of these factors and others will result in a degraded recreational experience.

WILDLIFE SENSITIVITY ANALYSIS

The sensitivities of the wildlife projections in the preceding paragraph are presented in this section. Each of these subsections contains a discussion of the variability of the predictions based on the validity of the applied assumptions and calculations. Since no quantitative projections were made of wildlife supply, no sensitivity analysis was conducted.

CONSUMPTIVE WILDLIFE SENSITIVITY ANALYSIS

The purpose of this section is to present an analysis of the sensitivity of the projections to changes in the basic assumptions.

In order to determine the confidence limits of the projections made for consumptive wildlife utilization, the following operations were performed.

The standard deviation of multiple regression (σ) was used as a test to measure the significance of the regression analysis. It measures the closeness of the actual values to the regression equation. Table 12-71 lists the standard deviations for each type of hunting.

Table 12-71

Standard Deviation For Hunting Effort (σ)

SMALL GAME	3.6869×10^4
BIG GAME	6.5153×10^4
WATERFOWL	5.2498×10^4
ALL HUNTERS	2.2228×10^5

About 68 percent of the actual values fall within $\pm\sigma$, 95 percent within $\pm 2\sigma$, and 99.9 percent within $\pm 3\sigma$. These are the confidence limits of the projections.
The projections should be interpreted in this manner; if the assumptions and input data are correct then the efforts in future years have probabilities of 68 percent, 95 percent, and 99.9 percent of falling within $\pm\sigma$, $\pm 2\sigma$, and $\pm 3\sigma$, respectively, from the lines on the hunter demand graph. The empirical data were assumed to remain the same over the period of the predictions. Only if this is valid will these confidence limits be realistic.

If the Series C population data had been used instead of Series E, the hunter effort projections would have been higher. To indicate the magnitude of difference, percentage of effort increase over Series E projections was calculated for big game (Table 12-72) using the Series C population data. Graphic representation of these variations are shown in Figure 12-34.

Table 12-72

Increases In Projection Using Series C Population Data

Years	Percentages
1980	7.6
1990	7.3
2000	11.2
2010	15.8
2020	20.3

This effect is typical of all areas of hunting.

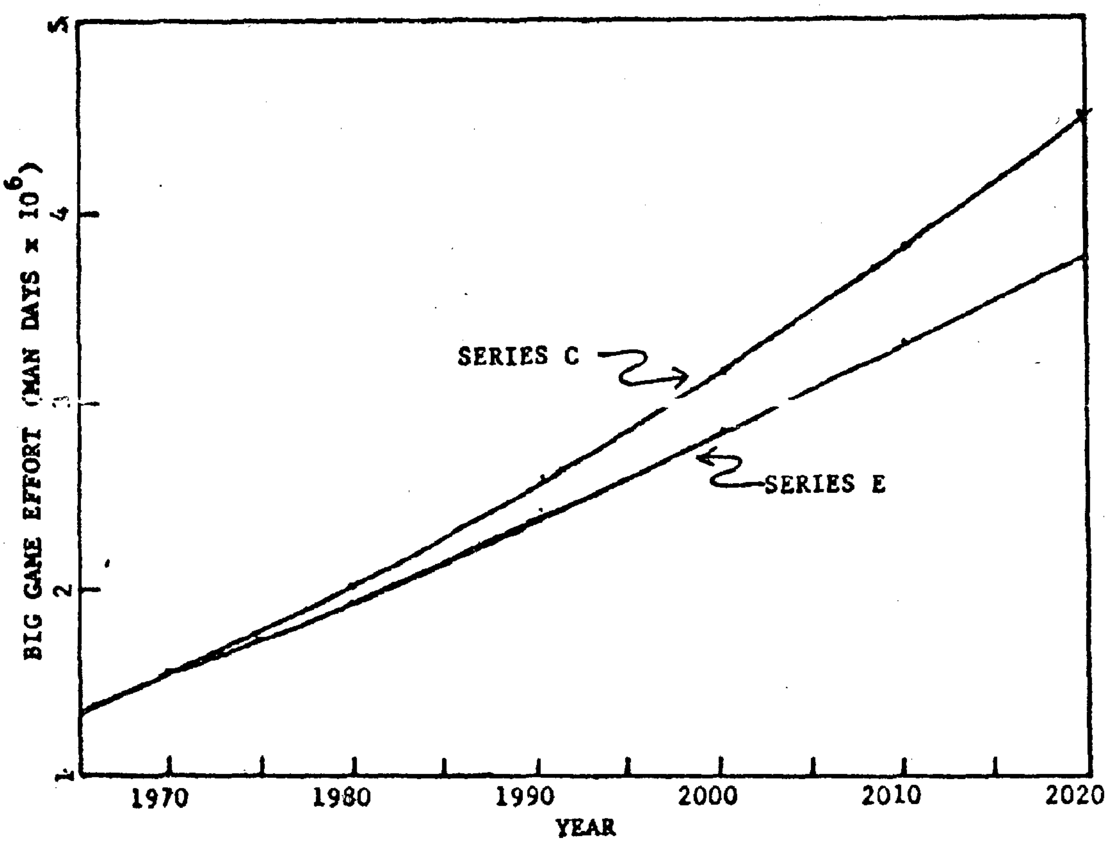


Figure 12-34 BIG GAME EFFORT POPULATION SENSITIVITY

In order to make the projections included in the consumptive wildlife demands section, certain assumptions were made which would affect the validity of the projections. One major assumption is that the independent parameters included in the regression equations are relevant and that no major factors affecting hunter use have been excluded. The initial independent variables included per capita income, which when applied to the projections had an inverse effect which was not compatible with the historical data. This inverse effect led to the rejection of per capita income as an independent variable to be applied in the projections. Past studies and records have shown that small game and waterfowl license sales drop markedly when there is an increase in license price, therefore, this factor was utilized as the economic independent parameter in the analysis for small game and waterfowl. The conclusions that per capita income does not affect hunting pressure and that only small game and waterfowl hunting are affected by license price increases are indicated by historical data. The data source upon which these conclusions are based on the National Surveys of Fishing and Hunting for 1955, 1960, 1965 and 1970. The trends and apparent relationships from these surveys may not be consistent with the long term response to the independent parameters included in the projections or some parameters which have not been included. Therefore, the factors which may affect the validity of the consumptive wildlife utilization projections are the accuracy of the parameters applied in the projections and the confidence limits provided by the calculations. It is reasonable to assume that, because of the long range of the projections, the dynamic social and economic situation in which we live, and the limited base data from which the projections have been made, the projections can not be viewed as quantitative certainties or even reliable probabilities. However, they can be viewed as an indication of expected future trends.

NON-CONSUMPTIVE WILDLIFE SENSITIVITY ANALYSIS

Since base data for non-consumptive wildlife demand and supply in the study area is not readily available, the projections are, only an indication of general trends. The purpose of this section is to provide a discussion of the potential sources of variation and, at the same time, to indicate the degree to which the demand and supply projections are valid.

NON-CONSUMPTIVE WILDLIFE DEMAND SENSITIVITY ANALYSIS

To accurately evaluate present and future non-consumptive wildlife use patterns in the Bay area it would be necessary to design and implement a resource use survey of the Bay area population. This, of course, would be an expensive and time consuming project far beyond the scope of this particular study. However, the resource manager must have some framework within which to plan utilization and management programs. In order to provide this information, utilization projections were made using existing data sources. In the case of non-consumptive wildlife use, the main data source for use patterns was the 1965 and 1970 National Survey of Fishing and Hunting. The use factors developed in these surveys represent a composite of the total United States population and of course do not accurately represent conditions in any particular section of the country. However, lacking data developed on a regional or local base, it was necessary to make an arbitrary decision that resource use patterns of the Chesapeake Bay region are similar to national use patterns. Unfortunately, there is no accurate method to test the validity of this assumption. An examination of the preliminary "Detailed Analysis, Economic Survey of Wildlife Recreation" prepared by Environmental Research Group, Georgia State University, reveals that Maryland and Virginia sustain a high level of participation in bird and wildlife watching and photography. Even though the information in the National Survey of Fishing and Hunting and the aforementioned "Detailed Analysis" is not directly comparable a review of the Georgia report does indicate that the projections provided in this chapter are extremely conservative. It would, therefore, be wise for readers of this study to consider these participation levels as minimum demands.

Population data for the Study Area is the primary factor in projection variability. Since the use projections vary in direct porportion to changing population levels, selection of population projection data plays a significant role in the magnitude of the user projections. For the purposes of these projections the Series E (OBERS) data was utilized. Series E data assumes a lower birth rate and consequently lower population levels for the study period than the previously utilized Series C data. Figure 12-34 illustrates the variation between Series C and Series E population data. Table 12-73 displays the percent increase due to the use of Series C versus Series E data.

Another demographic factor which would effect projections to an unknown degree is the population age structure of the Bay Area population versus the National population. The assumption is made that the percent of the National population 9 years of age or older is the same in the smaller Bay area population.

Table 12-73

Percent Increase Over Series E Figures

1980	4.7
1990	4.9
2000	7.9
2010	11.6
2020	15.4

Also, variability in age structure over the 50 year projection period is to be expected with a resultant variation in real user demands. Accurately anticipating such variability was beyond the scope of this study.

NON-CONSUMPTIVE WILDLIFE SUPPLY SENSITIVITY ANALYSIS

The wildlife available for non-consumptive utilization in the Bay Area was determined, in the non-consumptive supply section,to be primarily dependent upon future land use changes and public access. Since no firm data is available on the amounts of land used by non-consumptive users or the intensity of utilization which can be sustained while still providing a quality recreational experience, only the amount of public lands required to maintain the present quality of non-consumptive use were projected. This projection was based solely on the present acreage of available public lands and the number of non-consumptive recreation days projected in the non-consumptive wildlife demands section.

Therefore, the validity of this projection is related directly to the validity of the non-consumptive recreation days projection which is discussed in the sensitivity analysis for demand. Private lands which were not considered in the analysis would be expected to meet some portion of the future non-consumptive demands.

Chapter IV

MEANS TO SATISFY THE NEEDS

The primary concern of this chapter is to examine some of the methods by which the excess demands for fish and wildlife resources of the Bay region can be met. Prior to the fulfillment of any societal need for these resources some consideration must be given to the needs of the resources. It is assumed throughout this chapter that the aquatic and terrestrial habitat of the Bay region will be maintained at its present level of quality. This assumption allows the supposition that the populations of aquatic and terrestrial species for which there is a societal need, will maintain their present population levels unless they are harvested beyond their capabilities to recover. No consideration has been given to the potential losses of aquatic species due to degraded habitat; however, some discussion is included on the alteration of terrestrial habitat resulting from land use changes.

MEANS TO SATISFY FISHERY NEEDS

In Chapter III, a comparison of the supplies and future demands for the fisheries resources indicated that the demand for alewife, menhaden, soft-shell clams, oysters, yellow perch, sea bass, scup, and catfish could be satisfied by the supply. However, alewife, menhaden and soft-shell clams would be overfished such that increases in fishing effort would result in a decreased harvest per unit effort.

The projected demands for blue crab, white perch, shad, flounder, spot, weakfish, striped bass and eel are greater than the supplies. Thus, a future need for these species is indicated. Wherever, the demand exceeds the supply it has been assumed that the recreational demand will be satisfied before the commercial demand.

INDUSTRIAL SPECIES

Both menhaden and alewife are considered as industrial species. These species are processed for use in animal foods and for the oils which are used in paint bases, margarine and other commercial products. Although the supply is capable of meeting the predicted demand through the year 2020, some time prior to 2020 the harvest will be greater than the maximum sustainable yield for these species. Thus, if the harvest of these species is to continue beyond that time it will be forced to decrease because of a reduced supply. In order to fulfill the needs for the products derived from these species, substitute species or products will have to be found. Soy beans are currently being processed to produce many products which are used in the manner of menhaden and alewife products. Products from agricultural lands cannot, however, be considered as the ultimate solution to meeting these demands since the production capabilities of these lands are finite and must also meet the demands from other market sectors.

SHELLFISH

The shellfish of the Bay which are presently being harvested for commercial and recreational uses are oysters, soft-shell clams, blue crabs, and hard clams. Because the hard clams are limited to the higher salinity water near the mouth of the Bay and make up only a small fishery in the Bay, they were not considered in projections in Chapter III. Of the three remaining species, oyster supplies are predicted to be sufficient to meet the demands, soft-shell clams will meet the demands but will be overharvested, and blue crabs supplies will not be sufficient to meet demands.

Oysters are presently cultivated and managed under both state and private programs which increase the production of this species. It is possible that such practices will be developed for the soft-shell clam thereby allowing an increased harvest without reducing the potential for successive harvests as is indicated in Chapter III. The possibility also exists that other species may be exploited to fulfill some of the demand for soft-shell clams. This could be derived from an increased harvest of hard clams (which are already over harvested in some areas) or more likely, from utilization of a species such as the brackish water clams, (Rangia cuneata) which at present is not sought commercially.

The blue crab harvest is predicted to exceed the maximum sustainable yield shortly after 1980, based solely on the commercial harvest. Since this is a short lived species and exhibits cyclical population fluctuations the harvest is already subject to a great deal of variability. Because of this variability in harvest there will also be a fluctuation in the need generated for this species. The cost of culture practices would probably be prohibitive and the fluctuating supply would keep the culture of the species from being profitable on a regular basis. Thus, if the need is to be satisfied, it will probably be by the harvesting of some other species or by increasing the blue crab harvest from other areas and importing.

NON-INDUSTRIAL FINFISH

Edible species commonly sought by sport and commercial fishermen in the Bay include; white perch, striped bass, shad, flounder, spot, weakfish, eel, yellow perch, sea bass, scup and catfish. Of these eleven species only the last four are projected to have supplies that will meet the demands of the year 2020. The projections for the other species indicate an unsatisfied future demand. When considering the means to satisfy the needs for these species, the first alternative that might be considered is a management program that could be initiated to insure an increased production of these species.

If management practices are to be effectively implemented on a Bay wide basis, records of the sport fishing utilization are necessary. One method of providing information on this utilization and at the same time providing funds for the initiation of management and research programs would be through the sale of salt water fishing licenses. Although this proposal has been suggested and rejected previously, it is still a viable method for gaining the data and know edge necessary to insure continuance of a quality fishery in the Bay.

The primary function of any management program for the Bay fisheries should be directed toward maintaining the present quality and where feasible increasing the productive capabilities. It should be realized however, that the productive capability of an estuary is not infinite and those practices which benefit one species may adversely impact the population of another species. The oyster is one notable example of a species which is being managed to a great extent through leasing of Bay bottom for cultivation and reseeding of natural oyster bars to assure continuous production. Some of the existing areas which could be used for oyster cultivation are presently productive soft clam beds. Thus, if they were managed for increased oyster production a decrease in soft clam harvest would result.

The harvest of under utilized species has provided an interim solution to the fulfillment of the needs for fisheries products on previous occasions and could be an aid in the fulfillment of the needs for overall production in the future. Care should be taken, however, to provide sound management practices such that an under utilized species will not become rapidly depleted once a market is opened. Such exploitation has occured with the surf clam. Because of a lack of restrictions and an available market, vast areas of once productive surf clam beds have been rapidly depleted.

Since the productive capability of the aquatic system is limited, just as is the productive capability of the terrestrial system, resource needs cannot continue to be met solely by increased production. At some time the local, national and international demand for these resources will have to be stabilized. Until such time as this stabilization occurs the needs can only be met through a more efficient utilization of all resources and informed and coordinated management processes.

MEANS TO SATISFY WILDLIFE NEEDS

The future needs for the wildlife resources of the Bay area are derived from a comparison of the projected supply with the projected demand for resources. Trends developed in the projections of Chapter III, clearly show that the demands for both consumptive and non-consumptive utilization of the resources are increasing and will continue to increase through the year 2020. A notable exception to this increase is the projected demand for consumptive utilization of small game species when license prices are periodically increased. In this case, the demand is relatively stable with downward fluctuations in demand occuring when license price is increased. There are several factors that will ultimately determine to what degree these needs can be satisfied. Included are not only the population levels for the wildlife species concerned but also such factors as land use change, population distribution, changing fashions and available leisure time. The lack of information concerning factors influencing populations of many wildlife species and possible changes in human utilization of these species precludes an accurate determination of future needs. Since a precise determination of future needs for wildlife resources is not practical, any consideration of the means to satisfy the needs can only be dealt with in generalized terms. Because the projections indicate greatly increased demands for wildlife resources, the means to be discussed in this section will include methods for increasing supply and availability although no quantitative analysis will be presented.

