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January 18, 1990

Carol Kilbride
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Dear Carol,

Here is a current version of our revised draft final report on the finfish resources of Buzzards Bay. I think that most of the substantive comments made by the reviewers have been addressed in this version. Your comments and suggestions for further alterations will be gratefully received. If there are any particular problems or comments, please don't hesitate to give me a call.

Sincerely,

Sanford Moss

enclosure

THE FINFISH RESOURCES OF BUZZARDS BAY

Draft Final Report

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and
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PREFACE

This study gathered and collated the existing records of finfish collections from Buzzards Bay. The scattered (and sometimes proprietary) nature of the data assembled here required a high degree of cooperation among many individuals and institutions. We would like especially to acknowledge the following: From the Massachusetts Division of Marine Fisheries we were materially helped by Leigh Bridges, Arnold Howe, Drew Kolek, Phillips Brady, and Brian Kelly. Most of the tedious work of assembling the data base was the province of Gary Nelson. Barbara Moss cheerfully helped to construct tables and figures. Throughout the project we were capably guided and assisted by Dr. Wendy Wiltse and Carol Kilbride of the EPA Buzzards Bay staff, and by Bruce Tripp of the Executive Office of Environmental Affairs, Commonwealth of Massachusetts.

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EXECUTIVE SUMMARY

Published and unpublished data on finfish collections in Buzzards Bay, Massachusetts were assembled from 48 reference and raw data sources. They contain information on more than 889,500 individual fish representing 206 species. The records of these species, their collection dates, data sources, station locations, and their absolute and relative abundances, were entered into a data base designed to be compatible with others of the National Estuary Study Program. The sources of this information were assessed for their relative quality, and the data were arranged in two sub-sets--one dating from before 1920; the other after 1960 (no fish collection records were found that date from the intervening years). The present data base contains 5,021 records, 3,947 being in the post-1960 set.

The disparate collecting methodologies and sampling designs represented in the data base preclude any meaningful analysis of it, such as for historical trends in abundance. The details of the collection records for 11 representative species (Atlantic menhaden, bay anchovy, Atlantic silverside, butterfish, black sea bass, cunner, mummichog, northern searobin, scup, tautog, winter flounder) are presented, along with a synopsis of life history information for each. A brief history of the study of Buzzards Bay fishes and the fisheries for them is included.

INTRODUCTION

This study, as part of the larger Buzzards Bay Project, is an attempt to compile, summarize, and format into a data base all data for finfish resources in Buzzards Bay available through 1987. It specifically treats those fisheries resources comprised of finfish, and carries with it the following charge.*

Objective: To compile and summarize the existing finfish data base for Buzzards Bay.

Products: Final report to include a complete list of information sources used, a summary of the work which has been done in each of the major topic areas, species list of all finfish reported from Buzzards Bay, with particular attention to be devoted to the following 11 species that are deemed to be of particular ecological, recreational, and/or commercial importance in Buzzards Bay:

Atlantic menhaden
Atlantic silverside
Bay anchovy
Black sea bass
Butterfish
Cunner
Mummichog
Northern sea robin
Scup
Tautog
Winter flounder

These species were to be evaluated for status and trends where the integrity of the data base permitted such an analysis. Summaries of critical features of their life histories that might interact with the resources provided to them by Buzzards Bay were also to be undertaken.

This report is the product of our investigations and treats those elements (among others) in the charge above, although not necessarily in the order given.

This compilation of Buzzards Bay finfish resources was undertaken as one component of the larger Buzzards Bay Project, jointly sponsored and managed by EPA and the Massachusetts Executive Office of Environmental Affairs. One goal of this larger study is to develop an environmental master plan that will result in a sustained, acceptable level of environmental quality for Buzzards Bay.

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* - EPA Cooperative Agreement with Southeastern Massachusetts University. The Finfish Resources of Buzzards Bay. August, 1985. Renewed August, 1986.

CONCLUSIONS AND RECOMMENDATIONS

1. Records of finfish collections in Buzzards Bay were identified from 48 literature and data collection sources. This information was used to compile a data base that consists of 5,021 species-specific records that include information on more that 889,000 individual representing 206 species. 1,074 of these records stem from collections made before 1920, and 3,947 represent fishes collected after 1960.

2. Buzzards Bay has an early history of ichthyological research, and is a site of commercial fishery management. This history is summarized and reviewed.

3. The complex and open circulation pattern of the Bay, the diversities of sampling gear and uncoordinated sampling designs, and the widespread distribution of its fishes outside of the Buzzards Bay all conspire to make an analysis of the present data base for status and trends unreliable.

4. The species composition was determined and compared for the Pre-1920 and Post-1960 segments of the data base. It is suggested that the apparent differences that exist between the two segments are influenced by the different capture methods used in these eras (fish traps prior to 1920; seines and trawls after 1960) to such a degree that further analysis is unwarranted.

5. Eleven important fish species were chosen for closer examination of information relating to their life histories, and their occurrence in the data base. These species are: Atlantic menhaden, Atlantic silversides, bay anchovy, black sea bass, butterfish, cunner, mummichog, northern searobin, scup, tautog, and winter flounder.

6. The abundance of young-of-the-year size classes in late summer for all important species studied confirm the notion that Buzzards Bay is a nursery and rearing ground.

7. Recommendations for further study of Buzzards Bay finfish include:

a. Because of the relative dearth of scientific finfish collections in the recent past, a continually up-dated data base of Buzzards Bay finfish should be maintained and analyzed.

b. Efforts should be taken to extend sampling efforts through all months of the year, and throughout the Bay. A uniform data report form should be used by all collectors, and agreement should be reached on a common sampling protocol

c. Forage species resident to pollutant-impacted embayments should be the subjects of future study, especially since an adequate history of study exists for them. Such species as Atlantic silverside and cunner might be important indicators of ecosystem stress. Other species worthy of close attention include those larger fish that are not targeted by fisheries. These include the northern searobin and cunner.

d. Future studies and collections of finfish in the Buzzards Bay system should be better coordinated with respect to gear selection and sampling design.

METHODS

Data Sources

Finfish collection data for Buzzards Bay were gathered from the published scientific literature; raw data contained in trawl logs and collection summary sheets from both the Massachusetts Division of Marine Fisheries and Southeastern Massachusetts University; student theses and project reports; unpublished project and technical reports from SMU and DMF personnel; fisheries records maintained by the town of Bourne; and fisheries reports to the Great and General Court of Massachusetts. The complete reference sources are listed in Appendix A.

Evaluation Criteria

As these data were identified they were incorporated into the data base to be described below, each source being coded by a unique "reference number". These reference numbers provide keys to filtering the data base, so that users can apply their own criteria, whether to accept or reject certain data sets. We have applied (in annotations to the sources listed in Table I) our assessment of the relative quality of each source. The criteria upon which we based this analysis conform to the following:* (a) breadth of spatial and temporal coverage; (b) project design and completeness of the data set; and (c) general quality and reliability of the data set. Although few, if any, of the finfish data were collected under formal programs of quality assurance, we relied on our professional judgment to designate a reliability factor for each data set. Data accessibility is not a criterion that we applied. Although some of the data sets are not accessible, existing in poorly known locations, most of the information in them is now in the data base appended to this report, and is therefore widely accessible.

Data Record Format

Decisions about what data to include in the data base were constrained by requirements for inclusion of this data base into more inclusive ones, such as the Ocean Data Evaluation System (ODES) and that maintained by the National Estuary Program. The data had to be reported in an 80 column card image format. Each collection record carries with it the latitude and longitude, the date of collection, the gear used, and the abundance of fishes collected--either absolute where quantitative data is available or relative, where qualitative assessments were made by the collectors. Species are identified in the records by their unique National Oceanographic Data Center (NODC) codes and special notes or comments are also included. A detailed description of the fields within in each record is given in Appendix E.

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* - These criteria were developed for the Buzzards Bay Project by Dr. Betsy Brown of Batelle Institute, Duxbury, Massachusetts.

The primary key to the database entries is species--by NODC code number. Each record within the data base thus represents a unique collection record for a single species of finfish. Each sample of fish, collected at a single station on a single day is represented in the data base by as many records as there were species in the sample.

Data base form and size - The existing finfish data base, provided with this report, consists of 5,021 records, each occupying 80 columns. A print-out of the entire data base is attached to this report as APPENDIX F. The historical lack of continuity in Buzzards Bay finfish collections presents a logical and useful way to split the data base into two segments.