Chapter III presents discussions and projections of demands, supplies and needs relevant to consumptive wildlife demand and non-consumptive wildlife demand. These utilization types were presented separately as was necessary to clearly identify the needs. To continue to consider these human utilization types separately would only serve to reenforce the dichotomy that presently exists between hunters and non-hunters, and pro-hunting and anti-hunting groups. If wildlife populations and their associated habitats are to be maintained in the face of rapidly changing land uses and growing human populations, an end must come to the conflict between these opposing factions. Rather, there should come, on the part of each group, an understanding of the other's role in the maintenance of wildlife populations in order to present and support effective programs to protect and enhance the resource base.

In defining the demands and needs, the discussion was limited to human needs as related to the wildlife without giving consideration to the wildlife needs as related to human activities. It is, however, not realistic to consider only human demands to the point of exclusion of consideration of wildlife needs.

The problem of maintaining an adequate supply of wildlife to meet all our projected needs must be considered on two levels. The primary level being the requirements that must be met in order for wildlife to sustain viable populations. The secondary level being a problem of providing access to the wildlife for human utilization. In some instances the solutions at both levels may coincide.

Wildlife populations are impacted by three major areas of man's activities. These are land use, pollution, and wildlife utilization. Of the three, land use is probably the most significant.

Prior to the settling of the Bay area by European man, the Indians lived with what was undoubtedly a minimal impact on wildlife populations. The available game and fisheries resources were adequate to support relatively large populations of Indians. The assimilative capacity of the Bay for man's waste was nowhere near being exceeded although localized pollution problems may have existed. Land use changes effected by the Indian towns were probably minimal compared to the vast reaches of undisturbed land and marshes. The coming of European man brought new land use concepts and the land was changed to provide large tracts for profit motivated farming. During this initial period of development, populations of many species of wildlife were probably increased due to the breaking up of large forests and the provision of great amounts of edge habitat. This land use situation with many small fields interspersed with fence rows and woodlots has persisted until recent times. As a result, wildlife populations have generally flourished in the agricultural areas.

Wildlife near the cities of the western shore that formed along the fall line and at major harbor sites has not been so fortunate. During the period that agriculture was expanding there was a concurrent expansion of the western shore cities. The result has been the elimination of much significant wildlife habitat by urbanization and industrialization and varing degree of degradation of habitat in those areas that have become surburban residential areas. It appears that these trends will continue in the future with resultant impacts on wildlife. It is also apparent that current trends in agriculture are resulting in degraded wildlife habitat on private agricultural lands. Due to the development of large efficient harvesting machines it is no longer economically feasible to maintain small fields interspersed with fence rows and wood lots. This trend is resulting in the wholesale elimination of fence rows and other edge habitat. Although no hard data exists to allow precise quantification of the problem, a comparison between past and current aerial photography adequately illustrates the magnitude of the problem. The result of this process is a decreased ability of the land to support wildlife.

Resolution of the problems presented here must begin with a firm commitment on the part of the public and responsible public officials to conserve existing desirable wildlife habitat, reclaim certain lands to support desired wildlife types, acquire additional public lands, and discourage land use practices which are unnecessarily destructive of wildlife habitat. These measures would help insure stabilization and enhancement of wildlife populations.

If such a commitment is made, then the public must make decisions regarding the ultimate size and population desired in the several communities of the Bay area. It will then be the responsibility of local and state officials to take those actions neccessary to limit population growth. Strict zoning will be required to regulate land use. Coupled with zoning a purchasing mechanism should be developed to buy those lands considered especially important to wildlife. If purchase is not desirable, then long term leasing arrangements offer an alternative, as well as tax incentives to affected land owners. The State of Florida offers one example where such a commitment was made. The people of Florida in 1972 passed a 200 million dollar bond issue to purchase environmentally endangered lands. This money is being used to purchase large blocks of land that provide important wildlife habitat as well as many other natural values.

On agricultural areas where the threat of urbanization is not immediate, but where farming practices are damaging wildlife habitat, other solutions must be found. One alternative would be to develop a sound wildlife management plan for farms whereby the farmer would be reimbursed for the difference in crop yield and for any increase in farm operation cost. This could be done at the end of each harvest season by a direct money payment or through a tax allowance.

The above proposals will of course require large funding sources and it is impractical to believe that present tax revenues could absorb the total cost of such programs. The solution to satisfying human demands on wildlife resources lies in providing funds to carry out needed programs.

Current studies of wildlife utilization patterns in the southeastern United States including Maryland and Virginia substantiate the belief that both consumptive and non-consumptive wildlife users are willing to pay for the privilege of viewing and hunting wildlife. (Horvarth) (63) Therefore, user fees might be charged at selected natural areas and the revenues would be used to support wildlife programs.

As has been stated in previous sections the problem of meeting human demands on the wildlife resources related primarily to land access. Purchase of additional lands particularly valuable to wildlife certainly offers a partial solution to supplying use areas. Land purchase, of course, should not be considered a complete answer to land access shortages. Combined with purchase of lands especially valuable to wildlife, a program of wildlife access leases could also be instituted. Such leases could be an adjunct to the wildlife management leases previously proposed. The purpose of the combined wildlife management and access lease would be to provide large areas where wildlife habitat can be actively managed and where access by the wildlife viewer and hunter would be allowed on a managed basis. A fee for all wildlife users could be charged to supply funding for the program. Success of such a program would depend to a large extent on cooperation between the wildlife utilization groups, the involved state agencies, and the individual land owners.

Pollution, the by-products of man's civilization, also has a significant effect on wildlife populations. A prime example of the adverse impact of pollution on wildlife is the absence of many species of fish eating furbearers along stretches of rivers that are polluted by acid mine drainage. (Goldsberry personal communication)(64). Other examples include the impact of chlorinated hydrocarbons on the reproductive success of fish eating carnivorous birds such as the Osprey and Bald Eagle and the as yet unknown effects of trace metal consumption by certain species of waterfowl and shore and wading birds. Oil pollution can also exhibit a serious adverse impact on aquatic oriented bird populations. In the Bay area thousands of bird deaths have resulted from oil spills. Many other cases of habitat distruction or direct organism kill could be enumerated. The solution to this type of problem lies with careful and thorough enforcement of existing pollution control laws and with the vigorous pursuit of new technology to control and abate pollution sources.

Direct utilization of wildlife by man can also have an adverse impact on wildlife populations. A prime example of this problem was the near extirpation of beaver over much of its range as a result of unregulated hunting and trapping activities. In recent years wildlife monitoring and management programs make a reoccurrence of such a situation extremely unlikely.

The foregoing chapter has presented but a few alternatives to meeting fish and wildlife needs. There are undoubtedly numerous other approaches that could address the problem. A key realization that must underlie any successful solution is that the threat to fish and wildlife is not the sport and commercial fishermen nor the hunter or commercial trapper. The real threats to these resources are adverse land and water uses and an apathetic attitude on the part of the public toward preserving fish and wildlife habitat and a lack of public appreciation or awareness of fish and wildlife problems. If these factors can be incorporated into a comprehensive conservation, enhancement and preservation program directed toward maintaining quality habitat, then an effective program can be developed to balance human utilization with the productive capability of the resource. Until such programs are in effect the resource manager will be faced with a continuously dwindling resource base and a concurrent continuous increase in resource needs.

CHAPTER V

REQUIRED FUTURE STUDIES

The Chesapeake Bay Region is the home of several research institutions which have for many years been conducting research programs on the flora, fauna, chemical, physical, and geological properties of the Bay and its tributaries. Much of this previous research has dealt with a single species or environmental parameter which when considered by itself cannot be readily applied to formulate the policies necessary for effective management of the Bay. The problems of major concern to resource managers usually originate from the actions of man. Their actions affect numerous aspects of the habitat and biota. The application of existing information, coupled with a knowledge of the changes which will result from man induced alterations of the environment, could be used to formulate guidelines for management of the fish and wildlife resources. Several of the research and model testing programs that would be beneficial to the resource manager in filling the need for management information will be discussed in this chapter.

SUGGESTED RESEARCH PROGRAMS

A directed program of applied research in the many areas where information is lacking could fulfill resource management needs. This section discusses some of the research programs which would provide data to be utilized in the formulation of effective management programs.

MARSH ALTERATIONS

One area of great concern to resource managers is the destruction and alteration of wetlands. These wetlands are considered to have great value to public fish and wildlife resources. A publication entitled, "Coastal Wetlands of Virginia," Interium Report No. 3, identified several research needs for wetland areas. These research proposals were coupled with communications with numerous individuals involved in the management of these resources and are included in the following:

Marshes and Erosion

It has been established that marsh grasses deter erosion. However, determinations have not been made concerning the minimum width of marsh necessary to buffer wave energy and stabilize the shoreline. Other parameters which should also be studied for their effects on erosion rates are the depth of peat and type of substratum.

Species Association

Although much information is already available concerning productivity and the importance of marshes as a nursery ground for numerous fish species, documentation of the association between marshes as fish spawning and nursery habitat should be further investigated. Whenever possible, specific spawning and nursery sites should be identified. In addition, the correlation of fish species and numbers with the various marsh types should be provided.

Marshes As Filters

The ability of marshes to remove sediments and other pollutants from upland runoff and to utilize excess nutrients has been discussed by numerous authors. Little quantitative work has been done, however, to establish the limits of marshes to perform this function. Such quantitative studies would provide important information for determing the functional value of specific wetland areas and marsh types.

Mosquito Ditching

Because of the association of some marsh areas with high populations of mosquitos, numerous control projects have been undertaken which alter marsh lands. The primary attempts to control mosquito populations and the associated health and nuisance problems have been the marsh ditching programs, which have been initiated in nearly all tidewater areas of the Bay. The purpose of ditching is to flush and drain the marsh. This action is supposed to inhibit the reproduction of marsh mosquitos. In some areas this ditching has been found to be ineffectual and at the same time detrimental to the marshes. In order to gather information relative to the control of mosquitos and the environmental impact of ditching, several research programs should be initiated in order to determine the following:

a. Plant species associated with mosquito populations in the Bay Area.

b. Areas which are breeding habitat for mosquitos.

c. Specific parameters which could be used to determine areas to be ditched.

d. The most effective ditch design.

e. Short and long term impacts upon the marsh ecosystem.

f. Other methods of mosquito control.

DEAD END CANALS

With the increasing demand for access to the water and waterfront building sites, many developers and land owners have resorted to dredging canals through both wetlands and uplands in order to create this economically desirous real estate. The configuration and location of these canals often cause water quality problems and associated degraded fish and wildlife habitat. Several research projects would be useful in determining which factors cause the major water quality problems.

Comparative Water Quality

A comparison of several water quality parameters and the physical variations associated with dead end canal systems would aid in predicting environmental impacts. Some of the parameters which should be included are; length, width, depth, source of drainage, existing water quality, prevailing wind, land use in the watershed, flushing rate, type of perimeter (bulkhead, riprap, fringe marsh, unbulkheaded) and physical configuration of the canal.

Canal Utilization

Documentation of the utilization of man-made canals by finfish and shellfish would be useful in determining the value or detrimental effect of such a system within a given set of associated parameters.

Comparative Productivity

A comparative analysis of the water quality, productivity and biotic utilization of an area after construction of a canal system and a similar area without a canal could give information essential to an understanding of the changes which are imposed by man's actions.

SEDIMENT AND OTHER POLLUTANTS

Land use changes within the Bay Region have not only caused the destruction and alteration of wetlands and other aquatic habitat but have also increased the influx of sediment and other pollutants from upland runoff and industrial and municipal discharges into the Bay. Identification of the sources, nature and biological impact of many substances has already been made, still, numerous cases exist which demand the attention of intensified but directed research programs. To preclude aquatic degradation knowledge of the cumulative and synergistic effects of the many substances entering the system needs to be determined.

Agricultural practices have, since the earliest settlers began farming the shores of the Bay and its tributaries, caused increases in the sediment load and turbidity of the Bay waters. Recently, massive land areas cleared for developments along the shores of the Bay and its tributaries have intensified the erosion and siltation problem. Research regarding the effects of sedimentation and suspended sediment on aquatic biota would be useful in determining the need for measures to reduce the quantities of sediment entering the Bay.

Although numerous projects have been completed which determine the toxicity levels of some organic and inorganic chemical compounds upon various segments of the biota, a need exists for a comprehensive investigation of the sublethal effects of the numerous compounds found in industrial and minicipal discharges. A virtually unexplored area which also requires increased attention is the synergistic effects of the various sublethal pollutants. In order to provide background information on the effect of man's activities on the Bay biota, a survey of benthic organisms should be conducted to determine the present levels of several metals and chemical compounds in the organisms from areas throughout the Bay. This information would be useful in determining the impact of implementations of future projects or activities.

DREDGE HOLES

Accompanying much of the development of shorelines in the low lying areas bordering the Bay and tributaries, has been the dredging of estuarine bottoms for use as fill material. This method of obtaining fill material along with shell dredging practices and sand and gravel mining has caused the creation of many areas referred to as dredge holes or borrow pits since the operation creates an area deeper than the natural bottom. In order to understand the impact these areas have on aquatic resources and the neccessity for their restoration, alteration or cessation, several factors concerning physical, chemical and biological aspects should be investigated. Several of the factors which should be analyzed include the following:

ACKNOWLEDGEMENTS

Of the numerous individuals and organizations involved in the preparation of this report, the efforts of the Fish and Wildlife Coordination Group are gratefully acknowledged. Members of this group listed by agency are: Department of the Interior--Richard E. Griffith (Chairman), Warren T. Olds, Jr., Larry R. Shanks; Department of Commerce--National Marine Fisheries Service, Russell T. Norris, Marvin F. Boussu, Robert L. Lippson; Environmental Protection Agency --Thomas H. Pheiffer; Corps of Engineers--Noel E. Beegle; Delaware--Charles A. Lesser; Maryland--Robert Rubelman, Ralph A. Bitely, Frederick W. Sieling, Anthony Abar; Pennsylvania--Arthur D. Bradford; Virginia--Dr. W. Jackson Davis, James F. McInteer, Jr., James Douglass.

The actual preparation and compilation of the appendix were executed by David B. Harris and James P. Oland of the U. S. Fish and Wildlife Service. The fisheries gear, power plant, finfish and shellfish mortalities sections were prepared by Robert L. Lippson, Ronald D. Gatton and Timothy E. Goodger of the National Marine Fisheries Service. Fisheries supplies and demands projections were provided by Richard J. Marasco under contract to National Marine Fisheries Service. Consumptive wildlife demands projections were prepared by Control Data Corporation under contract to the U. S. Fish and Wildlife Service.

In addition to these individuals, significant assistance was also provided by: J. Abbott (Eagle Nest Sites), R. Andrews (Waterfowl Data), P. Aus (Technical Assistance), N. Beegle (Technical Assistance), K. Chitwood (Waterfowl Data), J. Goldsberry (Maryland Furbearers), J. Gwynn (Virginia Hunter Use), R. Keel, Jr. (Waterfowl Data), W. Parker (Waterfowl Mortalities), R. Pisapia (Research Needs), E. Roach (Non-Consumptive Wildlife Use), T. Robinson (Technical Assistance), J. Sandt (Maryland Hunter Use), F. Settle (Virginia Furbearers), J. Stotts (Waterfowl Data), N. Swink (Endangered Species), U. S. Coast Guard (Oil Spill Data), Dr. O. Villa, Jr. (Water Quality).

Typing of the numerous drafts and rewrites of this appendix was performed by B. Black, L. Cohen, K. Hall, M. Honeycutt, and J. Lowman.

salinity:	the total amount of solid material in sea water when all the carbonate has been converted to oxide the bromine and iodine replaced by chlorine, and all organic matter completely oxidized.
spat:	young oysters just past the veliger stage which have settled down and become attached to some hard object.
synergistic:	acting together with another substance to produce an effect which is greater or different than the sum of the individual effects.
TKN:	Total Kjeldahl Nitrogen (see Kjeldahl Nitrogen).
TOC:	Total Organic Carbon.
VIMS:	Virginia Institute of Marine Sciences.
Zooplankton:	animals that passively float or drift in a body of water.

NO3:	Nitrate.
P:	Phosphorous.
PO4:	Phosphate.
P.C.B.'s:	Polychlorinated biphenyls - these compounds are a subclass of chlorinated hydrocarbons used in chemical preparations for industrial uses including electrical insulating fluids, hydraulic fluids, heat exchanger fluids, as additives to plastic, inks, imbedding compounds paints and sealants - P.C.B.'s result in similar adverse effects to wildlife as chlorinated hydrocarbon pesticides.
P. E.:	Population Equivalent; an expression of the strength of organic material in wastewater. A discharge which consumes 0.17 pounds of oxygen per day has a P.E. of one.
pH:	symbol for the logarithm of the reciprocal of the hydrogen ion concentration; hence a measure of acidity. A ph of 7 is neutral, lower values are acidic, higher values alkaline.
photosynthesis:	the synthesis of complex organic materials by plants from carbon dioxide, water and inorganic salts using sunlight as the source of energy and with the aid of a catalyst such as chlorophyll.
phytoplankton:	passively floating or drifting plants in a body of water.
ppt:	part per thousand - a measure of concentration equal to 1/1000.
regression equation:	an equation used to measure the mean expectation of one variable relative to another.

demersal:	living at or near the bottom of a water column.
D. O.:	dissolved oxygen; refers to the amount of oxygen dissolved in water. A parameter used to determine the suitability of a water body to support aquatic life.
enzootics:	any disease affecting animals in a limited geographic region.
epizootic:	any disease affecting many animals of one kind in one region nearly simultaneously: Example: M. S. X.
euphotic zone:	area of a water column with adequate light for photosynthesis.
fluvial:	of, or pertaining to, a river or existing, growing or living in or near a river or stream.
halogenated hydrocarbons:	a group of organic compounds containing one or more of the halogens, chlorine, iodine, bromine, and flourine. Includes compounds such as D.D.T., D.D.E, dieldrin, endrine, lindane, Chlordane.
isohaline:	of equal or constant salinity, a line on a chart connecting all points of equal salinity.
Kjeldahl Nitrogen:	Nitrogen content determined by the interaction of organic compounds with concentrated sulfuric acid.
lacustrine:	of, or pertaining, to a lake; living or occurring on or in lakes.
microbes:	a microorganism, especially a bacterium of a pathogenic nature.
MSY:	maximum sustainable yield - the greatest harvest which can be taken from a population without affecting subsequent harvests.
NO2:	Nitrite.

GLOSSARY

anadromous: fish that ascend fresh-water streams from the sea or estuary to spawn. Example: Striped Bass, American Shad, Alewives.

anaerobic: the absence of oxygen, preventing normal life for organisms that depend on oxygen.

aquaculture: Sea farming: to promote or improve growth and hence production of aquatic plants and animals by labor and intention, at least at some stage of the life cycle.

aquifer: any geological formation containing water, especially one which supplies the water for wells, springs, etc.

benthic: of, pertaining to, or living on the bottom of a body of water.

benthos: the aggregate of organisms living on or at the bottom of a body of water.

bloom: the sudden development of conspicuous masses of organisms, as algae or dinoflagellates in bodies of fresh or marine water.

catadromous: pertaining to fishes which live in fresh water and migrate to spawn in salt water. Example: American Eel.

CBI: Chesapeake Bay Institute; research facility of the Johns Hopkins University devoted to the study of Chesapeake Bay.

CBL: Chesapeake Biological Laboratory; research facility of the University of Maryland devoted to the study of Chesapeake Bay.

CRC: Chesapeake Research Consortium, Inc.; an affiliation of research institutions investigating Bay Resources. Member organizations are Chesapeake Bay Institute, Chesapeake Biological Laboratory, Virginia Institute of Marine Science and Smithsonian Institution.

U. S. Department of the Interior, Fish and Wildlife Service, 1962. Waterfowl Populations in the Upper Chesapeake Region. Special Scientific Report Wildlife No. 65.

U. S. Department of the Interior, Fish and Wildlife Service, 1968. Fish and Wildlife Resources as Related to Water Pollution Chesapeake Bay and Tributaries (Except Susquehanna River Basin) Bureau of Sport Fisheries and Wildlife Southeast Region (4) Atlanta, Georgia.

Valiulis, George A. and Harold A. Haskin, 1963. Resistance of Crassostrea virginica to Minchinia nelsoni and Labyrinthomyxa marina. Proceedings, National Shellfisheries Association 63:6.

Van Engel, W. A., 1958. The Blue Crab and Its Fishery in Chesapeake Bay. Part I. Reproduction, Early Development, Growth and Migration. Virginia Fisheries Laboratory No. 79. Commercial Fisheries Review Vol. 20 No. 6.

______, 1962. The Blue Crab and Its Fishery in Chesapeake Bay. Part 2. Types of Gear for Hard Crab Fishing U. S. Department of the Interior, Fish and Wildlife Service, Sep. N. 655. Commercial Fisheries Review Vol. 24 No. 9.

Villa, Orterio Jr. and P. G. Johnson, 1974. Distribution of Metals in Baltimore Harbor Sediments. Technical Report 59. Annapolis Field Office. Region III. Environmental Protection Agency.

Wass, M. L. and T. D. Wright, 1969. Coastal Wetlands of Virginia Interim Report. Gloucester Point, Virginia. Virginia Institute of Marine Science.

Water Quality Office, Environmental Protection Agency, 1972. North Atlantic Regional Water Resources Study, Appendix L, Water Quality and Pollution.

Willner, Gale R., James R. Goldsberry, and Joseph A. Chapman, 1975. A Study and Review of Muskrat Food Habits with Special Reference to Maryland. Maryland Department of Natural Resources Maryland Wildlife Administration Monograph No. 1.

REFERENCES (CONTINUED)

Trippensee, Reuben Edwin, 1953. Wildlife Management, Furbearers, Waterfowl and Fish, Vol. II. New York, Toronto, London, McGraw-Hill Book Company.

Tubiash, Haskell S., Rita L. Collwell, and Riichi Sakazaki, 1970. Marine Vibrios associated with bacillary necrosis, a disease of larval and juvenile bivalve mollusks. Journal of Bacteriology 103:272-273.

U. S. Army Corps of Engineers, 1973. Chesapeake Bay Existing Conditions Report Appendixes. Baltimore, Maryland.

U. S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service, 1972. Fisheries of the United States, 1971, Current Fishery Statistics No. 5900. Washington, D.C.

U. S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service, 1973. Fisheries of the United States, 1972, Current Fishery Statistics No. 6100. Washington, D.C.

U. S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service, 1973. 1970 Salt-Water Angling Survey, Current Fishery Statistics No. 6200. Washington, D.C.

U. S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service, 1973. Fishery Statistics of the United States, 1970. Statistical Digest 64. Washington, D.C.

U. S. Department of Commerce News, BEA-74-42, July 15, 1974.

United States Government Printing Office, 1972. National Survey of Fishing and Hunting 1970. Resource Publication 95. U. S. Department of the Interior. U. S. Fish and Wildlife Service. Washington, D.C.

U. S. Department of the Interior, Fish and Wildlife Service, 1973. Threatened Wildlife of the United States.

U. S. Department of the Interior, Fish and Wildlife Service, 1974. Hunting Regulations No. 93.

U. S. Department of the Interior, Fish and Wildlife Service, 1974. Hunting Regulations No. 94.

Sandoz, Mildred and Rosalie Rogers, 1944. The effect of environmental factors on hatching, moulting, and survival of zoea larvae of the blue crab, Callinectes sapidus Rathbun. Journal of Ecology 25:216-228.

Sartor, James D. and Boyd, Gail B., 1972. Water Pollution Aspects of Street Surface Contaminants, EPA-R2-72-081. Office of Research and Monitoring U. S. Environmental Protection Agency.

Schubel, J. R. and E. W. Schiemer, 1972. The Origin of Acoustically Turbid Sediments in Chesapeake Bay. Special Report 23. Chesapeake Bay Institute. The John Hopkins University. Ref. 72-5.

Settle, Fairfax H., 1969. Survey and Analysis of Changes Effected by Man on Tidal Wetlands of Virginia, 1955-1969. Masters Thesis: Virginia Polytechnic Institute.

Seventy-second and Seventy-third Annual Reports of the Marine Resources Commission (Virginia) for the fiscal years ending June 30, 1970 and June 30, 1971.

Silberhorn, Gene M., 1974. Mathews County Tidal Marsh Inventory. Special Report No. 47 in Applied Science and Ocean Engineering. Gloucester Point Virginia. Virginia Institute of Marine Science.

Sinderman, Carl J., 1968. Oyster mortalities, with particular reference to Chesapeake Bay and the Atlantic coast of North America. U. S. Fish and Wildlife Service, Special Scientific Report, Fisheries No. 569.

Sixty-second and Sixty-third Annual Reports of the Commission of Fisheries of Virginia for the fiscal years ending June 30, 1960 and June 30, 1961.

Spaulding, W. M. and R. D. Ogden, 1968. Effects of Surface Mining on the Fish and Wildlife Resources of the United States. Department of the Interior. Bureau of Sport Fisheries and Wildlife Resource Publication 68.

Sprague, Victor and Robert L. Beckett, 1966. A disease of blue crabs (Callinectes sapidus) in Maryland and Virginia. Journal of Invertebrate Pathology 8:287-289.

Symposium on Oyster Pathology at Pensacola, Florida, February 1-3 1950.

Natural Resources Institute. Chesapeake Biological Laboratory, 1968. Biological and Geological Research on the Effects of Dredging and Spoil Disposal in the Upper Chesapeake Bay. Progress Reports.

Natural Resources Institute, University of Maryland, 1973. Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal Final Report, Summary of Research Findings.

Newman, Martin W. and George E. Ward Jr., 1973. An epizootic of blue crabs, Callinectes sapidus caused by Paramoeba perniciosa. Journal of Invertebrate Pathology 22:329-334.

Ninety-third Congress, 1973. Endangered Species Act of 1973, Public Law 93-205.

Paradiso, John L., 1969. Mammals of Maryland. U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. North American Fauna, Number 66.

Potomac River Fisheries Commission, 1972. Regulations. Maryland-Virginia Compact 1958.

Pearson, John C., 1948. Fluctuations in the abundance of the blue crab in Chesapeake Bay. Fish and Wildlife Service Research Report 14.

Pheiffer, T. H., D. K. Donnelly and D. A. Possehl, 1972. Water Quality Conditions in the Chesapeake Bay System. Technical Report 55. Annapolis Field Office, Region III, Environmental Protection Agency.

Roberts, W. M. and Todd, Inc., 1972. Maryland Chesapeake Bay Study. Maryland Department of State Planning. Comprehensive Planning Assistance Project No. MD. P-87.

Rogers-Talbert, R., 1948. The fungus Lagenidium callinectes Couch (1942) on eggs of the blue crab in Chesapeake Bay. Biological Bullentin 95:214-228.

Ryan, J. D., 1953. The Sediments of Chesapeake Bay. Bulletin 12. Baltimore, Maryland. Board of Natural Resources, Department of Geology, Mines and Water Resources.

Marasco, R. J., Unpublished. An Analysis of Future Demands, Supplies Prices, and Needs for Fishery Resources of the Chesapeake Bay. University of Maryland.

______, 1972. The Chesapeake Bay Fisheries: An Economic Profile M. P. No. 802. Agricultural Experiment Station. University of Maryland.

Marine Resources Commission, 1973. Laws of Virginia Relating to Fisheries of Tidal Waters. 1973 Cumulative Supplements. The Michie Co. Charolottesville, Virginia.

Maryland Department of State Planning and Maryland Department of Natural Resources. Appendix B. State of Maryland. Maryland's Water Resources, Management Requirements in the Susquehanna Chesapeake Bay Basin.

Maryland Natural Resources Institute. Chesapeake Biological Laboratory, 1971. A Biological Study of Baltimore Harbor. N. R. I. Ref. No. 71-76. Final Report.

Maryland State Department of Natural Resources, 1972. Rules and Regulations Promulgated by Fisheries Administration. 8.02.01 - 8.02.08.

Menzel, Winston, 1971. The mariculture potential of clam farming. The American Fish Farmer. pp. 8-14.

Metzgar, R. G., 1973. Wetlands in Maryland. Publication No. 157. Baltimore, Maryland. Maryland Department of State Planning.

Meyer, Caldwell D., 1967. Final Report on Fish Mortality Investigations in Chesapeake Bay and Tributaries June 1964 to September 1967. Natural Resources Institute of the University of Maryland.

Natural Resources Institute. Chesapeake Biological Laboratory, 1967. Biological and Geological Research on the Effects of Dredging and Spoil Disposal in the Upper Chesapeake Bay. Sixth Progress Report.

Natural Resources Institute. Chesapeake Biological Laboratory, 1968. Biological and Geological Research on the Effects of Dredging and Spoil Disposal in the Upper Chesapeake Bay. Ref. No. 68-2-A Seventh Progress Report.

Natural Resources Institute. Chesapeake Bioligical Laboratory, 1968. Biological and Geological Research on the Effects of Dredging and Spoil Disposal in the Upper Chesapeake Bay. Ref. No. 68-2B Eighth Progress Report.

Ford, Susan E., 1973. Recent trends in the epizootiology of Minchinia nelsoni (MSX) in Delaware Bay. Proceedings, National Shellfisheries Association 63:2.

Galtsoff, Paul S., 1964. The American Oyster, Crassostrea virginica Gmelin. Fishery Bulletin 64. Washington D.C. United States Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries.

Goldsberry, James R. Jr., 1974. Maryland Wildlife Administration Furbearer Project Leader. Personal Communication.

Guide, V. and O. Villa, Jr., 1972. Chesapeake Bay Nutrient Input Study. Annapolis Field Office Region III, Environmental Protection Agency. Technical Report 47.

Hamilton, William J., 1963. The Mammals of Eastern United States. New York and London. Hafner Publishing Company.

Hamons, Frank L., Jr., 1971. Soft clam mortality studies. Preliminary Report No. 1. Maryland Department of Natural Resources, Fisheries Administration.

Hoese, Hinton D., 1962. Studies on oyster scavengers and their relations to the fungus, Dermocystidium marinum. Proceedings, National Shellfisheries Association 53:161-174.

Jachowski, Richard L., 1969. Observations on blue crabs in shedding tanks during 1968. University of Maryland Reference No. 69-24.

Laws of Maryland Relating to Fish and Fisheries, 1974. Chapter 4. Acts of Extraordinary Session.

Lippson, A. J., 1973. The Chesapeake Bay in Maryland. An Atlas of Natural Resources. John Hopkins University Press

Lippson, Robert L. and Robert E. Miller, 1971. Blue crab study in Chesapeake Bay, Maryland. Quarterly Progress Report Ref. No. 71-42. Natural Resources Institute, University of Maryland.

Lovelace, T. E., H. Tubiash, and R. R. Collwell, 1968. Quantitative and qualitative commensal bacterial flora of Crassostrea virginica in Chesapeake Bay. Proceedings, National Shellfisheries Association 58:82-87.

Carpenter, James H. and David G. Cargo, 1957. Oxygen requirement and mortality of blue crabs in Chesapeake Bay. Technical Report XIII. Chesapeake Bay Institute, John Hopkins University.

Center for Natural Areas Ecology Program, Smithsoniam Institution, 1974. Natural Areas of the Chesapeake Bay Region Ecological Priorities.

Chesapeake Bioligical Laboratory, University of Maryland, Natural Resources Institute, 1970. Gross Physical and Biological Effects of Overboard Spoil Disposal in Upper Chesapeake Bay N. R. I. Special Report No. 3.