The first (and smaller) section comprises the "older" collections, all obtained prior to 1920*, and most of which include often vague identifications as to collection locations, dates, and absolute or relative abundances of the fishes caught. Much of these data were collected under quite different sampling protocols than all of the modern collections. These factors allowed the decision to divide the data base into two parts, composed on one hand, of the older data sets, and on the other, of the relatively recent, post-1960, data sets. This decision does not preclude sorting the two data bases, selecting certain categories (species, references, or sampling stations, for example) and then merging the cloned data bases for analysis. Database software easily allows this.

The interactive database software used in this project is PC-FILE:dbf version. This is a widely distributed program that is inexpensive, not copy protected, "user friendly", and relatively powerful. The software is compatible with IBM personal computers and nearly all others that use the MS-DOS operating system. A useful aspect of this version of PC-FILE is the fact that the format of the records is the a form compatible with dBASE III, another widely used database system. Instructions for accessing the data base through PC-FILE are given in Appendix D.

* - Marshall (1946) makes reference to fish traps operating in the summer of 1943 in Buzzards Bay, and of experimental trawls made near the Weekpecket Islands on August 27, 1943, but we have been unable to locate collection records for this sampling.

RESULTS AND DISCUSSION

History of Buzzards Bay Ichthyology

Buzzards Bay was an important setting in the early study of the fishes of Massachusetts. Massachusetts coastal marine ichthyology began even before the establishment of the English settlements. Nathanial Gosnold in 1602 feasted on codfish and "red herring" with Indians on the shore of Buzzards Bay (Gookin and Barbour, 1963). Capt. John Smith explored the Massachusetts coast in the spring of 1614 and his sketch map for the Plymouth Company included the region to be known as Buzzards Bay. In A Description of New England (1616), he listed 16 species of fishes: "turbut, sturgion, cod, hake, haddock, cole, cusk or ling, shark, mackerrell, herring, mullet, base, pinacks, cunners, perch, eels."

This report influenced the colonists as they moved toward Massachusetts, and one of the new immigrants, Higginson (1630), confirmed Smith's observations when he wrote, "The aboundance of Sea-Fish are almost beyond beleeving and I should scarce have beleeved it except I had seene it with my own eyes." Numerous other reports testified to the richness of the inshore Massachusetts waters. The most lengthy by Josselyn (1675), An Account of Two Voyages to New England, includes 65 names of presumed fishes, of which approximately 45 are what we now call fishes.

Early scientific memoirs on fishes of coastal southeastern Massachusetts were prepared by Lesueur (1816-1819). He collected from many coastal Massachusetts fishing towns and fish markets. His collections produced a number of new species, which he subsequently described in the Journal of the Academy of Natural Sciences of Philadelphia.

In 1833 and 1843, J. V. Smith issued his Natural History of Fishes of Massachusetts. Seemingly authoritative, but in fact a compendia of misinformation, these volumes misled many of the fishermen and fish and fishing writers of the 19th century. Frequent evidences are to be found of Smith's influence in the first American book on angling--Brown's (1850) American Angler's Guide, Herbert's (1859) Frank Forrester's Fish and Fishing of the United States, and in Scott's (1875) Fishing in American Waters. These three works served as fishing guides for over 30 years, and because of their dependence on Smith's incorrect species descriptions, distributions, and habits, played no small part in confusing legislators, fishermen, and even esteemed naturalists.

Another author, contemporary with Smith, who for nearly 30 years published extensively on the fishes of Massachusetts, is David H. Storer. Storer produced one of the first comprehensive illustrated volumes on regional fishes in the United States. His Report of the Fishes of Massachusetts (1839 and 1843), remains a landmark. And to his credit, he completely ignored Smith's work. The report of 1839 was a useful compilation of information about fishes, and for the first time it brought together species descriptions which were previously widely scattered in scientific publications. Much of the material was provided to Storer by his friend, Dr. Leroy M. Yale, a practicing physician of Holmes Hole on Martha's Vineyard (Gill, 1904). It is of special interest because it specifically notes records for Buzzards Bay.

Spencer Baird, who was to become the first U. S. Fish Commissioner, spent several summers at Woods Hole in the 1860's. Theodore Gill catalogued most of his collections from this region and they are recorded in the Proceedings of the Academy of Natural Sciences of Philadelphia.

In 1872 Lyman published a paper entitled, "The fishes taken in the Waquoit weir, April 18 to June 18, 1871." Only 44 species were obtained. The nomenclature was outdated and the area is only proximal to our study region. Nevertheless no species previously unknown to the state or region were added. This is generally recognized as the last authoritative faunal contribution by an amateur Massachusetts fish naturalist.

The United States Fish Commission was established in 1871, and Woods Hole was selected as a field station. In a few years 23 new species were recorded for the region. These were enumerated in a List of the Fishes Collected at Woods Hole by S. F. Baird. The list consisted of 120 species.

At the turn of the century, H. M. Smith catalogued "The fishes found in the vicinity of Woods Hole." It was published in the Bulletin of the U. S. Fish Commission and later supplemented in two separate papers. Smith gave a useful summary of the fishes of the region and their biology. The specimens catalogued by Smith were collected chiefly with a 150 foot bag seine on the beaches of Vineyard Sound and Buzzards Bay. These collections were supplemented with fyke nets, tow nets, dip nets and hand lines. Commercial fish traps provided many specimens.

In the Report of the U.S. Fish Commission for 1882, Tarleton Bean published a "List of fishes collected by the U.S. Fish Commission at Woods Hole, Mass., during the summer of 1881." It mentions 115 species, but less than half of this number were fishes actually obtained in the vicinity of Woods Hole, the others being deep-sea or offshore fishes brought to the station by exploring vessels.

In the next 15 years, Kendall (1908) and Sumner et al. (1913) published major catalogs on the fishes of the region. They are updated summaries mostly from Smith (1898) with notes on occurrence, comparative abundance and time of appearance and departure. The species arrangement and nomenclature are after Jordan and Evermann (1896-1900).

This brief history would be incomplete without noting Louis Agassiz and his summer school on Penikese Island at the southwestern end of Buzzards Bay. In this rather remote location, the first marine laboratory in this country opened its doors on July 6, 1873 (Cornish, 1943). Agassiz, then in the twilight of his career, taught his students to go to nature herself for truths. Thus Buzzards Bay became the platform for an important advance in the methodology of biological education, for prior to this period college laboratories in the life sciences did not exist. The students who spent that summer on Penikese were hand-picked by Agassiz, and (unheard of in those days) included women as well as men. Many of them subsequently became leaders in science. Perhaps the most distinguished of this class was David Starr Jordan, who became the dominant figure in American ichthyology for the next half century.

Buzzards Bay has played an important part in the fisheries of Massachusetts. In colonial days its tributaries were crowded with shad, salmon, blueback herring and alewives, while schools of mackerel, bluefish, sea bass, butterfish, scup and menhaden were caught within the bay. As early as 1869 apparent declines in fish stocks in Massachusetts coastal waters, including Buzzards Bay, prompted petitions for fishing restrictions (Joint Special Committee [R.I], 1870). Consequent legislation in place since 1896, protected Buzzards Bay from commercial trap fishing and seining. In the early 1900's the Marine Biological Laboratory and the United States Bureau of Fisheries at Woods Hole maintained the last traps and these were for scientific purposes (Board of Commissioners on Fisheries and Game, 1917). Another trap may have been operated for scientific purposes in the summer of 1942. At present, Buzzards Bay is unique in being the only significant east coast water body that has been closed to commercial net fishing for almost a century. The justification for the closure is found in the claim that the welfare of the fisheries in general are dependent on this refuge for a breeding ground.

Data Sources

The sources for the information contained in each data set are presented in Appendix A. Also included here are annotations (in parentheses) below each source that indicate the number of species characterized in the data set, the number of records included, the total number of individual fishes included, and the seasons in which sampling occurred. Each annotation also provides our assessment (as determined by application of the evaluation criteria [p. ??]) of the relative quality of the data set in question. This information will be helpful to users of the data base, allowing appropriate filters to be set up for sorting and screening.

Distribution of Sampling Within Buzzards Bay

After sorting the entire data base for collection latitude and longitude, the collection locations were plotted and the number of records (a measure of sampling intensity and success) determined (Fig. 1). In general it seems that the sampling sites are fairly uniformly distributed throughout the bay, and show little bias toward one area or another. A few sampling locations (e.g. Slocums River, Westport River, SMU Bay stations, Weeweantic River) have been most intensively sampled.