Clark J. and Willard Brownell, 1973. Electric Power Plants in the Coastal Zone: Environmental Issue. American Littoral Society Special Publication No. 7.

Clark, L. J., D. K. Donnelly and O. Villa Jr., 1973. Summary and Conclusions, Technical Report 56, Nutrient Enrichment and Control Requirements in the Upper Chesapeake Bay. Annapolis Field Office Region III Environmental Protection Agency.

Clarke, W. D. and L. C. Murdock, 1972. Chester River Study State of Maryland Department of Natural Resources and Westinghouse Electric Corporation.

Costlow, John D. Jr., 1967. The effect of salinity and temperature on survival and metamorphosis of megalops of the blue crab Callinectes sapidus. Helgolander wiss. Meeresuntes 15:84-97.

Dozier, Herbert L., 1947. Salinity as a factor in Atlantic Coast Tidewater Muskrat Production. Transactions of the Twelfth North American Wildlife Conference.

Eberhart, R. C., V. J. Chapman and M. S. Dugger, 1974. Pressures on the Edges of Chesapeake Bay - 1973. CRC Pub. No. 26. Chesapeake Research Consortium, Inc., Wetlands/Edges Program.

Engle, James B., 1946. Commercial aspects of the Upper Chesapeake Bay oyster bars in the light of recent oyster mortalities. In Third Annual Report of the Maryland Baord of Natural Resources. pp 134-140.

Environmental Research Group, 1973. Southeastern Preliminary Detailed Analysis Economic Survey of Wildlife Recreation. Georgia State University, Atlanta, Georgia.

REFERENCES

Andersen, A. M., W. J. Davis, M. P. Lynch and J. R. Schubel. 1973. The Effects of Hurricane Agnes on the Environment and Organisms of Chesapeake Bay. Chesapeake Bay Research Council.

Andrews, Jay D. and Willis G. Hewatt, 1957. Oyster mortality studies in Virginia II. The fungus disease caused by Deomocystidium marinum in oysters of Chesapeake Bay. Ecological Monographs 27:1-26.

______1962. Oyster mortality studies IV. MSX in James River public seed beds. Proceedings, National Shellfisheries Association 53:65-84.

Barber, Yates M. Jr. 1973. Potential Adverse Impacts of Once Through Cooling. Unpublished. National Marine Fisheries Service.

Beaven, G. F. and R. V. Truitt, 1938. Crab mortality of Chesapeake Bay shedding floats. Chesapeake Biological Laboratory Contribution No. 33.

Becker, C. D. and T. O. Thatcher, 1973. Toxicity of Power Plant Chemicals to Aquatic Life. Richland, Washington. Battelle Pacific Northwest Laboratories.

Boyd, M. B., W. H. Bobb, C. J. Huval, T. C. Hill, 1973. Enlargement of the Chesapeake and Delaware Canal Hydraulic and Mathematical Model Investigation, Vicksburg, Mississippi. U. S. Army Engineer Waterways Experiment Station Hydraulics Laboratory.

Browning, J., 1972. Eutrophication, A Natural Process Compounded by Man. In: In Depth Report. Central and Southern Florida Flood Control District Vol. 1, No. 8.

______, 1972. Man's effect on the quality of our water. In: In Depth Report. Central and Southern Florida Flood Control District Vol. 1, No. 2.

Bureau of Sport Fisheries and Wildlife. Fish and Wildlife Service. U. S. Department of Interior, 1972. North Atlantic Regional Water Resources Study, Appendix O, Fish and Wildlife.

55. Settle, Fairfax H. Survey and Analysis of Changes Effected by Man on Tidal Wetlands of Virginia, (1955 - 1969) Masters Thesis: Virginia Polytechnic Institute. (December 1969).

56. Center for Natural Areas Ecology Program Smithsonian Institution. Natural Areas of the Chesapeake Bay Region Ecological Priorities. (May 1974).

57. Ninety-third Congress. Endangered Species Act of 1973, Public Law 93-205 (December 1973).

58. U. S. Department of the Interior, Fish and Wildlife Service: Threatened Wildlife of the United States. (March 1973).

59. Sartor, James D. and Boyd, Gail B. Water Pollution Aspects of Surface Contaminants, EPA-R2-72-081. Office of Research and Monitoring U. S. Environmental Protection Agency (November 1972).

60. Guide, V. and O. Villa, Jr. Chesapeake Bay Nutrient Input Study. Annapolis Field Office Region III, Environmental Protection Agency. Technical Report 47. (September 1972).

61. Clark, L. J., D. K. Donnelly and O. Villa Jr. Summary and Conclusions, Technical Report 56, Nutrient Enrichment and Control Requirements in the Upper Chesapeake Bay. Annapolis Field Office Region III Environmental Protection Agency. (August 1973).

62. U. S. Department of Commerce News, BEA 74-42. (July 15, 1974).

63. Environmental Research Group. Southeastern Preliminary Detailed Analysis Economic Survey of Wildlife Recreation. Georgia State University, Atlanta, Georgia. (September 1973).

64. Goldsberry, James R. Jr. Maryland Wildlife Administration Furbearer Project Leader. Personal Communication. (1974).

42. Sprague, Victor and Robert L. Beckett. A disease of blue crabs (*Callinectes sapidus*) in Maryland and Virginia. Journal of Invertebrate Pathology 8:287-289. (1966).

43. Newman, Martin W. and George E. Ward Jr. An epizootic of blue crabs, *Callinectes sapidus* caused by *Paramoeba perniciosa*. Journal of Invertebrate Pathology 22:329-344.

44. Jachowski, Richard L. Observations on blue crabs in shedding tanks during 1968. University of Maryland Reference No. 69-24. (1969).

45. Rogers-Talbert, R. The fungus *Lagenidium callinectes* Couch (1942) on eggs of the blue crab in Chesapeake Bay. Biological Bulletin 95:214-228. (1948).

46. Menzel, Winston. The mariculture potential of clam farming. The American Fish Farmer. July, 1971; pp. 8-14. (1971).

47. Hamons, Frank L., Jr. Soft clam mortality studies. Preliminary Report No. 1. Maryland Department of Natural Resources, Fisheries Administration. (1971).

48. Laws of Maryland Relating to Fish and Fisheries, Chapter 4. Acts of Extraordinary Session. (1974).

49. Maryland State Department of Natural Resources. Rules and Regulations Promulgated by Fisheries Administration 8.02.01-8.02.08. (September 1972).

50. Marine Resources Commission. Laws of Virginia Relating to Fisheries of Tidal Waters. 1973 Cumulative Supplements The Michie Co. Charolottesville, Virginia. (1973).

51. Potomac River Fisheries Commission. Regulations. Maryland-Virginia Compact 1958. (1972).

52. U. S. Department of the Interior. Fish and Wildlife Service Hunting Regulations No. 93. (August 1974).

53. U. S. Department of the Interior. Fish and Wildlife Service Hunting Regulations No. 94. (September 1974).

54. Eberhart, R. C., V. J. Chapman, and M. S. Dugger. Pressures on the Edges of Chesapeake Bay-1973 CRC Pub. No. 26. Chesapeake Research Consortium, Inc.; Wetlands/Edges Program. (April 1974).

31. Valiulis, George A. and Harold A. Haskin. Resistance of *Crassostrea virginica* to *Minchinia nelsoni* and *Labyrinthomyxa marina*. Proceedings, National Shellfisheries Association 63:6. (1963).

32. Tubiash, Haskell S., Rita L. Collwell, and Riichi Sakazaki. Marine Virbrios associated with bacillary necrosis, a disease of larval and juvenile bivalve mollusks. Journal of Bacteriology 103:272-273. (1970).

33. Lovelace, T. E., H. Tubiash, and R. R. Collwell. Quantitative qualitative commensal bacterial flora of *Crassostrea virginica* in Chesapeake Bay. Proceedings, National Shellfisheries Association 58:82-87. (1968).

34. Sixty-second and Sixty-third Annual Reports of the Commission of Fisheries of Virginia for the fiscal years ending June 30, 1960 and June 30, 1961.

35. Sinderman, Carl J. Oyster mortalities, with particular reference to Chesapeake Bay and the Atlantic coast of North America. U. S. Fish and Wildlife Service, Special Scientific Report, Fisheries No. 569. (1968).

36. Pearson, John C. Fluctuations in the abundance of the blue crab in Chesapeake Bay. Fish and Wildlife Service Research Report 14. (1968).

37. Lippson, Robert L. and Robert E. Miller, 1971. Blue crab study in Chesapeake Bay, Maryland. Quarterly Progress Report Ref. No. 71-42. Natural Resources Institute, University of Maryland. (1971).

38. Sandoz, Mildred and Rosalie Rogers. The effect of environmental factors on hatching, moulting, and survival of zoea larvae of the blue crab, *Callinectes sapidus* Rathbun. Journal of Ecology 25:216-228. (1944).

39. Costlow, John D. Jr. The effect of salinity and temperature on survival and metamorphosis of megalops of the blue crab *Callinectes sapidus*. Helgolander wiss. Meeresunters 15:84-97. (1967).

40. Beaven, G. F. and R. V. Truitt. Crab mortality of Chesapeake Bay shedding floats. Chesapeake Biological Laboratory Contribution No. 33. (1938).

41. Carpenter, James H. and David G. Cargo. Oxygen requirement and mortality of blue crabs in Chesapeake Bay. Technical Report XIII. Chesapeake Bay Institute, Johns Hopkins University. (1957).

FOOTNOTES (CONTINUED)

21. Boyd, M. B., W. H. Bobb, C. J. Huval, T. C. Hill Enlargement of the Chesapeake and Delaware Canal Hydraulic and Mathematical Model Investigation. Vicksburg, Mississippi, U. S. Army Engineer Waterways Experiment Station Hydraulics Laboratory.

22. Spaulding, W. M. and R. D. Ogden. Effects of Surface Mining on the Fish and Wildlife Resources of the United States. Department of the Interior. Bureau of Sport Fisheries and Wildlife Resource Publication 68.

23. Meyer, Caldwell D. Final Report on Fish Mortality Investigations in Chesapeake Bay and Tributaries June 1964 to September 1967. Natural Resources Institute of the University of Maryland.

24. Symposium on Oyster Pathology at Pensacola, Florida, February 1-3, 1950.

25. Andrews, Jay D. and Willis G. Hewatt. Oyster mortality studies in virginia II. The fungus disease caused by Deomocystidium marinum in oysters of Chesapeake Bay. Ecological Monographs 27:1-26. (1957).

26. Hoese, Hinton D. Studies on Oyster Scavengers and Their Relations to the Fungus, Dermocystidium marinum. Proceedings, National Shellfisheries Association 53:161-174. (1962).

27. Engle, James B. Commercial Aspects of the Upper Chesapeake Bay Oyster Bars in the Light of Recent Oyster Mortalities. In Third Annual Report of the Maryland Board of Natural Resources. pp 134-140. (1946).

28. Andrews, Jay D. Oyster mortality studies IV. MSX in James River public seed beds. Proceedings, National Shellfisheries Association 53:65-84. (1962).

29. Seventy-second and Seventy-third Annual Reports of the Marine Resources Commission (Virginia) for the fiscal years ending June 30, 1970 and June 30, 1971.

30. Ford, Susan E. Recent trends in the epizootiology of Minchinia nelsoni (MSX) in Delaware Bay. Proceedings, National Shellfisheries Association 63:2.

12. Barber, Yates M. Jr. Potential Adverse Impacts of Once Through Cooling. Unpublished. National Marine Fisheries Service. (June 1973).

13. Becker, C. D. and T. O. Thatcher. Toxicity of Power Plant Chemicals to Aquatic Life. Richland Washington. Battelle Pacific Northwest Laboratories. (June 1973).

14. Ryan, J. D. The Sediments of Chesapeake Bay. Bulletin 12. Baltimore, Maryland. Board of Natural Resources, Department of Geology, Mines and Water Resources. (1953).

15. Galtsoff, Paul S. The American Oyster, Crassostrea virginica Gmelin. Fishery Bulletin 64. Washington D. C. United States Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries. (1964).

16. Andersen, A. M., W. J. Davis, M. P. Lynch, and J. R. Schubel. The Effects of Hurrican Agnes on the Environment and Organisms of Chesapeake Bay. Chesapeake Bay Research Council. (1973).

17. Clarke, W. D. and L. C. Murdock. Chester River Study. State of Maryland Department of Natural Resources and Westinghouse Electric Corporation. (November 1972).

18. Chesapeake Biological Laboratory, University of Maryland, Natural Resources Institute. Gross Physical and Biological Effects of Overboard Spoil Disposal in Upper Chesapeake Bay N. R. I. Special Report No. 3. (July 1970).

19. Natural Resources Institute, University of Maryland. Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal Final Report. Summary of Research findings. (September 1973).

20. Natural Resources Institute. Chesapeake Biological Laboratory. Biological and Geological Research on the Effects of Dredging and Spoil Disposal in the Upper Chesapeake Bay. Progress Reports. (1968).

FOOTNOTES

1. U. S. Army Corps of Engineers. Chesapeake Bay Existing Conditions Report. Baltimore, Maryland. (1973).

2. Pheiffer, T. H., D. K. Donnelly and D. A. Possehl. Water Quality Conditions in the Chesapeake Bay System. Technical Report 55. Annapolis Field Office, Region III, Environmental Protection Agency. (August 1972).

3. Water Quality Office, Environmental Protection Agency. North Atlantic Regional Water Resources Study, Appendix L: Water Quality and Pollution. (May 1972).

4. Marasco, R. J. The Chesapeake Bay Fisheries: An Economic Profile. M. P. No. 802. Agricultural Experiment Station. University of Maryland. (February 1972).

5. Metzgar, R. G. Wetlands in Maryland. Publication No. 157 Baltimore, Maryland. Maryland Department of State Planning. (September 1973).

6. Wass, M. L. and T. D. Wright. Coastal Wetlands of Virginia. Interim Report. Gloucester Point, Virginia. Virginia Institute of Marine Sciences. (1969).

7. Silberhorn, Gene M. Mathews County. Tidal Marsh Inventory. Special Report No. 47 in Applied Science and Ocean Engineering Gloucester Point, Virginia. Virginia Institute of Marine Science. (January 1974).

8. United States Government Printing Office. National Survey of Fishing and Hunting (1955, 1960, 1965, 1970). Resource Publication 95. U. S. Department of Interior, U. S. Fish and Wildlife Service. Washington, D. C.

9. Villa, O. Jr. and P. G. Johnson. Distribution of Metals in Baltimore Harbor Sediments. Technical Report 59. Annapolis Field Office, Region III, Environmental Protection Agency. (January 1974).

10. Maryland Natural Resources Institute. Chesapeake Biological Laboratory. A Biological Study of Baltimore Harbor. N. R. I. Ref. No. 71-76 Final Report. (September 1971).

11. Villa, Orterio Jr. and P. G. Johnson. Distribution of Metals in Baltimore Harbor Sediments. Technical Report 59. Annapolis Field Office, Region III, Environmental Protection Agency. (January 1974).

currents to the dispersion of materials and plankton suspended in the water column. Some of the factors which could be analyzed through the use of tagged water masses are included in the following list.

Power Plant Effluents

The distribution of heated effluents from power plants and the dilution rates for these effluents could be projected and thus the potential impact of power stations such as those located at Calvert Cliffs and Hog Island and the proposed plants at Douglas Point, Perryman, and on the Chesapeake and Delaware Canal as well as others could be determined.

The thermal information obtained from a model test which also simulated low flow conditions could be coupled with knowledge of tolerance limits for the indigenous species to provide a partial assessment of the environmental impact of the project.

Municipal and Industrial Waste

Municipal and industrial waste discharges could be represented on the model in order to provide information regarding the relative impact of alternative discharge sites, the ultimate disposition of polluted materials, and the impact of altering both the discharges and the river flows.

Sediment Distribution

In order to provide a determination of the environmental impact of erosion and overboard disposal of dredge spoils, model studies could be utilized. Erosion from upland sources and shoreline areas could be simulated to determine the ultimate destination of such eroded material and the effect of this material on the Bay topography. Since dredge spoils, especially from polluted areas, are of great concern to many agencies and individuals, studies should be initiated to determine the distribution patterns of spoils from specific ongoing projects and proposed projects.

Icthyoplankton Distribution

Tagged water masses within the model could be used to determine the distribution of eggs and larvae of several species of finfish and shellfish. Information gained from these studies could be used in the determination of areas which are of the greatest value to fisheries production. Additionally, potential sites for oyster production or spat collection could be delineated.

The model testing programs discussed in this section have not been outlined in detail and are given only as the base upon which a more detailed plan of study can be developed. Prior to the implementation of any such programs a meeting of the resource management and other agencies and the engineering staff of the hydraulic model would be required. At such a time a formal plan could be developed to provide maximum utilization within the constraints of the model capabilities.

initiated to determine the effects of this proposed project with regard to the magnitude of salinity changes. This information can then be related to the species affected by the project.

Water Supply Projects

Water supply projects also have the potential for alteration of salinity regimes through reduced flow or by diversion. The following list includes several proposed projects which have the potential to affect Bay and tributary habitat and should be included in hydraulic model studies.

a. Sixes Bridge Dam and Reservoir Project on the Monocacy River in Maryland

b. Verona Dam and Reservoir Project on Middle River in Virginia

c. Bloomington Reservoir on the North Branch Potomac River

d. Little Creek Reservoir on a tributary to James River

e. Gathright Lake Project on Jackson River in Virginia

f. Blackwater to James River diversion

g. Susquehanna to Patapsco River diversion

Not only should the impact of individual projects be analyzed but also the cumulative impact of consumptive withdrawals from the major tributaries, such as the Potomac, Susquehanna, James, York and Rappahannock Rivers.

Topographic Changes

Changes in the bottom topography due to spoil deposition, channel dredging and shoreline development can affect the salinity and current patterns over significant portions of the Bay. There are several major projects which should be investigated to determine their effects upon the movement of water masses in the Bay. The proposed project at Hart and Miller Islands and the expansion of Craney Island are two projects with a potential for changing flow characteristics. Any future projects which could change the topography of the Bay bottom or flow patterns of its waters should similarly be investigated through the use of the hydraulic model.

WATER FLOW AND DISTRIBUTION

Determination of the distribution of water masses by utilization of the hydraulic model can be an aid in analyzing the potential impact of numerous types of projects as well as the relationship of tides and

MODEL TESTING PROGRAM

Following completion of its construction and verification, a program of testing will be initiated on the Chesapeake Bay Hydraulic Model. Implementation of this testing program will provide an opportunity to gain valuable information for utilization by management agencies as well as to determine the versatility and limitations of the model. The purpose of this segment of the report is to outline programs which will be beneficial in testing the capabilities of the model and at the same time provide information useful in the development of management programs for the fish and wildlife resources of the Bay.

NAVIGATION AND WATER RESOURCES PROJECTS

Navigation and water resources programs which affect the flow characteristics and salinity regimes within the Bay system can, at the same time, cause a shift in the species makeup or productivity of the affected area. In order to ascertain the extent of influence of certain proposed projects and thus the potential shift in habitat types, model testing programs could include studies on the effects of some projected projects. Several projects which are presently proposed or under construction and should be examined for their effect on the aquatic system are included in the following subsections.

Chesapeake and Delaware Canal

The enlargement of the Chesapeake and Delaware Canal from 27' x 250' to 35' x 450' is one such project which could cause significant changes in the aquatic environment of the northern part of the Bay. Studies have already been conducted regarding the existing conditions in the region and the projected changes which will occur based on mathematical model studies. Studies conducted with the Chesapeake Bay hydraulic model could be used to make additional predictions regarding the effects of the Canal enlargement and could also be used to determine the validity of the mathematical model studies. Upon completion of the Canal enlargement, data can be collected which will aid in determining the limitation of the hydraulic model. The Chesapeake and Delaware Canal project presents an ideal opportunity to test our present predictive capabilities.

Baltimore Harbor

The dredging of Baltimore Harbor and its approach channels to a depth of 50 feet could possibly cause habitat alteration through salt water intrusion into the Upper Bay Areas. Hydraulic model studies should be

d. What benefits to associated terrestrial habitats and their faunal populations are accrued from the existence of a high marsh?

e. What is the role of the high marsh in nutrient cycling in the estuarine ecosystem?

f. What are the long term effects of ditching and diking for furbearer management.

FISH AND WILDLIFE HABITAT

Nearly everyone involved with management of our natural resources is aware that significant changes in fish and wildlife populations occur as a result of habitat alteration. Such alterations may be caused by physical changes of the habitat or indirect effects resulting from actions outside of the impacted area. Documentation of the effects of various land and water use activities and development of procedures to prevent or minimize the adverse effects should be a primary goal of future studies. Since no single document could realistically identify all pertinent studies, the following broad topics are intended to identify only general concepts.

a. Direct loss of habitat for important species has rarely been quantified. Documentation of existing habitat, known habitat losses, projected habitat losses and population changes within the Study Area would provide a basis for preserving certain habitat types and developing compensation habitat.

b. Aquatic habitats are especially susceptible to activities far removed from the area of impact. Rapid urbanization with attendant increases in storm water outfalls, sewage treatment plant discharges, and other sediment and pollutant sources has resulted in both chemical and physical alterations of aquatic habitat. Quantification and prediction of water quality parameters as impacted by development would provide much needed background information. Such information could be utilized to determine the future capabilities of the Bay Area to sustain harvestable populations of sport and commercial species with a given degree of development. See also Existing Problems and Conflicts, Chapter II.

which would insure continuous supplies of these species. This concept would, of course, require a coordinated effort on the part of the fishing industry throughout the species range. For many species, this would necessitate international agreements. Comparable information should be gathered for the species which are confined to the estuary or are not subjected to significant losses outside of the Bay.

One management technique utilized in commercial fisheries is restriction of gear type. In order to provide a sound basis for regulating gear type, studies should be initiated to determine the catch rates per unit of effort by gear type.

Sport Fisheries

Several of the Bay species are subject to extensive harvest by both commercial and sport fishermen. In some cases the sport fishermen account for nearly all of the catch. In order to effectively manage these species, information in addition to that required for the commercial species is necessary. In addition to data on population levels, recruitment rates and spawning requirements, sport fishing utilization data is needed. A comprehensive continuing sport fishing survey should be implemented to accurately monitor sport fishermen effort and catch by species. An intelligent management system will not be possible until such a project is undertaken.

HIGH MARSH

Since wetlands located above the mean high tide line are particularly vulnerable to alteration by man, their values to estuarine and marine ecosystems should be further investigated and these values clearly delineated. Of particular interest are the following questions:

a. To what extent does the low marsh community depend on supplies of dissolved organic material originating in the high marsh as a nutrient subsidy?

b. What is the nature and magnitude of dependency of fish and invertebrate species on the high marsh?

c. Is the carrying capacity of a tidal stream system increased for fish and invertebrates by the existence of associated high marsh? In other words, the high marsh during extremely high tides (spring tides, storm tides and seasonally high runoff periods) is flooded and is utilized by many species of fish and invertebrates normally found in sub-tidal and low marsh habitats. Does this utilization result in a significant increase in the total carrying capacity of the system, or in a strong year class of fishes that are spawning when the flooding of the high marsh occurs?

EROSION CONTROL

Erosion caused by both normal wave action and storms is a major problem in the Bay Area that has been further aggravated by rising tidal elevations and losses of aquatic vegetation. Every year man alters several miles of shoreline in order to abate this erosion problem. Research is needed which will determine the relative effects of the various control measures, the biota associated with them, and the impact upon the biota of shorelines which were previously unaltered. Included should be the following:

a. The effects of scouring on benthic assemblages associated with bulkheads, riprap and natural shorelines (eroding and stable).

b. The effects of various types of erosion control structures on current flows, wave behavior, sediment transport and benthic communities of nearby areas.

The ultimate goal of this research would be to determine the most environmentally acceptable and most effective methods of erosion control.

FISHERIES DATA

In order to provide proper management of the Bay fishery resources, basic information regarding population levels, recruitment rates, and spawning requirements of estuarine dependent sport and commercial fish and invertebrates species and the associated major food web species is required.

Commercial Fisheries

Since commercial species such as menhaden, herrings and flounder are subject to intense selective harvest both in the Bay and along the Atlantic coast, many of the factors relative to the abundance and availability of these species occur outside the Bay proper. To provide for the proper management of these species, it is necessary to know the range of the populations which utilize the Bay and the cummulative pressures to which they are subjected. Studies should therefore be conducted to determine which portion of the population uses the Bay, the harvest from this population throughout the species range, and the recruitment rates of this population. Additional information should be gathered on environmental factors affecting population levels of the species concerned. Continous monitoring of Bay population trends should be initiated. Availability of this information would allow resource managers to implement regulations

Physical Alterations

Although every dredging project will deal with different physical conditions, and alterations will cause a diverse range of changes, documenting the results of numerous projects would aid in predicting the changes which may occur in similar situations.

AQUA-CULTURE

With the increasing population and demand for seafood products, methods for intensive culture of some aquatic species have been developed. It has been shown that many of those practices associated with high concentrations of cultured organisms may cause water quality problems. Prior to the development of any area for the intensive culture of a species, a determination of the effects on the surrounding habitat should be made. In order to make these determinations, background data on the effects of various concentrations of certain species should be made with respect to the change which they incur on the water quality.

AQUATIC PLANTS

The boating public often thinks of rooted aquatic plants as a nuisance and a detriment to its desired recreation. However, these same rooted aquatic plants supply an important source of food and shelter for numerous aquatic organisms as well as food for waterfowl. In recent years, large areas of the Bay which were once covered with rooted plants are no longer supporting this type of vegetation. The reasons for the change may be due to increased turbidity resulting from upland runoff, excessive nutrients which are conducive to planktonic blooms or other unknown parameters and synergistic effects.

Research should be oriented toward the determination of the environmental factors necessary for the establishment and maintenance of several species of rooted aquatic plants and the measures which are necessary to reestablish those plants in areas where they previously thrived. Such factors as sediment particle size, nutrient levels and turbidities should be included. It should be noted that research of this type is being undertaken by the Maryland Wildlife Administration in conjunction with the U.S. Fish and Wildlife Service.

a. The benthic biota in a dredge hole compared to the benthic biota from an adjacent non-dredged area;

b. The chemical and physical aspects of the interstitial and interface waters;

c. A comparative analysis of sediments from dredged and non-dredged areas;

d. The correlation between the physical configuration of dredge holes, and the associated biota.

DREDGING

Dredging of channels for commercial and recreational access to deep water has been the source of much debate regarding the detrimental effects of resuspension of sediments, changes in bottom topography. Losses of benthic organisms, changes in species composition and diversity, and the releasing of absorbed and adsorbed pollutants from sediment particles. In order to provide sound background information for the formation of policies which deal with dredging numerous research projects should be conducted to supply supplementary information to that already available on the effects of dredging. Some of the research programs which should be initiated are included in the following list.

Turbidity

A primary concern of many individuals and organizations involved with protection of aquatic resources is the effect of increased turbidity on the biota of regions adjacent to dredging operations. The determination of the tolerance to increased levels of suspended sediments of the eggs and larvae as well as the adults of various species of fish and invertebrates would aid in the development of acceptable turbidity levels for incorporation into criteria to be adopted.

Settling Time

The settling time for particles of varying sizes under diverse conditions of salinity and current could be used to determine the extent of an area which might be affected by a dredging or spoiling operation.

Reestablishment of Benthos

The long term effects of dredging operations could be better understood if a comprehensive study program were initiated to determine the rate of reestablishment of the benthic community and the alterations which occur in community composition.

ATTACHMENT A

SPECIFIC DATA ON REPORTED FISH MORTALITIES IN CHESAPEAKE BAY FROM 1954 TO 1972

C.F.D. means commercial fishery discards
* means that the kill occurred in more than one area.
** A bacterium of the genus <u>Pasteurella</u> is now believed to have caused these mortalities.

Area A

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
20-VI-63	Unknown	1%		99%				
5-VIII-63	Unknown**	Major						Unknown Species
7-8VIII-63	Unknown							Unknown Species
10-VIII-63	Unknown**	X						
15-VIII-63	Unknown**	X						
16-VIII-63	Unknown**	X						
16-VIII-63	Unknown**	X						
20-VI-64	Unknown				X			
29-VI-64	Unknown				X		X	
24-V to 20-VI-66	Disease	Millions						
13-VI-67	C.F.D.	X						
Early May to end June-71	Natural	X	X					Herring other than Alewives Catfish Carp Misc. - 3,000,000

Area A - cont'd

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
Early May to End July-71	Unknown			X				Hundreds of Thousands

TOTAL KILLS - 13

Area B

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
27-V-55	Unknown							Species unknown
24-31-V-55	Unknown	X				X		
27-V-55	Unknown				X			Spot Minnows
10-I-56	Unknown			X				
6-7-II-57	Unknown							Spot
4-VI-59	Unknown				X			
7-VI-59	Unknown			X				
18-VI-59	Unknown			X				
25-VI-59	Unknown			X				
13-V-60	Unknown	X						
16-V-60	Unknown	X		X				
6-V-to 6-VI-60	Unknown	X		Major		X		Toadfish
7-VI-60	Unknown			X				

Area B - cont'd
Page 2

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
30-V-62	Unknown	X						
12-VI-62	Unknown							Unknown species
2-VIII-62	Unknown			X				
1-VII-63	Unknown	X	X	Major		X	X	
1-VIII-63	Unknown**	Major					X 7# to 10#	
3-VIII-63	Unknown**	Thousands					5 to 20#	Herring other than Alewives Spot
3-VIII-63	Unknown**	50,000						
6-VIII-63	Unknown**	X						
6-VIII-63	Unknown**	X					X	
2 to 8 VIII-63	Unknown**							Unknown species
11-VIII-63	Unknown**	X				X	X	
16-VIII-63	Unknown**	Major					X	
27-VIII-63	Unknown**	Major	50				25	Sunfish

Area B- cont'd
Page 3

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
19-VI-64	Unknown				X			
22-VI-64	Unknown			X				
23-VI-64	Unknown	X		Major		X	X	Toadfish - 1
11-VII-64	Unknown			X	X		1	
9-VIII-to 16-VIII-64	Unknown							Unknown species - Large kill
21-V to 10-VII-65	Spinning Disease	Few		1000's		Few		Oyster Toadfish
29-V to 23-VI-66	Unknown			1000's				
11-13-VII-67	Unknown			X				
8-VI to 21-IX-68	Whirling Disease			X				Total - Millions
26-V to 9-VII-69	Unknown			X				Total - Tens of Thousands
22-V-69	D.O. & C.F.D.	1000's				Dozens		

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
16-IX-70	C.F.D.			Few			Few	Bluefish - Few
*Mid-Sept. to Mid-Oct. '70	Spinning Disease			X				Hundreds of thousands
* Early May to End July-71	Unknown			X				

TOTAL KILLS = 40

Area C

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
26-V-59	Unknown	X			X			
*4-VI-59	Unknown				X			
*18-VI-59	Unknown			X				
22-VI-59	Unknown			X				Hogchoker Toadfish
7-VI-60	Unknown			Major		1		
12-VI-62	Unknown							Species unknown
30-VII-63	Unknown**	Major					X	
2-VIII-63	Unknown			X				
5-VIII-63	Unknown**	18,200	10	160		107	212	Sunfish - 5 Toadfish - 40
6-VIII-63	Unknown**	Major		Few		Few	24	Toadfish- few
6-VIII-63	Unknown**	Major			X	Few	14	
14-VIII-63	Unknown**	Major					X	
16-VIII-63	Unknown**	X					X	
21-VIII-63	Unknown**	X						

Area C - cont'd
Page 2

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
22-VIII-63	Unknown**	X						
28-VIII-63	Unknown**	X						
20-VI-64	Unknown				X			
25-VI-64	Unknown				X			
27-VI-64	Unknown				35		17	
27-VI-64	Unknown				75		13	Hogchoker - 3
9 to 16 VIII-64	Unknown							Unknown Species - Large kill
* 29-V to 23-VI-66	Unknown			X				Total- Tens of thousands
15-V-72	Unknown	683		196	8	28	3	
25-26 VIII-72	Unknown	3176		314,374				Hogchoker - few Unknown species
28-VIII-72	Low D.O. Plankton			189,000				Sunfish - 20
2-IX-72	Low D.O. Plankton			400,000				

TOTAL KILLS = 26

Back River, Md.