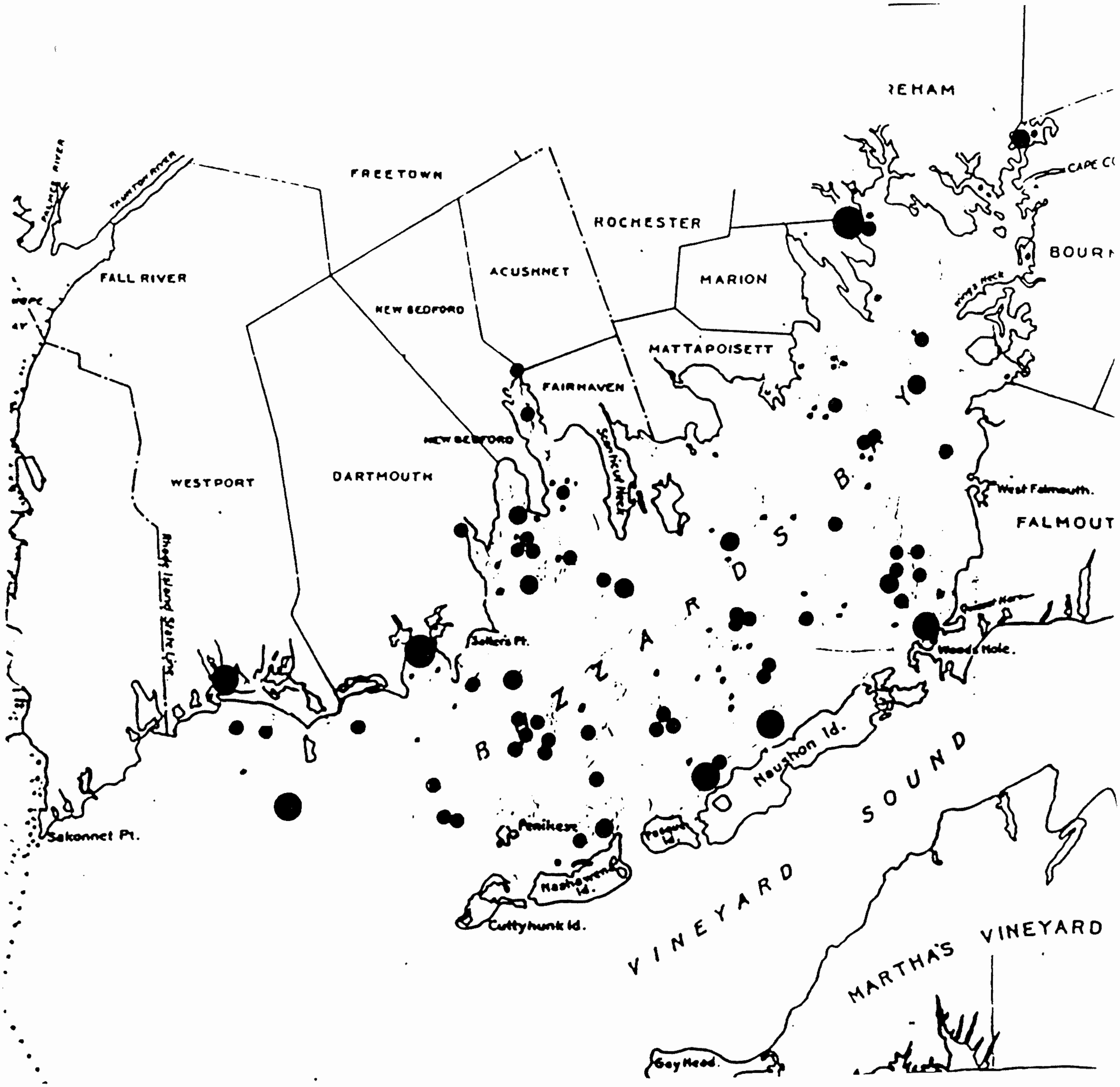

Figure 1. Each closed circle represents the location of finfish collection site in the Buzzards Bay data base. The total records for each site are proportional to the diameter of each circle according to the following key:

• = 1-10; ● = 11+ ● = 40+ ● = 100+ ● = 500+

Species Composition and Abundance

Table I compares the total species composition of both elements of the overall data base. The pre-1920 collections are dominated by Atlantic mackerel, butterfish, silver hake, alewife, blueback herring, and scup. The more recent (post-1960) collections are richest in scup, bay anchovy, Atlantic silverside, butterfish, and mummichog.

TABLE I - PERCENTAGE OF FISH CAUGHT BY SPECIES

Post-1960		Pre-1920	
scup	51.1	Atlantic mackerel	46.0%
butterfish	8.4	butterfish	14.5
Atlantic silverside	7.9	silver hake	9.5
bay anchovy	7.5	alewife	9.3
mummichog	4.5	blueback herring	7.3
winter flounder	2.6	scup	5.1
fourspine stickleback	2.0	round herring	1.3
sheepshead minnow	1.6	summer flounder	1.2
striped anchovy	1.6	spiny dogfish	1.1
black sea bass	1.4	smooth dogfish	0.6
striped killifish	1.3	little skate	0.5
Atlantic menhaden	1.2	Atlantic menhaden	0.5
American sand lance	0.9	hickory shad	0.5
Atlantic herring	0.9		
northern searobin	0.8		
Total number:	399,790		454,008

The obvious differences in species composition are most certainly due, in part, to differences in the kinds of gear and the locations sampled in the two data sets. The recent, post-1960, data set includes both trawl and seine samples that used relatively fine-meshed nets. Most of the seine samples were taken in shallow embayments such as Slocums, Westport, and Weeweantic Rivers. This collecting strategy will successfully sample the smaller species of fish, as well as the young life stages of other fish. For the most part the trawl samples were taken in the open waters of the Bay by both the Massachusetts Division of Marine Fisheries and by biologists from SMU. A total of 977 seine derived records exist in this data base, accounting for 64,834 individual fish. 2,862 trawl records are in the data base providing information on 367,108 individuals. A year by year comparison of the relative seine and trawl-caught elements in post-1960 segment is shown in Figure 2.

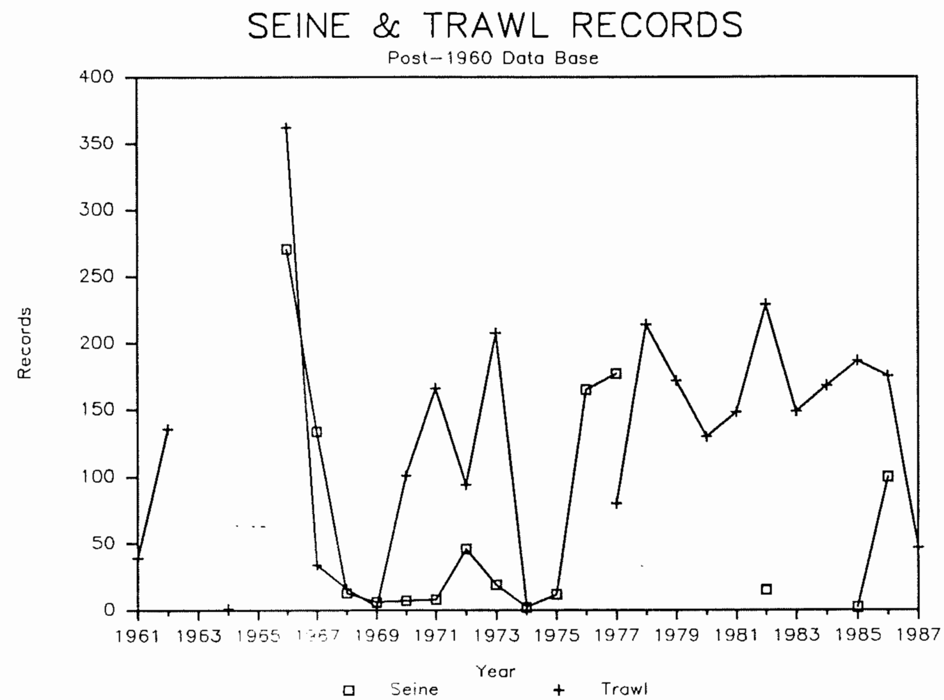

Figure 2. Distribution of seine-caught and trawl-caught records in the post-1960 data base.

The older, pre-1920 data set is particularly rich in collections made by commercial trap nets. The larger mesh sizes of these nets, and their placement in deeper waters of the open bay favored the collection of more mobile, larger fishes such as Atlantic mackerel and butterfish. Of some interest is the relative absence of scup from the early trap fishery, and the abundance of silver hake. Because the modern Rhode Island trap fishery harvests striped bass and bluefish, the old Buzzards Bay fishery should have landed them also.