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
19-V-63	Unknown	X						Minnows
25-VI-64	Unknown	X						Sunfish Carp - Total killed in the hundreds
21-IV-66	Low D.O. Pollution	X	X			X	X	Brown Bullheads Pumpkinseed
6-VII-70	Sewage Pollution	X						Bullheads Carp
5-VIII-72	Low D.O. Plankton			X Thousands				
5-VIII-72	Unknown	14	12	49,561				Brown Bullhead - 42
3-IX-72	Low D.O. Algae			5000 to 10,000				

TOTAL KILLS = 7

Chester River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
*16 to 21 VI - 63	Unknown	X		X Major		X	X	
5-VIII-63	Unknown**	X Major					X	
6-VIII-63	Unknown**	X Major					X	
21-VIII-63	Unknown**	X						
4-V-70	Commercial Discards	90	5	5				Sunfish - 25 Toad fish - 115
2-IX-72	Natural Low D.O.	2059	79				16	Pumpkin Seed - 1505 Brown Bullhead - 53

TOTAL KILLS = 6

Eastern Bay &
Miles River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
4-VI-59	Unknown				X			
1-VI-60	Commercial Discards							Species Unknown
2-VII-62	Unknown							Catfish
6-VIII-63	Unknown**	X Major			X			
9-VIII-63	Unknown**	X Major					2	
21-VIII-63	Unknown**	X						
26-VIII-64	Unknown				X			
10-IX-65	Low D.O. Natural							Stickleback - 1000 Pipe Fish - 1000 Winter Flounder - 100 Mummichog - 50 Silverside - 50 Oyster Toadfish - 50 Striped Killifish - 100
15 to 17 VIII-69	General Pollution							Hogchoker - 50 Naked Goby - 20,000 Striped Blenny - 500 Toadfish - 300 Silverside - 100

Eastern Bay &
Miles River - cont'd

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
28 to 29 VIII-69	Pollution			50	100		2	Hogchoker - 10 Silverside - 100,000 Killifish - 300 Spot - 20 Anchovy - 50 Toadfish - 10
13 to 18 IX-69	Pollution			60,000	28,000			Hogchoker - 11,000 Silverside - 900,000 Anchovy - 600,000 Mummichog - 200,000 Killifish - 200,000 Spot - 28,000 Variegated Minnow - 17,000 Naked Goby - 17,000 Toadfish - 11,000 Seven other species - 3600
18-VIII-72	Low D.O. Natural	26		1598			17	Spot - 42 Anchovy - 17
22-VIII-72	Low D.O. Natural							Species Unknown

TOTAL KILLS = 13

Fairlee Creek

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
20-VIII-63	Unknown **	X Few						Large Mouth Bass - 5 or 6

TOTAL KILLS = 1

Gunpowder River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
9 to 10 VIII-63	Unknown**							Large Mouth Bass
30-V-64	Unknown	X				X		Catfish Bluegill Pumpkinseed Large Mouth Bass
3-VI-64	Unknown	X						
2-V-70	Unknown	1000						
3-IV-70	Oil Pollution					400		Red Breast Sunfish - 360 White Sucker - 720 Red Sided Dace - 480 Northern Hogsucker - 480 Northern Creek Chub - 280 Johnny Darter - 3000 Blacknose Dace - 1080 Common Shiner - 40 Madtom - 40 Longnose Dace - 40 Bigeye Shiner - 40 Satin Finshiner - 40 Yellow Bullhead - 40 Unidentified Fish - 120 Total - 7160

Gunpowder River - cont'd

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
* Mid May to end June 71	Natural Diseases	X	X					Herring other than Alewives Catfish Carp Total - 3,000,000
*Early May end July 71	Spinning Disease			X				

TOTAL KILLS = 7

Magothy River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
27-V-55	Unknown							Species Unknown
8-V-60	Unknown			X				
9-VIII-63	Unknown**	X Major	X					
17-VIII-63	Unknown**	X						
19-VIII-63	Unknown**	X	3					Pickerel
21-VIII-63	Unknown**	X						
22-VIII-63	Unknown**	X						
26-VIII-63	Unknown**	X					X	
20-XI-63	Unknown						X	
19-VI-64	Unknown	X			X			
10-VII-64	Unknown			X			1	
11-VII-64	Unknown							Sunfish
*29-VI to 23-VI-66	Unknown			X				Total - Tens of Thousands

Magothy River - cont'd

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
*8-VI to 21-IX-68	Unknown				X			Total - Millions
26-V-69	Stranded by tide							Carp - 200
* 26-V to 9-VII-69	Unknown			X				Total - Tens of Thousands
29-VII-71	Unknown	X	X					Sunfish - 100
20-IX-72	Unknown	10	30	200				Pumpkinseed - 100 Shiners - Few Carp - 3

TOTAL KILLS = 18

Middle River, Md.

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
15-VII-57	DDT	X		X				Several Thousand Menhaden were killed
2-IV-63	Unknown							Bluegill Pumpkinseed
8-VIII-67	Unknown	10						Pumpkinseed - 100
15-V to 15-XI-71	Natural	X	X					Herring other than Alewives Catfish Carp
* Early May to end July -71	Unknown			X				Total = Hundreds of Thousands

TOTAL KILLS = 5

Patapsco River, Md.
Page 1

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
27-V-55	Unknown							Species Unknown
7-IV-57	Pollution	X	X Major	1			X	
24-I-59	Natural							Gizzard Shad
18-V-59	Dredging							Species Unknown
18-VI-59	Unknown			X				
21-VII-59	Pollution	X	X	X				Catfish
31-V-60	Unknown			X				
7-VI-60	Sewage	X		X		X		White Catfish
12-VIII-63	Unknown			X				
12-VIII-63	Unknown**	X 5000	X					Pumpkinseed - 3
27-VIII-63	Unknown**	40					2	Sunfish - 4
26-VI-64	Unknown			X				
2-VII-64	Unknown			X				
10-VII-64	Unknown			X		X		

Patapsco River, Md. cont'd
Page 2

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
18-IX-64	Unknown			X				
31-VIII-65	H_2SO_4 Pollution			2000				
15-VII-67	Unknown	X	X	X			X	Pumpkinseed Minnows Thousands in Aggregate
26-VIII-67	Low D.O.					200		
10-II-68	Temp. Shock	Dozens	Hundreds					Pumpkinseeds - Dozen Pickerel - Few Carp - Few
30-V-68	Unknown	Thousands		Few				Catfish - Few
* 8-VI to 21-IX-68	Unknown							Total - Millions
*26-V to 9-VII-69	Unknown			X				Total - Tens of Thousands
20-21 VIII-69	Sewage	Thousands						Bullheads - Dozens Pumpkinseed - Dozens
4-IX-69	Unknown	200	150				50	Silverside - 20,000 Needlefish - 50 Gizzard Shad - 20 Pumpkinseed - 20

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
14-XI-69	Unknown		Dozens					Silversides - Hundreds
5-II-70	Pollution	100						
13-VII-70	Unknown	5		5		3		Silversides - 10,000
27-VIII-70	Unknown			200,000+				
7-IX-70	Unknown			7000 #			350 #	
Mid Sept. to Mid Oct. 1970	Unknown			X				
18-II-71	Industrial Pollution	X		X			X	Thousands
31-VII-71	Unknown	X	X	X			X	Catfish Killifish Total - 70,000
24-25 VIII-71	Unknown	X		X			X	6500 killed
6-IX-71	Unknown			X				200,000 killed
15-IX-71	Related to Pollution	X	X	X	X		X	Killifish Pumpkinseed Sunfish 3240 fish killed

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
16-IX-71	Industrial Pollution			X			X	177,550 fish killed
12-X-71	Unknown							Anchovies - Thousands
9-XI-71	Industrial Pollution	X	X	X			X	Tens of thousands killed
4-I-72	Unknown			Few				
18-19 IV-72	Chlorine	13,852	1394					Catfish
6-V-72	Chlorine	91	43					Catfish - 7
6-V-72	Unknown			4		10		Pumpkinseed Sunfish
10-V-72	Unknown							Unknown species
19-25 V-72	Unknown	2-22%	1%	71-95%		1%	1%	Sunfish 1% Toadfish - 1% Brown Bullhead - 1,8% Carp - 1% Clupeids - 1%
21-V-72	Unknown	X	X	X				Gizzard Shad Carp

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
3-10 VI-72	Unknown	X	X	X			X	Goldfish 1,800,000
14-15 VI-72	Pollution	X	X	114,244			X	Catfish
30-VII to 4-VIII-72	Unknown	X	X	99%			X	Catfish Sunfish
								2,000,000 fish killed
13-14 IX-72	Unknown		445,463					
25-27 IX-72	Algae Bloom			7.27 Million				
2-XI-72	Unknown			X				

TOTAL KILLS = 51

Sassafras River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
3-VI-55	Unknown	X	X	X		X		Catfish Large Mouth *Bass*
18-IV-68	Commercial Discards	Hundreds						
*Early May to End July - 71	Unknown			X				Hundreds of thousands

TOTAL KILLS = 3

Severn River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
20-V-59	Unknown	X						
21-VI-59	Unknown			Major				Species Unknown
2-VI-60 to 6-VI-60	Unknown	X		Major				
12- to 13 VIII-63	Unknown**	X						
14-VIII-63	Unknown**	15					Few	Sunfish - 1
20-VIII-63	Unknown**	1						
24-VI-64	Unknown			500+				
6-IV-65	Industrial Pollution		31,000		Few	100		Brown Bullhead - 400 Pumpkinseed - 100 Chain Pickerel - 100 Golden Shiner - 50 White Sucker - 50 Large Mouth Bass - few Bonded Killifish - few Bluegill - few Johnny Darter - few

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
29-V to 23-VI-66	Unknown			X				Total - Tens of Thousands
8-VI to 21-IX-68	Unknown			X				Total - Millions
27-X-69	Unknown		100					Brown Bullheads - 2 Pumpkinseed - 4
15-IX-71	Related to Pollution	X						Pumpkinseed Spot
8-10 II-72	Unknown	74	1377	11,272				Pumpkinseed - 10,640 Spot - 74 Hardheads - 2

TOTAL KILLS = 13

South River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
26-V-60	Unknown	X						
14-VII-62	Unknown	X					X	Sunfish Pickerel
3-VI-63	Unknown	X				X		
11-IX-63	Unknown**	X						
20-VIII-63	Unknown**	X						
23-VIII-63	Unknown**	X						
30-XI-63	Unknown**		X					
20-24 VI-64	Unknown	1		20		10		Sunfish
27-VI-64	Unknown			X				
7-VII-65	Unknown							Pumpkinseed - 3
23-XII-65	Unknown		Hundreds					
*29-V to 23-VI-66	Unknown			X				
14-VI-67	Low D.O.	X						Hogchokers Pumpkinseeds

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
*8-VI to 21-IX-68	Unknown			X				Total - Millions
27-III-69	Unknown		100					
*26-V to 9-VII-69	Unknown			X				Total - Tens of Thousands
20-V-70	Unknown							Catfish - 40
26-VI-72	C.F.D.			250				
28-VIII-72	Low D.O. Plankton			54,000				
5-6-IX-72	Low D.O. Plankton			2,000,000				

TOTAL KILLS = 20

Susquehanna Flats Area

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
21-VIII-63	Unknown**	Major	X				X	
22-VIII-63	Unknown**	Major					X	
1-6-VI-64	Dredging						X	Herring other than Alewives Catfish Sunfish Large Mouth Bass American Shad
30-VII-64	C.F.D.						200	Large - 20# ea.
4-V-65	Conowingo Dam	Few	Few					Herring other than Alewives Tons Channel Catfish - Tons River Herring - Tons Minnows - Few
23-V-66	Commercial Discards							Herring other than Alewives 3000
7-8-III-67	Temp. Shock		100's					
31-III-67	Pollution							Bluegills Suckers Crappies Minnows Pumpkinseeds Hundreds in Aggregate

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
4-V-67	Conowingo Dam							Herring other than Alewives - thousands
*13-VI-67	Commercial Discards	1000's						
7-V-68	Chromium		Few					Herring other than Alewives - Hundreds Hickory Shad - Dozens
7-V-70	Pollution	1	2					Silvery Minnows - 300
20-V-70	Pollution	7						Herring other than Alewives - 10 Minnows - 200
29-V-70	Unknown							Catfish - 50 Sunfish - 25 Carp - 50 Crappie - 25
18-VI-70	Pollution	X						Catfish Carp
16-VII-70	Cannery Pollution	Hundreds	Hundreds		Thousands			Sunfish - Tens Chain Pickerel - Tens Spottail - Hundreds

Susquehanna Flats Area - cont'd

Page 3

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
9-V-71	Operations at Conowingo Dam	Few	Few					Herring other than Alewives - 1,253,516
*Mid May to End June 71	Natural	X	X		X			*** Catfish Carp - Millions killed
*Early May to End July 1971	Unknown			X				*** Hundreds of thousands
12-VIII to 2-IX-71	Explosives	X					X	Catfish Sunfish Crappie Carp Gizzard Shad Carp Suckers Total - 7056

TOTAL KILLS = 20

*** Total kill for these two incidents estimated at 2.8 million (MDNR); both kills are related to kill of 9-V-71 (decaying fish, etc.)

West and Rhode Rivers

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
19-V to 1-VI-60	Unknown							Species unknown
18-VI-63	Unknown							Species unknown
8-VIII-63	Unknown**	Major	2			Several	X	Pumpkinseeds - 2
6-VII-64	Unknown							Sunfish
*8-VI to 21-IX-68	Spinning Disease			Millions				
26-V to 9-VII-69	Unknown			X				Total - Tens of thousands
25-VIII-72	Low D.O. Plankton			X				
Early Sept. 1972	Low D.O. Plankton			X				
8-IX-72	Unknown			3300				
13-IX-72	Unknown			909,000				

TOTAL KILLS = 10

Wye River

UPPER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
5-V-62	Unknown	X						Herring other than Alewives
22-VII-70	Silage							Species Unknown

TOTAL KILLS = 2

Area A

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
26-V-59	Unknown	X			X			
4-VI-59	Unknown				X			
9-VII-67	Blasting			Hundreds				
18-VIII-72	Low D.O. Plankton	X		X		X	X	Sunfish Hogchokers Brown Bullhead

TOTAL KILLS = 4

Middle Bay Area A

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
Mid April to Mid May 72	Unknown	683		196	8	28	3	Bay Anchovy - 3

TOTAL KILLS = 1

Area B

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
*26-V-59	Unknown	X			X			
*4-VI-59	Unknown				X			
27-VII-68	C.F.D.						X	

TOTAL KILLS = 3

Appendix 12

Chesapeake Bay off
Barren Island
Navy Explosions

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
7-11-V-56	N.E.	1		28,000 #			15	Herring other than Alewives Weakfish - 1 American Shad Carp - 2
23-31 VII-56	N.E.				100+			Weakfish - 35
19-28 VI-57	N.E.			16,135				Weakfish - 333 Spot - 260
10-VI-59	N.E.							Species Unknown - 2 bushels
11-14 VI-60	N.E.	2		27,900			76	Silver Hake - 736 American Shad - 2 Weakfish - 3
12-21 XI-60	N.E.	139		2,900		2	1500	Weakfish - 27 Blueback Herring - 62 Star Butterfish - 1 File Fish - 1 Searobin - 1 Anchovy - Several Hundred
9 to 14 VIII-61	N.E.	1			1500			