Eleven Species Synopses

Eleven species of Buzzards Bay fish were identified as worthy of preliminary analysis of the data contained about them in the data base. These species were chosen for the contrasts that they offer in their ecological, commercial, and recreational values. They include important sport and commercial species (black sea bass, tautog, winter flounder, butterfish, Atlantic menhaden, scup) that are heavily exploited, both in Buzzards Bay and without; species for which no important fishery exists (cunner and northern searobin), and which, therefore, are relatively unexploited by fishing activities; forage species (Atlantic silversides, mummichog, butterfish, Atlantic menhaden, bay anchovy) that serve as important sources of food for many desirable sport and commercial fishes as well as birds and cetaceans; year-round residents of the Bay (winter flounder, tautog, cunner, Atlantic silversides, mummichog) that are more or less constantly exposed to its characteristics; and, finally, seasonal visitors to Buzzards Bay (butterfish, Atlantic menhaden, northern searobin, scup, black sea bass, bay anchovy) that seasonally find refuge within it.

Another consideration in identifying these species is the experience that they susceptible to the gear that has been most used to collect fishes in Buzzards Bay. The 11 chosen species comprise about 86 percent of the total number of fishes in the modern segment of the data base. Figure 3 presents the monthly catch of the 11 species as a percentage of the entire monthly catch.

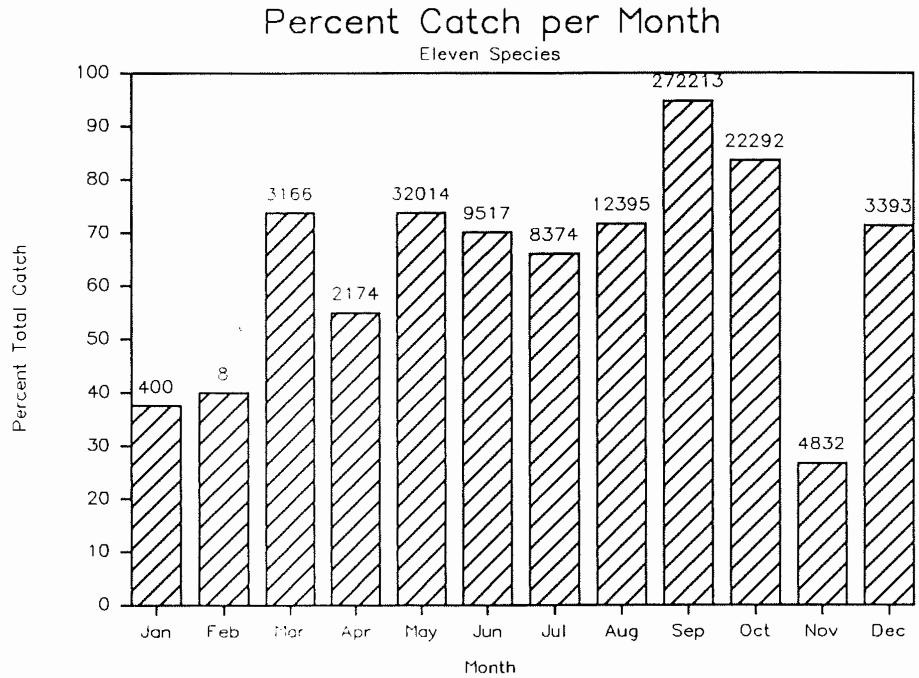

Figure 3. Percentage and numbers of the monthly catch that are comprised of the eleven species. Post-1960 data base.

Certainly there are other important species which are abundant in Buzzards Bay, but which are poorly represented in trawl and seine collections. Fishes of recreational and commercial significance such as bluefish, striped bass, squeteague, and Atlantic herring quickly come to mind, as do relatively unexploited ones such as several elasmobranchs, and important forage fishes like American sand lance. These species, and others, are surely more important in the true species composition of Buzzards Bay than is indicated by their occurrence in the present data base.

Any detailed analysis of the catch records contained in the current data base is confounded by several features of both the data base itself and the physical characteristics of Buzzards Bay. First, Buzzards Bay is a relatively open system with a complex circulation pattern. In addition to a wide mouth at its western end, water (and fish) circulate through the several "holes" that connect the Bay on the south with Vineyard Sound between the islands of the Elizabeth archipelago, as well as through the Cape Cod Canal connection to Cape Cod Bay at the eastern end. Second, all of the fishes found in the Bay are widely distributed species, the total populations of which greatly dwarf the segments found in Buzzards Bay. Fluctuations in the populations of these fishes, therefore, are likely due to factors existing outside of the Bay. It would be difficult to determine that activities in Buzzards Bay significantly affect these larger populations. Finally, the data base is built on collection records that have accrued from no consistent sampling design or plan. Quite different gear has been used by different agencies for different purposes in the collection of fish. Such an amalgam of information is difficult, if not impossible, to analyze for population trends or fluctuations.

With these caveats in mind, the following synopses of eleven species of Buzzards Bay fishes is presented with the purpose of identifying significant features of the life histories of these fishes, and presenting an overview of the information about them that exists in the current data base.

Atlantic Menhaden - Brevoortia tyrannus

The Atlantic menhaden is a euryhaline species that occurs in the Atlantic Ocean and inland tidal water from Nova Scotioa to Indian River, Florida. Adults and juveniles occupy bays and estuaries to the uppermost reaches. In the ocean, they generally are found in waters over the continental shelf.

These fish spawn at sea, as well as in inshore waters. Spawning occurs somewhere along the Atlantic coast in every month of the year, but in southern New England it occurs from April to October, months in which eggs have been collected from Buzzards Bay. Larvae are transported by swimming and currents to inshore areas. After entering estuaries, they move to areas of low salinity (even into fresh water) and develop through the juvenile stage. Young-of-the-year stay in or near estuaries until autumn when they begin their migration south. Individuals mature at two years.

The diet of menhaden varies with the availability of food resources. Larval menhaden feed mainly on planktonic crustaceans. Juveniles and adults usually filter unicellular phytoplankton from the water column, although they are also known to scrape diatoms and other microorganisms from the bottom. Menhaden are known to grow at a rate of about 7 mm per month for their first three years. At their maximum size they may weigh about 1.5 kilograms and be seven years old.

Juvenile and adult menhaden form sometimes immense schools and present an food source for many predatory species. Large dense schools are known to affect their environments by decreasing oxygen and phytoplankton densities, while increasing ammonia and carbon dioxide. Their large population biomass, concentrated in shallow water, helps to support populations of fishes such as bluefish and striped bass as well as piscivorous birds, cetaceans and sharks.

Menhaden are a most important commercial species throughout their range and are in particular demand for oil and fish meal products. Substantial quantities are used locally for lobster bait. Because of its oiliness, large number of bones, and poor keeping qualities, menhaden are not favored as a food fish.

In the post-1960 Buzzards Bay data base, Menhaden are represented by 51 records representing 5,338 individuals. Most of the database records are for seine-caught, young of the year fish. The monthly catch record histogram (Figure 4) reflects the seasonal abundance of young-of-the-year menhaden in the Buzzards Bay system. The schooling habit of these fish, coupled with their adult size and speed, and preference for the pelagic habitat make them difficult to sample effectively with either beach seines or trawling gear. Consequently, their relatively low abundance in the data base is a poor indicator of their prominence in Buzzards Bay.

Because these fish spawn offshore and represent an enormously valuable fishery resource, their year-to-year abundance may be affected by details of hydrographic and biological factors in the spawning areas, as well as by fishing pressure placed on the adult populations. Their reliance on estuaries for nursery grounds places them at risk, for certain kinds of pollution may impact juveniles heavily.

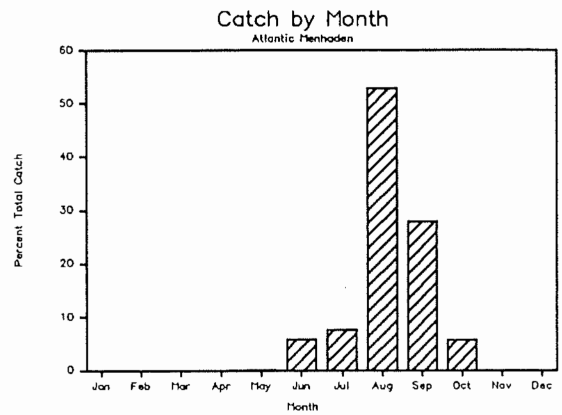

Figure 4. Occurrence by month of Atlantic menhaden in the post-1960 data base.

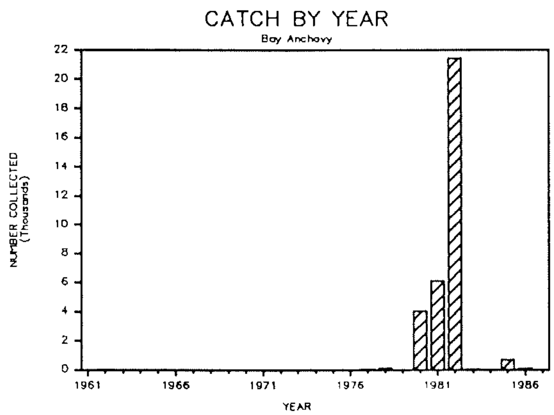

Figure 5. Yearly abundance of bay anchovies in the post-1960 data base.

Bay Anchovy - <u>Anchoa</u> <u>mitchilli</u>

The bay anchovy ranges from Maine to the Yucatan Peninsula in Mexico, with its region of greatest abundance stretching from Cape Cod to Texas. They are small, silvery, schooling fishes that have proportionally larger mouths than their herring relatives. Bay anchovies are nearshore and estuarine in their distribution, rarely found in waters deeper than 25 meters, where they tolerate a wide range of salinity and temperature conditions. The young especially are euryhaline, tolerating low salinities and sometimes form a component of the fish fauna in coastal freshwater rivers. Indeed, completely landlocked populations are known to exist. Their seasonal movements vary with age. Smaller individuals tend to congregate near shore. Larger fish are known to move away from the coastline in the winter. Generally their movements are to and from deeper water and there appears to be no significant north-south migration.

Bay anchovies become sexually mature at 35 mm and over much of the range the earlier-hatched individuals are able to spawn the same season. Spawning occurs throughout the summer, apparently early in the evening, in waters less than 20 meters.

Bay anchovies feed on zooplankton and they select larger food items as they grow. They feed in currents at nights, and during the day form large schools in protected areas to escape predation. Their eyes have an unusual and elaborately constructed retina that is supported by a reflective tapetum lucidum, suggesting good vision at night or in turbid water. The photoreceptive cells in the retina are arranged by alternating vertical rows of rods and two types of cones, prompting the notion that these fish may be able to perceive polarized light

There is no fishery for bay anchovies in southern New England, and the National Marine Fisheries Service estimates the population to be of considerable size. The bay anchovy plays an important role as a forage species and any piscivorous fish species whose range overlaps with this species probably includes the bay anchovy in its diet.

In the post-1960 segment of the Buzzards Bay data base, bay anchovies are represented by 25 records and 32,652 individuals. The yearly and monthly

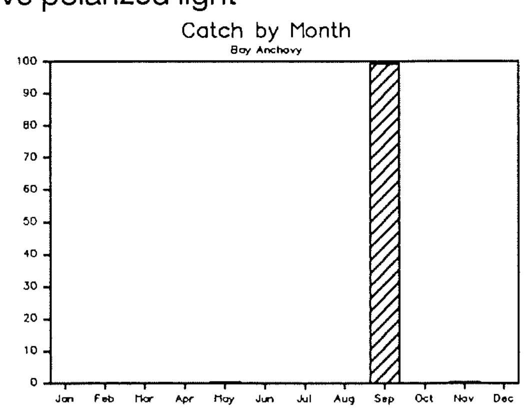

Figure 6. Occurrence by month of bay anchovies in the post-1960 data base.

capture data are presented in Figures 5 and 6. Their small size and schooling habit prohibit their capture by all but the finest mesh nets. By far the greatest numbers (over 98 percent) are taken in September, when the young-of-the-year have grown large enough to be captured in seines. In other east coast estuaries the bay anchovy is usually listed as one of the most abundant fish. When suitable seines or trawls with fine-mesh cod liners are used, a measure of their true abundance can be gained. A confounding feature of the analysis of bay anchovy catches is the fact that not all workers distinguish the bay anchovy from the related and similar striped anchovy (Anchoa hepsetus).

As an exceedingly abundant forage species that is confined to relatively shallow water, bay anchovies are an important element of the Buzzards Bay fish fauna that we do not know enough about. The impact of deteriorating water quality on these small fish has not been well studied.

Atlantic silverside - Menidia menidia

Atlantic silversides are found from the Gulf of St. Lawrence to Florida. They are among the most common estuarine species in southern New England where they populate protected sandy habitats. A schooling species, Atlantic silversides tolerate a wide range of salinities and have been collected in fresh water at the heads of embayments. As a sometimes exceedingly abundant, albeit small, species, this fish is important to important ecological relationships within estuaries.

Like its closely associate peer, the mummichog (page 22), the Atlantic silverside spawns in the summer on a semilunar schedule. When water temperatures reach about 18 C in May schools of these fish gather at the times of new and full moon high tides for three- or four- day bouts of communal spawning, which take place at the water's edge during high tide. The newly fertilized eggs attach by tendrils to filamentous brown or green algae. Those in the upper part of the intertidal zone are exposed to air for several hours each day--a position that seems to protect them from the degree predatory mortality suffered by eggs and larvae lower down that spend a greater percentage of time immersed. The adults continue to spawn in batches through June and into July on subsequent full and new moon tides.

About 15 days after fertilization the developing larvae sexually differentiate in a manner unusual among fishes. Environmental temperature affects the determination of sex in Atlantic silversides so that lower temperatures (ca. 18 C) influence the production of females, while larvae developing at higher temperatures (21 - 28^{o}C) are more likely to develop as males. Although both sexes are produced in all batches, the earlier (cooler temperature) broods favor females, while larvae raised later in the year show higher proportions of males. Because more females are produced earlier (and because hatchlings raised at cooler temperatures are larger), females in the population tend to be larger than males, especially at the end of the first growing season. By November these young-of-the-year fish have grown to 90 or 100 mm long, and will become sexually mature the following spring.

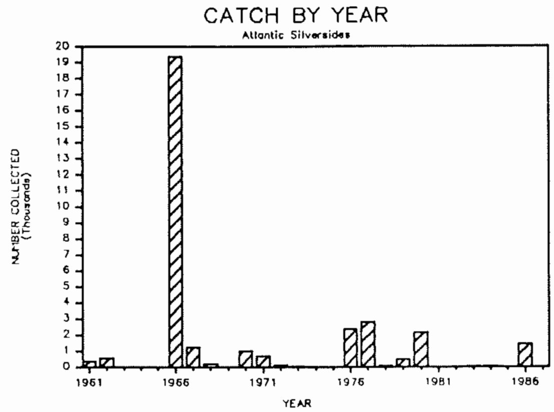

Figure 7. Yearly abundance of Atlantic silversides in the post-1960 data base.

As water temperatures cool in autumn Atlantic silversides move toward deeper water, forsaking the shallow embayments for off shore wintering sites as far as several kilometers at sea and at depths of 20 meters or more. This migration begins in October in our region and may continue through December. During the summer, they have a diverse diet that may include plant material as well as a variety of zooplankton, usually featuring copepods. In their deeper winter habitat they eat much less and seem to favor benthic mysids. They show little growth in the winter, and mortality has been reported to be high--in some populations as great as 99 percent.

In their second year Atlantic silversides return to shallower water, spawning and continuing to grow, reaching a maximum size of about 150 mm in lifetimes that maximally are probably no longer than three or four years. Extremes of winter-associated mortality and other factors can operate to create swings of their abundance from year to year. Because they are a staple item in the diets of predaceous fish like juvenile bluefish, the success (or lack of it) of Atlantic silversides can have cascading effects on the populations of other species.

While they are of no commercial importance to the traditional commercial fisheries, they are locally sold frozen as bait. And, they are an excellent food fish on the table, those that have tried them generally prefer them to smelt. Because Atlantic silversides are amenable to culture in the laboratory, techniques have been developed to raise them from the egg through juvenile stages, making them available for standardized toxicity tests to estimate the effects of environmental pollution.

Atlantic silversides are represented in the Buzzards Bay post-1960 data base in 142 records totaling 32,870 individuals. Their annual abundance in the data base (Figure 7) reflects seining effort in the embayments, and (outside of a large catch in the Slocum River in 1966) no discernable changes in their abundance seem to have occurred during the past 25 years. The monthly catch records (Figure 8) show them to be taken in every month but February, with peak abundances occurring in the late summer and fall seasons.