Chesapeake Bay off
Barren Island - cont'd.
Navy Explosions

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
9-IX-61	N.E.			110 #				
6-VII-65	N.E.			X				
6-VI-68	N.E.			Hundreds		Few		Puffer - Few Black Drum - 1
26-IX-68	N.E.						Dozens	Harvest Fish - Hundreds Anchovy - Hundreds Weakfish - Few
24-X-68	N.E.			Thousands			Dozens	Harvest Fish - Hundreds
24-XI-71	N.E.			X		X		Weakfish Anchovies Harvest Fish File Fish Total - 1 Million
6-V-72	N.E.	27				250		
12-V-72	N.E.			1000			9	
18-V-72	N.E.			300			300	Herring other than Alewives - 300
19-20 VI-72	N.E.			3500				File Fish - 4

TOTAL KILLS = 17

MIDDLE CHESAPEAKE BAY

Choptank River

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
8-VIII-63	Unknown**	X						
9-VIII-63	Unknown**	X				X		Toadfish
13-VIII-63	Unknown**	X						
21-VIII-63	Unknown**	X						
4-IX-63	Unknown**	X					1	
30-VI-64	Unknown							Sunfish
16-VI-64	Pollution							Sunfish
8-VIII-65	Pollution		X Few			X Few		Sunfish - Hundreds White Catfish - Thousands Madton - Hundreds White Sucker - Hundreds Johnny Darter - Hundreds
*26-V to 9-VII-69	Whirling Disease			X				
5-VIII-69	Low D.O. Pollution	30,000	6000	10,000	6000			Spot Spottail Shiner - 10,000 Pumpkinseed - 3000 Golden Shiner - 1500 Brown Bullhead - 600

Choptank River - cont'd

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
16-VII-70	Cannery Wastes	Hundreds	Hundreds		Thousands			Sunfish - Tens Spottail Shiner - Hundreds Chain Pickerel - Tens
19-V-71	Unknown	200						Catfish Toadfish

TOTAL KILLS = 12

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
Fishing Bay								
22 & 23 VIII-63	Low D.O.	X					X	Sting Ray Spotted Trout
Honga River								
28-I-63	Unknown **	X					X	
Manokin River								
2-12-IX-63	Unknown**	X						

Nanticoke River

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
3-4-IX-63	Unknown**	X						
26-VIII-71	Related to Pollution			X				
31-VIII-71	Related to Pollution			X				

TOTAL KILLS = 3

Patuxent River

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
27-29 VII-63	Unknown**	13,025					2	
15-16 VIII-63	Unknown	X						
18-VIII-63	Unknown	X						
18-VIII-63	Insecticide							Minnows
9-VI-64	Unknown							Unknown species
27-IX-67	Rodimene Dye						300	Hogchoker - 10
2-IV-68	Commercial Discards	Hundreds						
18-VI-68	C.F.D.			Thousands				
Mid April 1972	Unknown	683		396	8	28	3	Bay Anchovy - 3

TOTAL KILLS = 9

Patuxent River
Navy Explosions

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
Oct & Nov. '56	N.E.				4200			Weakfish - 50 Spot - 55
13-V-69	N.E.	Hundreds						Am. Shad - Dozens
23-IX-71	N.E.	X					X	Weakfish Spot Total - 59
2-XII-71	N.E.			25				
20-V-72	N.E.	5 #		30 #		1		Catfish - 1
11-VII-72	N.E.	23	1650				1	Catfish - 15 Spot - 1 Carp - 1
8-VII-65	N.E.							Pumpkinseed - 3

TOTAL KILLS -= 7

Potomac River, Md.
Page 1

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
19-IX-62	Blue Green Algae							61,000 # - Unknown species
6-10 IX-62	Sewage	X			X	X	X	Catfish Blues Gizzard Shad
28-VIII-62	Unknown						X	
14-V-62	Unknown	X						
30-VI-63	Unknown**	X						
10-VII-63	Unknown**	Major				X	X	Hogchoker
11-VII-63	Unknown**	X					X	
4-VIII-63	Unknown							Catfish
24-IX-63	Unknown**	X						
2-I-64	Unknown	X						
18-V-64	Unknown	X				X	X	Catfish
29-V-64	Unknown	Major				X		Catfish Gar

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
29-VIII-64	Unknown	200	3		5000		1	Catfish - 25
19-I-65	Cold Shock	20,000						
16-28 V-65	Disease	X	Few			Few		Herring other than Alewives - Thousands White Perch - Hundreds of thousands Gizzard Shad - few Oyster Toadfish - few Hogchoker - few Carp - few
22-VI-65	Unknown				Many			Gizzard Shad - few
16-VII-65	Insecticides							Minnows
11-31 V-66	Pollution & C.F.O.	X				Thousands		Herring other than Alewives Thousands White Perch - Tens of Thousands Shad - Thousands
4-VI-67	Unknown	Thousands		Hundreds				
27-VIII-67	C.F.D.	Hundreds						

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
15-16 II-68	Unknown	X						White Perch - Tens of Thousands
18-VII-68	C.F.D.	Hundreds					Hundreds	
29-VII-68	Unknown	Dozens	Dozens					Herring other than Alewives - Thousands Catfish - Dozens
8-V-69	Pollution	Thousands						Herring other than Alewives - Sunfish - Hundreds Herring - tens of Thousands
10-VI-69	Low D.O.							Catfish - Thousands
7-VII-70	C.F.D.						X	Spots - 5-6 boxes
29-VIII-70	Pepco Intake	8		500				Hogchoker - 100 Summer Flounder - 4
19-IX-70	Disease							Catfish - 1000-2000
15-X-70	Low D.O. Disease	Thousands		Thousands				
Mid-X-70	C.F.D.	X		X			X	Spots

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
26-V-71	Unknown	1000						Species Unknown
13-VI-71	Unknown	10,000						Herring other than Alewives Catfish Shad Species unknown
21-VII-71	Natural			Millions				
28-VII-71	Natural			Thousands				
15-II-72	Unknown	X						White Perch - estimated 615-500

TOTAL KILLS = 35

Potomac River
Navy Explosions

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
26-VI-62	N.E.	25						
13-VII-62	N.E.	480	6		50	2		Catfish - 10
20-VII-62	N.E.	150						
25-VII-62	N.E.	45						
1-VIII-62	N.E.	180						Catfish - 15 Madtom Gizzard Shad
14-VIII-62	N.E.	300			100			
17-VIII-62	N.E.	200			75			
31-VII-69	N.E.	1000's						
24-II-71	N.E.	20						
1-IV-71	N.E.	1000's			1000's		1000's	
28-IV-71	N.E.	X					X	Herring other than Alewives Total - 25

TOTAL KILLS = 11

Potomac River, Va.

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
8-V-69	Unknown							Blueback Herring 5000 to 10,000
26-II-70	Red Tide							Flounder - 5
27-VII-70	Chlordane							Bluegill - 300 Lamprey - 3
27-30 VII-72	Low D.O.			5000				

TOTAL KILLS = 4

Wicomico River

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
15-17 VII-59	Creosote	X	X			X	X	Herring other than Alewives Catfish Sunfish Hogchoker Largemouth Bass Spot Carp American Shad Gizzard Shad
5-VI-63	Unknown							Species Unknown
21-VIII-63	Unknown**	X						
24-VIII-63	Unknown**	117						
28-VIII-63	Unknown**	200						
1-IX-63	Unknown**	Thousands						
4-IX-63	Unknown**	X						
5-IX-63	Unknown**	X						
9-IX-63	Unknown**	X						

Wicomico River - cont'd

MIDDLE CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
8-IX-66	Unknown	10				10		Carp - 50
17-VII-67	Industrial Pollution	X	X			X		Catfish Crappies Anchovy Gizzard Shad Silversides Carp Minnows Total - Thousands

TOTAL KILLS = 11

Area A

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
4-VI-71	C.F.D.			15,000 to 17,000				
25-VII-72	Low Salinity							Bluefish Filefish

TOTAL KILLS = 2

Appomattox River, Va.

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
1-X-68	Low D.O.							Catfish Largemouth Bass - 300,000 Bluegill - to 500,000

TOTAL KILLS = 1

Back Bay

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
24-V-68	Toxaphene		100					Sunfish - 800 Largemouth Bass - 4 Rock Bass - 100 Pickerel - 6 Chubs, Suckers & Carp - 190

TOTAL KILLS = 1

Area C

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
9-VIII-68	Unknown			X				Unknown Species
26-VII-73	Unknown			200,000				

TOTAL KILLS = 2

LOWER CHESAPEAKE BAY

Elizabeth River

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
21-VIII-63	Unknown							Unknown Species
6-IX-63	Low D.O.							Unknown Species
5-VI-70	Low D.O.							Unknown Species
17-VII-71	Unknown			5000				

TOTAL KILLS = 4

Great Wicomico River

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
1-VI-60	C.F.D.			X				Toadfish

TOTAL KILLS = 1

James River

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
25-26 III-68	Oil				1000			Bluegills - 2
21-V-68	Sewage							Herring other than Alewives
5-VII-68	Sewage					10		Carp - 400 Brown Bullhead - 350
11 to 12 VII - 68	Pollution							Largemouth Bass - 15 Perch - 375 Shad - American - 50
27 to 28 VII-68	Pollution	15,000						Catfish - 60,000 Sunfish - 5000 Shad - 20,000
13-VIII-68	Lime Slurry	X	X					Catfish Sunfish Unknown Species
8-VIII-68	Unknown							Sunfish
6-IX-68	Unknown							Unknown Species - 1000
21-IX-68	Sewage				X			Catfish
7-X-68	Oil	X						Herring other than Alewives Catfish - 1500

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
11-VI-70	Pollution							Catfish Hickory Shad
25-VI-70	Sewage					8		Gizzard Shad - 180 Bluegill - 20
30-VI-70	C.F.D.							Catfish - 43 Carp - 2 Shad - 5 Toadfish - 1
23-IV-71	Sewage	3414						Herring other than Alewives - 3413 Bluegill - 3413 Channel Catfish - 3413
18-V-71	Unknown	X						Catfish
15 to 25 V-71	Unknown	X				X		Herring other than Alewives American Shad Catfish Carp Total Fish killed - 3296
29-IV-71	Sewage					200		Catfish - 500 Sunfish - 700 Largemouth Bass - 100 Carp - 500
2-VI-71	Pollution	X						Catfish American Shad Total - 2000

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
28-VII-71	Unknown			1500				
28-VII-71	Chromium							Spot - 94
4 to 5 VIII-71	Unknown							Catfish - 1000
20-VIII-71	Unknown							Catfish - 6000+
8-IX-71	Sewage	X				X	X	Catfish Gar Carp Total - 12,077
22-XI-71	Low D.O. Pollution							Catfish - 10
2-XII-71	C.F.D.							Spot
6-VI-72	Unknown					X		Sunfish Shad
18-V-73	C.F.D.							Bluefish - 500

TOTAL KILLS = 27

Lynnhaven Bay

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
30-VI-70	Unknown			X				

TOTAL KILLS = 1

Rappahannock River

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
9-VIII-68	Pollution Low D.O.	9181	766					Largemouth Bass - 26 Bluegill - 422 Pumpkinseed - 53 Warmouth - 26 Chain Pickerel - 53 Channel Catfish - 53 Bullhead Catfish - 106
28-IX-68	Low D.O.					X		Hogchoker Mummichog Oyster Toadfish Sheepshead Minnow Silversides
30-VII-71	Unknown			300				
25-VII-72	Low Salinity							Bluefish Filefish

TOTAL KILLS = 4

York River

LOWER CHESAPEAKE BAY

Date of Kill	Most Probable Cause	White Perch	Yellow Perch	Menhaden	Alewives	Eels	Striped Bass	Other Species Observed
10-VIII-61	Unknown							Unknown species