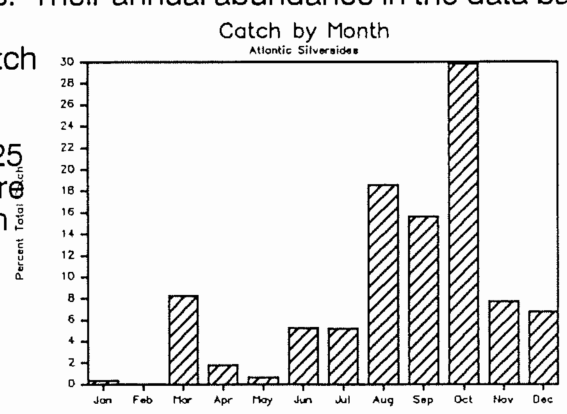

Figure 8. Occurrence by month of Atlantic silversides in the post-1960 data base.

Along with mummichogs and winter flounder, Atlantic silversides are dominant year-round presences in the Buzzards Bay system. They are well-positioned to experience most directly degradations in water quality imposed on this estuary by human activities.

Butterfish - Peprilus triacanthus

The butterfish is a schooling species which ranges from Florida to Newfoundland. It is most abundant between southern New England and Cape Hatteras. In Buzzards Bay it is recognized as the only small, silvery, deep-bodied fish that lacks ventral fins In summer and autumn, butterfish are found over the entire mid-Atlantic shelf. In late autumn they move offshore and south, at least in shoaler water. In April, the inshore and northern migration occurs, with younger and smaller fish preceding the older and larger ones.

Butterfish spawning takes place chiefly during summer in water away from shore. Butterfish eggs are found throughout the Mid-Atlantic Bight and on Georges Bank. After hatching the larvae and juveniles move inshore. Growth is fastest during the first year and decreases each year thereafter. Young are 120 mm by October, 170 mm at 16 months and 200 mm by 40 months. They probably only live to four years and all are sexually mature by age two.

Young butterfish are commonly associated with symphomedusae and ctenophores, and are reported to feed on their tentacles, although the relationship is not constant nor obligatory. The adult butterfish is a plankton feeder, feeding primarily on copepods, small fish, jelly fish and polychaetes.

The butterfish is an important commercial fish from North Carolina to Cape Cod. It is also one of the important forage species off southern New England. Bluefish, silver hake, striped bass and red hake are all reported to eat this species.

Butterfish are recorded in the post-1960 segment of the data base in 103 records totaling 36,548 individuals. By September the young of the year have grown to catchable size for trawls with cod end liners, and these young fish dominate their recorded catch, more than 90 percent of those in the data base being taken in this month (Figure 9). They are seldom captured in beach seines used to sample the embayments. The year to year variability seen in the catch from 1978 to 1986 is based on relatively few samples, and reflects the vagaries of catching an abundant, but patchily-distributed schooling fish, rather than real changes in the population.

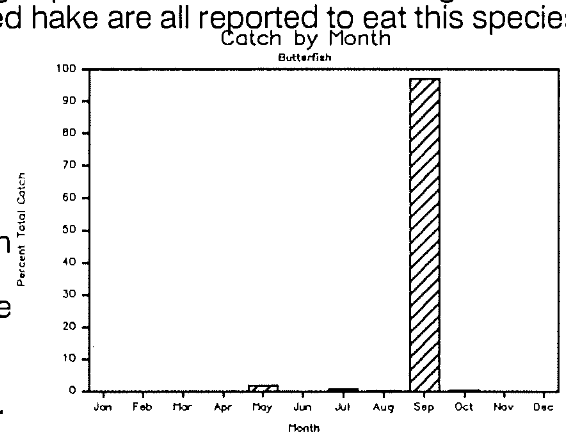

Figure 9. Occurrence by month of butterfish in the post-1960 data base.

Young butterfish find a suitable nursery area in Buzzards Bay, and the larger predaceous fish in the Bay certainly must find them to be suitable prey. Their predilection for the open waters of the bay reduces the likelihood that this species will directly experience the harshest water quality changes imposed by humans on

the embayments. Their adaptations for stable, pelagic conditions, however, may make them susceptible to even subtle pollution-related alterations.
Figure 8. Yearly abundance of butterfish in the post-1960 data base.

Black Sea Bass - Centropristis striata

Black sea bass range from Cape Cod to Florida. Two populations that together straddle Cape Hatteras, North Carolina, have been identified. The northern population migrates inshore and north in spring; and offshore and south in autumn. In the spring, adults move to their coastal spawning grounds and juveniles to the estuarine nursery grounds. Older sea bass (200 mm and larger) move offshore sooner than do young-of-the-year fish and winter in deeper waters, to as deep as 165 meters at temperatures of 8 - 9 C. Black sea bass from southern New England apparently spend the winter offshore of Chesapeake Bay.

Black sea bass usually become sexually mature first as females and later transform into males when they are two or three years old (although in the southern population, at least, a small percentage of sexually mature males can be found even in year-old fish). This pattern of sex reversal, technically known as protogynous hermaphroditism is usual among many species in the sea bass family (Serranidae). Indeed, some species--although not the black sea bass--have functionally hermaphroditic forms. The transformation from female to male can occur rapidly and seems to be initiated in the fall following the summer spawning season.

The northern black sea bass population spawns during summer primarily between Chesapeake Bay and Cape Cod in water 15-45 meters deep. In the planktonic larval stage the yolk reserves are depleted less rapidly than in many other fishes (e.g. bay anchovy). This allows them adequate time to become efficient feeders on their zooplankton support. Juveniles become demersal when they grow to 13 - 24 mm in length. At this time they move into saline areas of estuaries such as Buzzards Bay and the lower reaches of its principle embayments, which they use as nursery grounds. Females are more abundant than males because they predominate in small size and young age classes. Sex ratios in the southern population have been reported as 1.7 females for every male.

Black sea bass feed principally on crustaceans, fish, and molluscs that are found in the rocky reef habitat that they prefer in the summer. Young sea bass less than l50 mm long are bottom feeders in the shallows and feed primarily on mysids. Feeding decreases in autumn during migration and during the spawning season.

The habitat preference of this species has protected it from commercial trawl fisheries except on its wintering grounds in the Chesapeake Bight. Traditionally it has been commercially fished using fish pots off Long Island and New Jersey in the summer. The recreational harvest is now estimated to be larger than the commercial catch. It is thought that increased sport fishing has contributed to the higher sea bass mortality. Certainly hook and line landings from Buzzards Bay have increased where it is usually caught as an adjunct to the scup fishery in recent years. Black sea bass are considered an excellent table fish, and the premium price that is paid to fishermen for them is incentive for their exploitation.

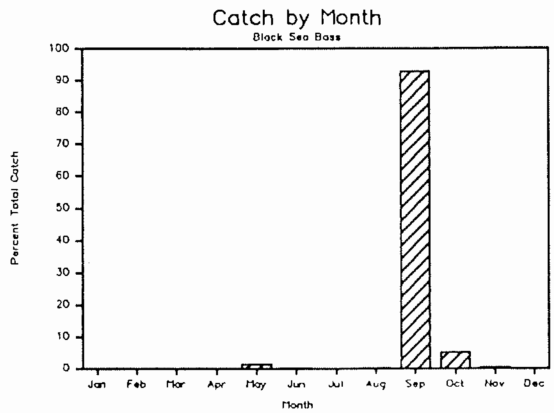

Figure 10. Occurrence by month of black sea bass in the post-1960 data base.

Because most of the harvested fish are males (current regulations prohibit the possession of black sea bass shorter than 12 inches long), some have suggested that heavy fishing pressure could cause the sex ratio of the population to so favor females that the number of remaining males would not be sufficient to maintain adequate reproduction. The dynamics of sex reversal are poorly understood, however. It may be true that a reduction of the "standing crop" of males can trigger enhanced sex reversal in the remaining females.

In the post-1960 Buzzards Bay data base, black sea bass are represented by 101 records totaling 6,142 fish. The lower numbers of this fish may reflect the adult's selection of habitat that is difficult to sample with trawl and seine. As a summer visitor to Buzzards Bay, black sea bass are recorded here from May to November, with the largest catches occurring in September (Figure 10). The higher numbers of fish caught in September and October reflect the abundance of young-of-the-year, as well as greater collecting effort for those months.

Cunner - Tautogolabrus adspersus

The range of the cunner extends from the Gulf of St. Lawrence to Chesapeake Bay. Its adult habitat is mainly from the tide mark seaward among rocks and pilings. They do not undergo extensive migrations, remaining instead under rocks in shallow water during the winter. Activity dwindles in the autumn as water temperatures cool. Unlike most temperate fish (cunners and their close relative, the tautog, belong to a mainly tropical family), they are unable to make metabolic adjustments to cold temperatures. When temperatures drop below about 5^{o}C they become torpid, sometimes packed in groups in caves and holes in the bottom rocks. The larger fish become dormant first.

Cunners spawn from May through September along the coast or over offshore ledges. Sexual dimorphism occurs among adults, with breeding males having a bluish cast with more orange-red spots. Spawning behavior occurs when females enter a breeding male's territory, often accompanied by non-territorial males. Apparently both sexes mature and spawn as one year-olds with some individuals spawning in their first year. Average sizes at the end of each year are approximately: 65 mm, 100 mm, 135 mm, 175 mm and 200 mm. Juvenile fish are frequently collected in eelgrass meadows in embayments, away from the more highly structured adult habitat.

Cunners are decidedly a diurnal fish. They have none of the ocular specializations that are associated with nocturnality. At night they rest in contact with the substrate, and are completely inactive.

The cunner is omnivorous. As juveniles, the food consists chiefly of small crustaceans. The diet of adults is composed primarily of barnacles and bivalves, although they will eat almost anything. They are an opportunistic species. They are the first fish to inhabit a new wreck or wall. They prefer structured bottoms and are rare over newly created sand-filled areas.

Because of its small size, the cunner is of little commercial importance. Its eagerness to take the hook, combined with its inshore availability, have made this an important hook-and-line species for the beginner angler.

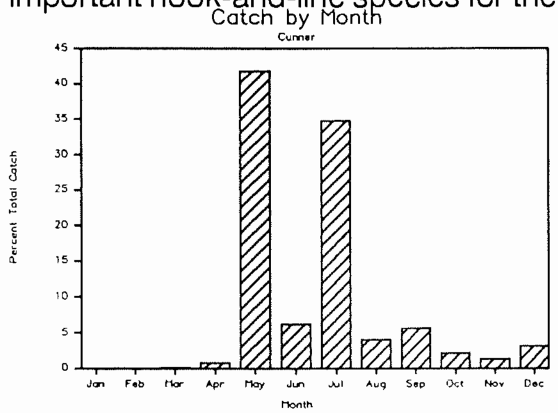

Figure 11. Occurrence by month of cunner in the post-1960 data base.

Cunner are represented in the post-1960 segment of the data base by 139 records that include 3,267 fish. Their social organization, which features territoriality, and their habit of occupying rough bottoms make them difficult fish to capture in large numbers by either seine or trawl. The pattern of their yearly abundance in the data base reflects patterns of sampling in the embayments, where they are most often captured as juvenile fish. No trend in their abundance can be determined. The monthly catch records (Figure 11) show them to be active in all months but January and February. The peak capture months are May and July.

Mummichog - Fundulus heteroclitus

Mummichogs range from the Gulf of St. Lawrence to northern Florida. They reside in salt marsh creeks, harbors, tidal pools, and along most sheltered shorelines. In studies of New England salt marshes they usually rank as the most abundant fish species, making up as much as 90 percent of the total number of fishes found in these environments. Rarely are they collected even a hundred feet from the shore.

Their distribution and abundance is in part due to their tolerance to wide-ranging salinities--from fresh to hypersaline waters. They are resistant to low oxygen concentrations, high carbon dioxide, and large extremes of temperatures. Indeed, as environmental salinities increase (such as in a drying pool of water on an upper salt marsh) their ability to tolerate high temperatures increases. In general, they can thrive in even highly polluted waters, although organochlorine insecticides, such as endrin, DDT, aldrin and dieldrin, are particularly toxic to them. They survive the winter in a torpid state on or buried in the bottom sediments. This species has no significant movement or migration.

Mummichogs have a prolonged reproductive season which begins in early May in southern New England and continues throughout the summer. As syzygial spawners they deposit their eggs high in the intertidal zone on a semilunar cycle. In New England the eggs are deposited on sand bottoms or in algal mats where they must escape frequent immersion if development is to proceed normally. Upon

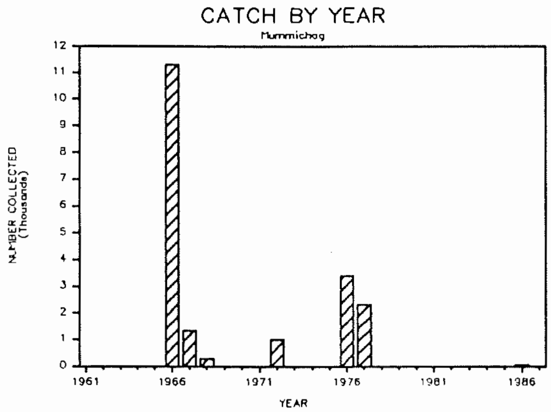

Figure 12. Yearly abundance of mummichogs in the post-1960 data base.

inundation at the next set of spring tides, approximately two weeks later, the eggs hatch (even as the adults are depositing more eggs) and the young seek refuge in grass and wrack of the marsh, surviving low tides in shallow puddles of water. They spawn as one-year-olds at lengths as small as 30 mm. Adult mummichogs are difficult to age, but have survived for several years in aquaria. Maximum length is approximately 125 mm.

They are omnivorous with an almost limitless diet. Being toothless, mummichogs feed mainly on items that they can ingest at a bite. The range of food reported for them extends from detritus, diatoms, and eelgrass at the plant end of the spectrum to copepods, eggs, snails, and young fishes at the other. The abundance of mummichogs in salt marshes and their voracious omnivory play important roles in the economy of these habitats. Cannibalism of their own fry as well as predation on the young of many marsh invertebrate species can affect population sizes of these animals. Indeed, as the summer progresses, mummichogs may eat themselves out of high quality food sources, and come to rely more on detritus and algae as dietary staples. Being nutritionally less adequate, detritus does not support good growth or reproduction in these fish, and it is typical to find that late summer mummichog populations show reduced growth rates and fecundity.

Mummichogs are an important estuarine forage species. Many commercial fish species, using the estuary as a nursery, utilize mummichogs as prey. Estuarine birds such as egrets and herons depend upon them. While the mummichog is commercially important as bait for both fresh and salt water fishing in southern New England, its principal direct value to humans has been as a subject for scientific investigation. With more than 3000 published reports of its embryology, physiology, genetics, endocrinology, and toxicology, this species is probably the most studied fish in the world.

The pattern of yearly abundance for mummichogs in the post-1960 data base reflects the pattern of seine sampling in the embayments, and does not reveal population trends (Figure 12). This sampling is dominated by the catch of mummichogs in the Slocum River during 1966. Monthly catch records (Figure 13) show mummichogs to be available during every month of the year (the only species in the data base to be so caught). Peak catches are recorded in June (when spawning activity reaches a zenith, and in October (when young-of-the-year reach catchable size. The hardiness of mummichogs makes them a

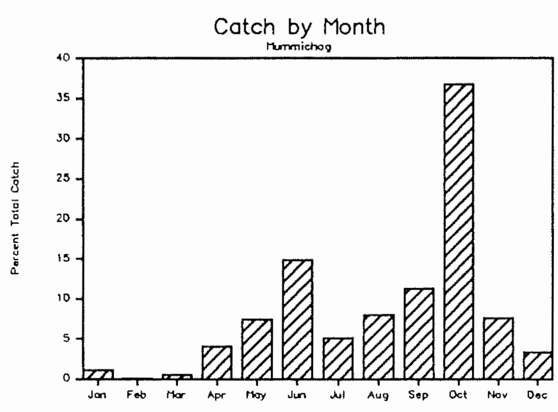

Figure 13. Occurrence by month of mummichogs in the post-1960 data base.

poor indicator of degradative changes in the environment.

Northern Searobin - Prionotus carolinus

Northern sea robins range in coastal waters from the Bay of Fundy to South Carolina. They are plentiful seasonally in southern New England, when as migratory visitors to Buzzards Bay, they first appear in late April or early May from their offshore wintering grounds. They remain inshore throughout the summer, utilizing these productive waters as feeding, spawning and nursery grounds. They begin to leave the coastal waters in October to pass the colder months in deeper waters (to 300 m) far out on the continental shelf.

In New England, the northern sea robin spawns throughout the summer with peak activity occurring in July. The eggs, being well supplied with oil droplets, are buoyant, and hatch within a few days. The young fish stay near shore and are commonly found within inshore embayments, sometimes penetrating to fairly brackish water. Northern sea robins grow rapidly and reach an average length of about 140 mm after one year--a size at which they become sexually mature. Older fish reach a maximum length of about 300 mm

They spend much of their time on or near the bottom preferring smooth sandy substrata where they feed on crustaceans, squid, worms, and small fish. Northern sea robins caught in Buzzards Bay generally are found with their stomachs filled with mysids and amphipods.