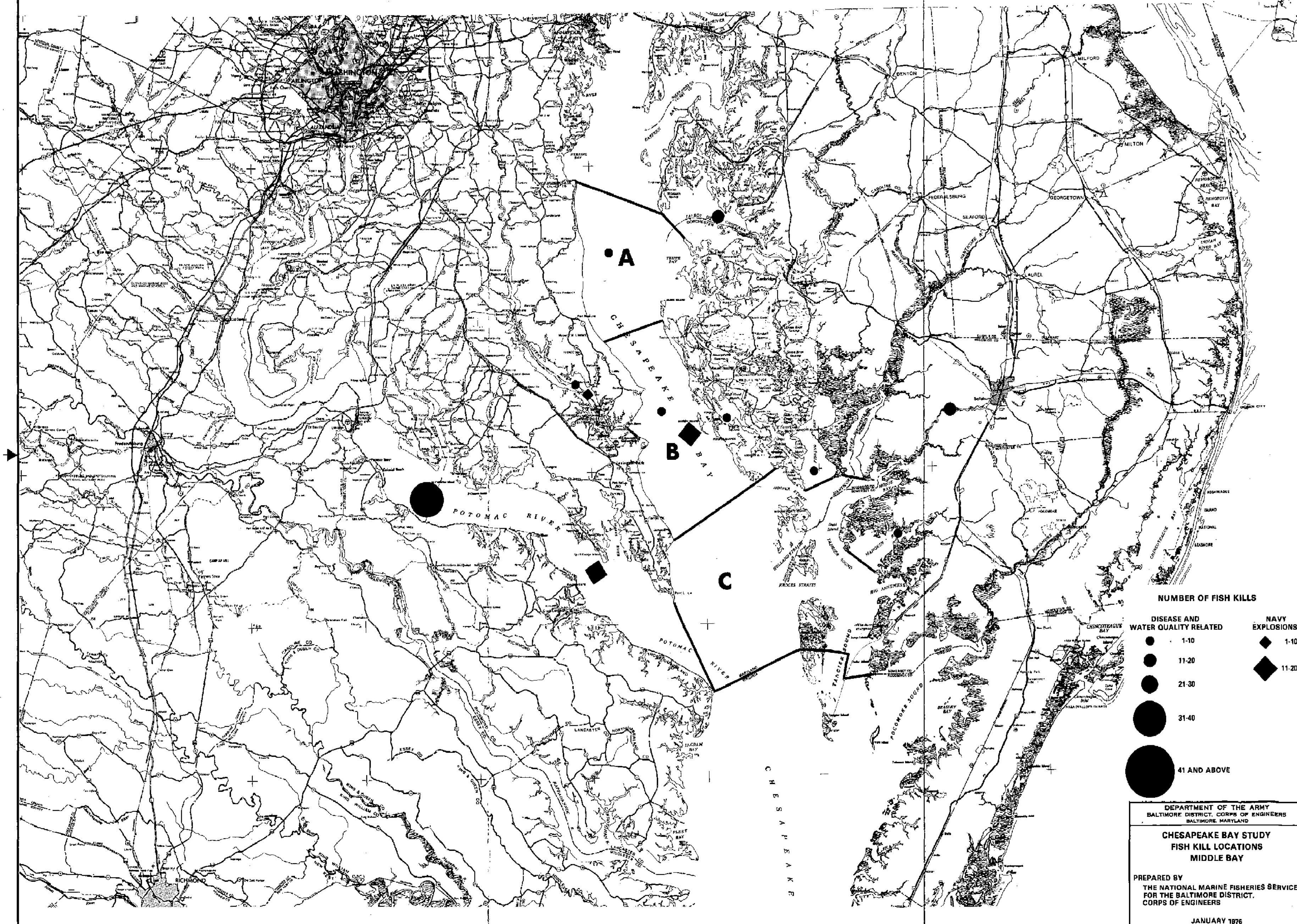
TOTAL KILLS = 1

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

CHESAPEAKE BAY STUDY
FISH KILL LOCATIONS
UPPER BAY

PREPARED BY
THE NATIONAL MARINE FISHERIES SERVICE
FOR THE BALTIMORE DISTRICT,
CORPS OF ENGINEERS

JANUARY 1976



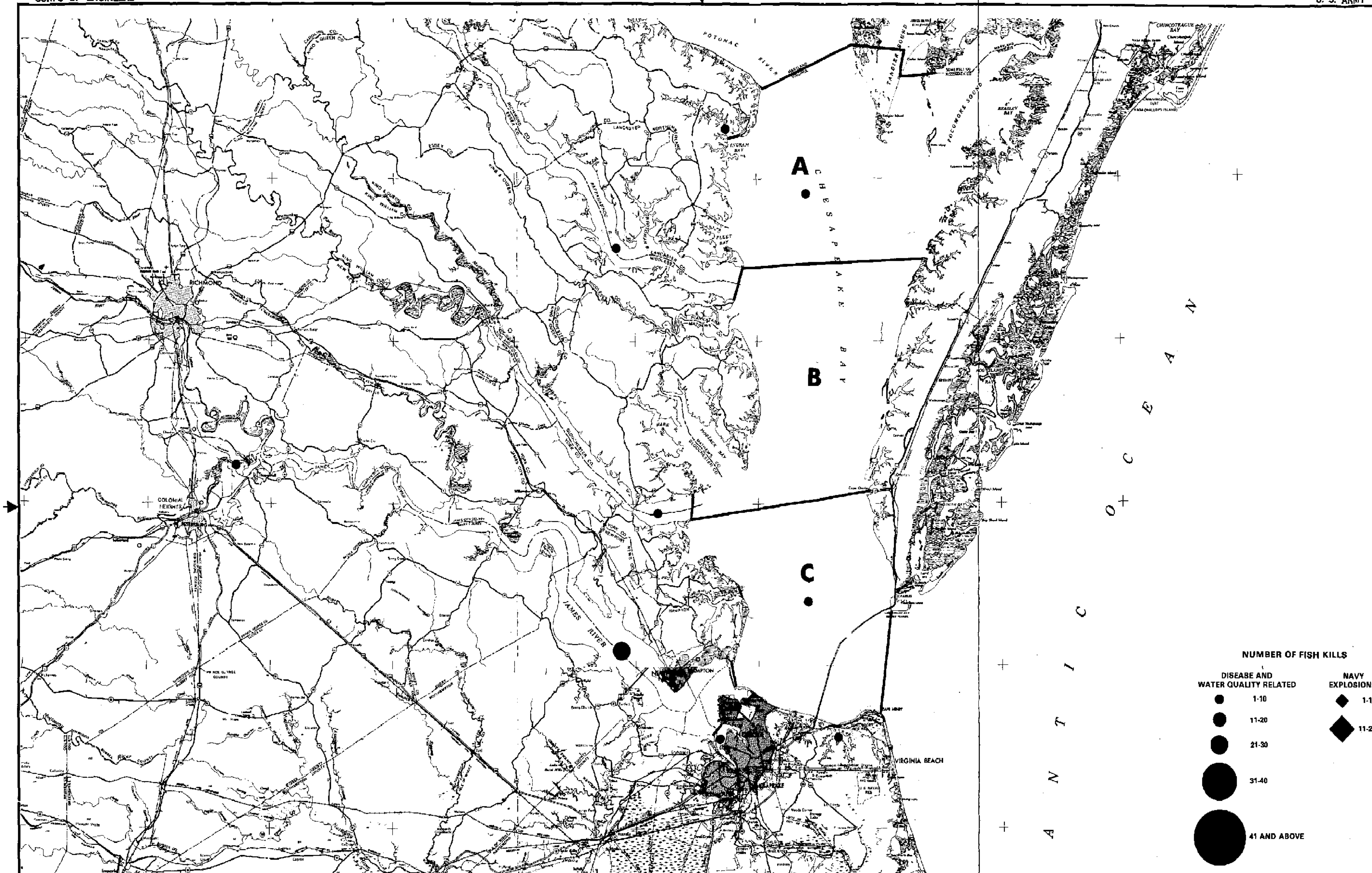
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

CHESAPEAKE BAY STUDY
FISH KILL LOCATIONS
MIDDLE BAY

PREPARED BY
THE NATIONAL MARINE FISHERIES SERVICE
FOR THE BALTIMORE DISTRICT,
CORPS OF ENGINEERS

JANUARY 1976

PLATE 12-2

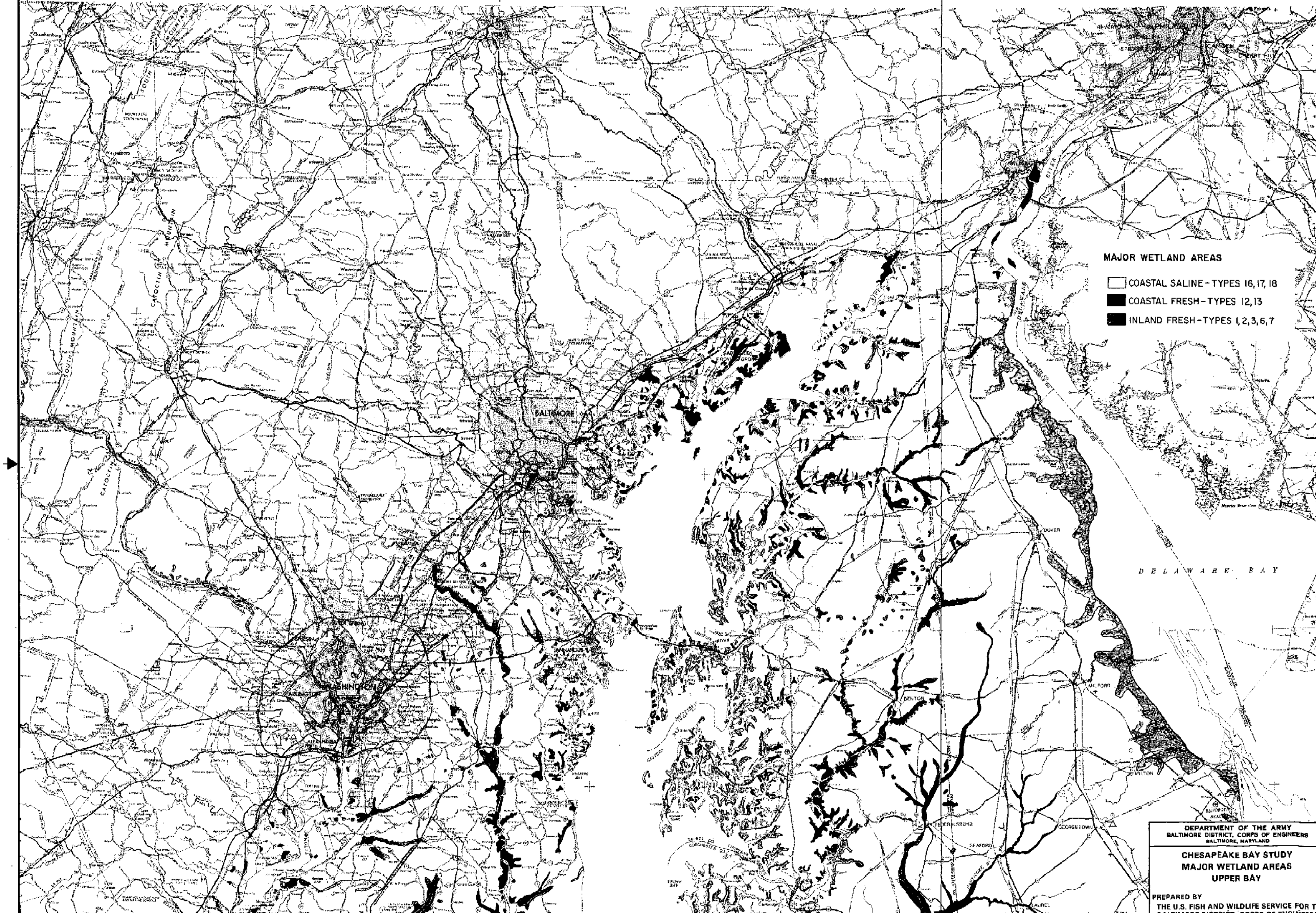


DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

CHESAPEAKE BAY STUDY
FISH KILL LOCATIONS
LOWER BAY

PREPARED BY
THE NATIONAL MARINE FISHERIES SERVICE
FOR THE BALTIMORE DISTRICT,
CORPS OF ENGINEERS

JANUARY 1976

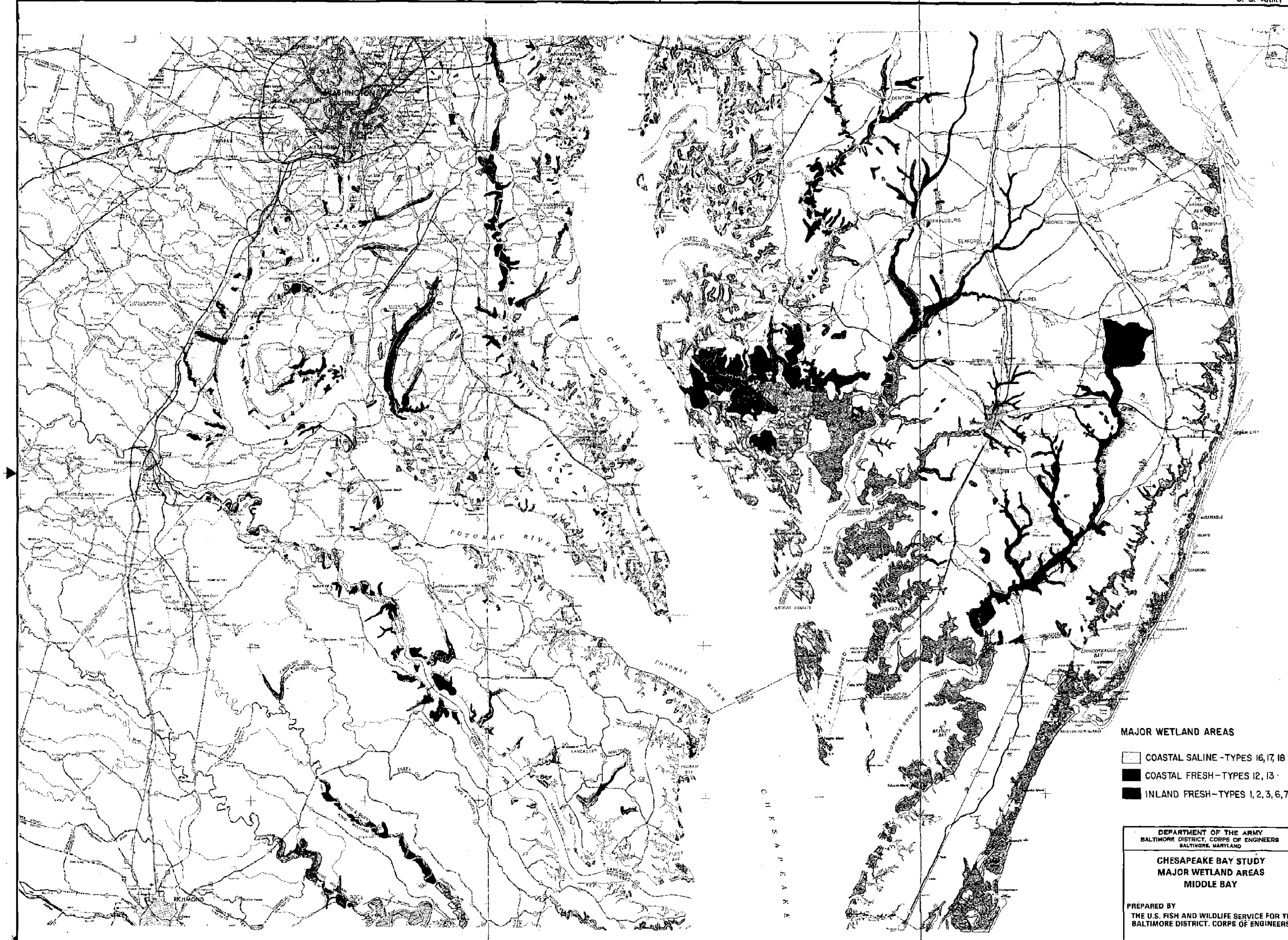


DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

CHESAPEAKE BAY STUDY
MAJOR WETLAND AREAS
UPPER BAY

PREPARED BY
THE U.S. FISH AND WILDLIFE SERVICE FOR THE BALTIMORE DISTRICT, CORPS OF ENGINEERS

JANUARY 1976



DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND

CHESAPEAKE BAY STUDY
MAJOR WETLAND AREAS
MIDDLE BAY

PREPARED BY
THE U.S. FISH AND WILDLIFE SERVICE FOR THE BALTIMORE DISTRICT, CORPS OF ENGINEERS

JANUARY 1976

CORPS OF ENGINEERS U. S. ARMY

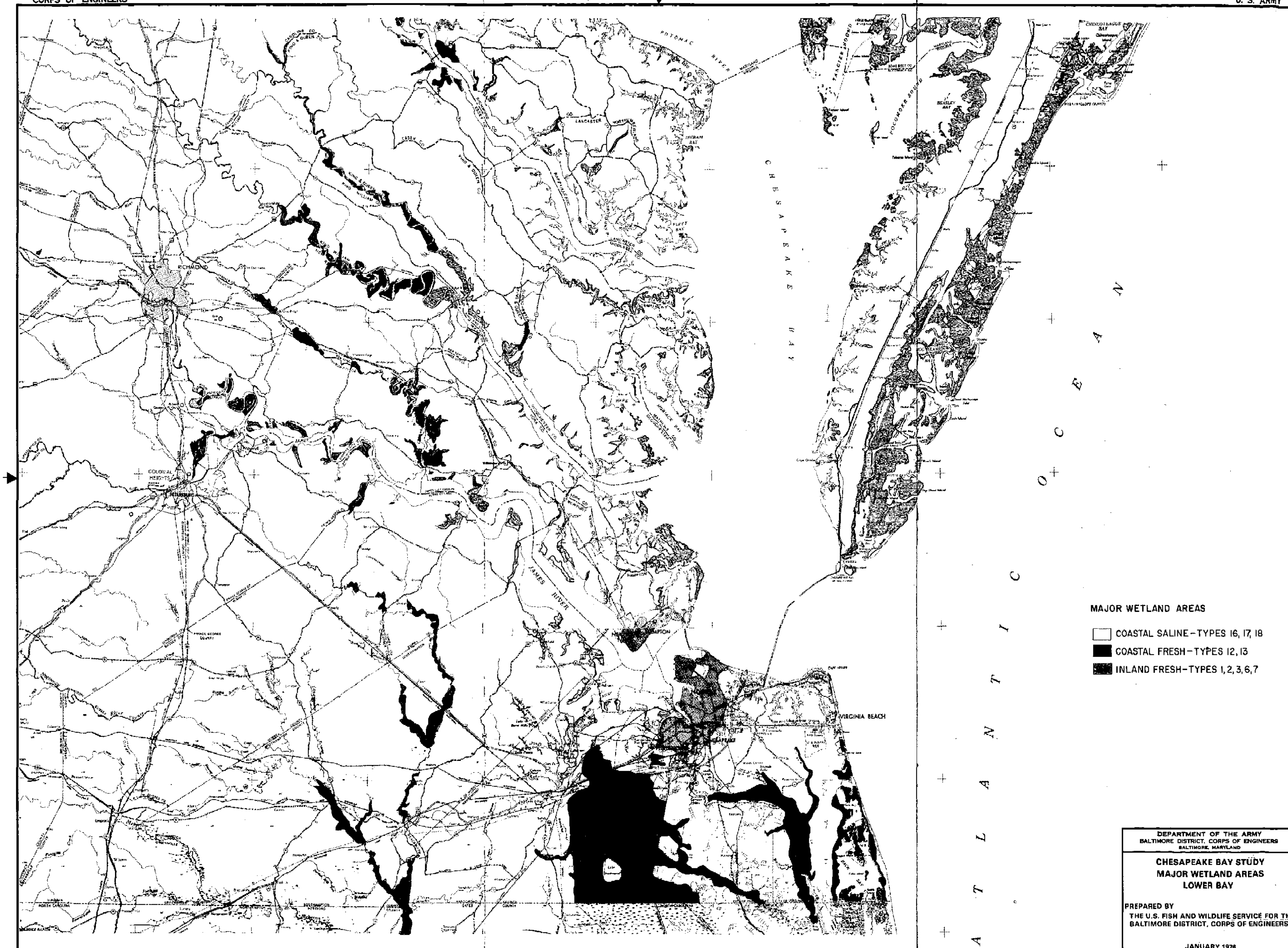


PLATE 12-6