Because this species has historically been of little commercial importance, scant attention has been paid to its biology. The large, wing-like pectoral fins are each preceded by anterior free rays that function as sensory structures well equipped with tactile receptors. Its luminous green eyes reveal a reflecting tapetum lucidum behind the retina that is typical of nocturnally active animals. Sea robins are noisy fish that typically produce grunting sounds when caught. Although the meaning of their sonic capabilities has not been well studied it is likely that sounds are important in some aspect of the social behavior of this fish.

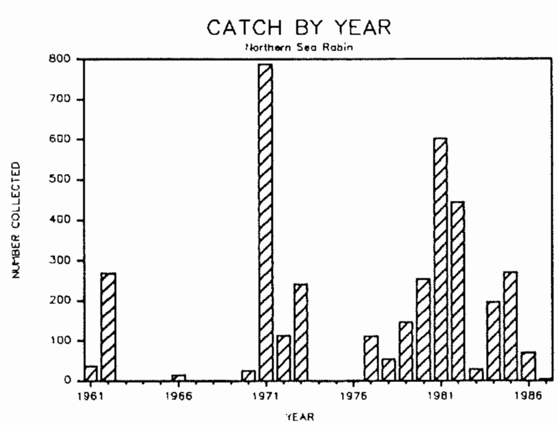

Figure 14. Yearly abundance of northern sea robins in the post-1960 data base.

The species is currently of no commercial importance except for its use for lobster bait when it is caught incidentally to other fishing efforts. In areas where it is abundant it is often considered a nuisance by anglers. The flesh, however, is excellent and as our now accepted commercial fish species decline it is certain more interest will develop on the utilization of this fish.

The annual catch records for northern sea robins in the post-1960 data base reflect the pattern of sampling the open bay by trawl (Figure 14). There is, however, a pattern of abundance that is somewhat different from that of other trawl-caught species (e.g. scup, tautog) found with northern sea robins. The large catch in 1971 reflects an experimental tagging program that targeted the northern sea robin. However, following an abundance peak in 1981, the catch of sea robins seems to have steadily dwindled through 1986. This is consistent with hook and line fisherman reports that catches of sea robins have declined in the Bay in recent years. The monthly catch pattern (Figure 15) shows peaks in May, when newly arrived spawning adults are abundant; and September, when young-of-the-year are reaching catchable size. Sea robins are particularly vulnerable to trawl sampling, and are readily taken in adult sizes by this gear.

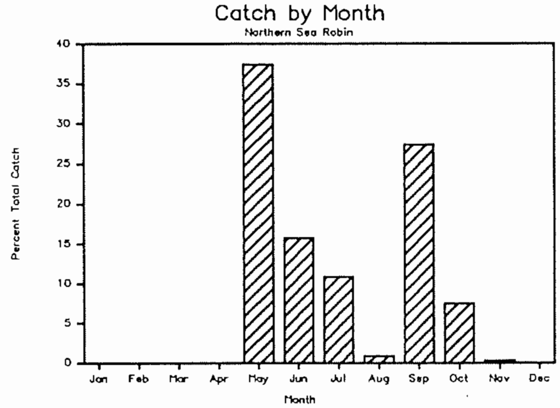

Figure 15. Occurrence by month of northern sea robins in the post-1960 data base.

Scup - Stenotomus chrysops

The only member of the subtropical Atlantic family Sparidae to regularly reach southern New England, the scup os a conspicuous and important member of the Buzzards Bay fish fauna during the warm months of the year. This fish is easly distringuished by its silvery color, laterally compressed, deep body, long dorsal fin spines and lunate tail.

Scup occur on the continental shelf primarily from Cape Hatteras to Cape Cod. Seasonal migrations occur from inshore summer grounds to offshore winter grounds. In April the first individuals reach the inshore waters of southern New England late in the month or by early May. Large fish appear about a week before the smaller fish. Throughout the summer, four year and older fish are most abundant in nearshore ocean waters or near the mouths of larger bays. Younger fish remain nearer shore and tend to concentrate in the higher salinity waters of embayments. In October and November scup migrate to their winter grounds which are from New Jersey to Cape Hatteras in waters 50-150 meters deep. Year-to-year differences in winter distribution are correlated with bottom temperatures warmer than 7o^{C}.

Scup spawn from May through August. Peak spawning occurs inshore in June. Juveniles from 50-80 mm are common during September; by November they are 60-100 mm. There is little growth during winter. During the first three years they will grow to 60% of their maximum size. At age one they average 106 mm, at two 160 mm, and at three, 204 mm. They live 15 years and reach a length of 370 mm. Scup become sexually mature at two years.

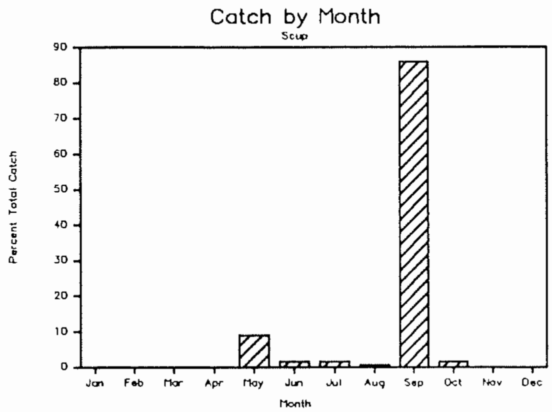

Figure 16. Occurrence by month of scup in the post-1960 data base.

Scup are bottom feeders, primarily consuming coelenterates, polychaetes, crustaceans and molluscs. Scup are eaten by other fishes and man is probably the principal predator of this important commercial species. They aggregate in groups and are often associated with reefs and wrecks where they find their principle food. They are a wary fish and are difficult for divers to approach closely.

As active, fast-swimming fish, larger scup are able to escape both beach seines and smaller, research trawls. Young-of-the-year fish dominate in the post-1960 data base, with September appearing as the peak month (Figure 16). The September scup records in the data base are heavily influenced by the semi-annual finfish stock assessment survey of the Massachusetts Division of Marine Fisheries that takes place in May and September, and which uses gear that effectively catches scup. The pattern of annual abundance in the post-1960 data base is again colored by the DMF's finfish survey (Figure 17). Scup have been the subject of an intensifying fishery in Massachusetts in recent years, including commercial hook and line fishery in Buzzards Bay.

Although scup utilize Buzzards Bay as a nursery ground, and are known to respond to exposure to organic pollutants here by activating certain enzymes, there are no data to suggest that deteriorating water quality is impacting the population. Fishing mortality on the much larger segment of the population outside of Buzzards Bay is probably the significant determinant of population dynamics.

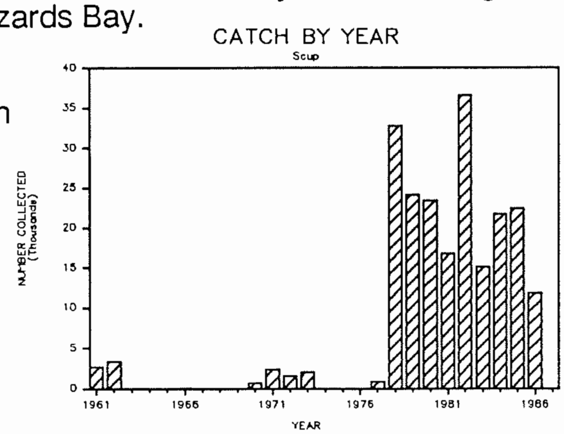

Figure 17. Yearly abundance of scup in the post-1960 data base.

Tautog - <u>Tautoga</u> <u>onitis</u>

Tautog occur from Nova Scotia to South Carolina, but in New England they are most abundant south and west of Cape Cod. Their favorite habitats as adults include steep, rocky shores, ledges, submerged wrecks, near wharf pilings, and shellfish beds. Areas that are flushed with strong currents are also preferred. When tautog are not feeding (especially at night or in their winter torpor), they crowd into rock clefts and holes where they lie inert, often on their sides.

As wintering adults tautog generally forsake their summer inshore spawning and feeding habitats and move to deeper water where they eat sparingly and, like their close relative, the cunner (pp ??), appear to be captives of their inability to compensate metabolically for colder temperatures. In the spring, usually about mid-April in Buzzards Bay, tautog move back into shoaler water and feed avidly, providing sport and food for numbers of anglers who traditionally seek them then. They feed mostly on molluscs, especially on blue mussels, but they also take crabs, sand dollars, worms and lobsters.

Most spawning occurs in June, although ripe fish may be found throughout the summer, suggesting that they are repeating batch spawners. Spawning behavior is associated with dramatic changes in their generally dull, mottled color patterns. Males, especially, show transient light-colored spots or blotches when engaged in courtship. The larvae and juveniles remain inshore, where young tautog are often found associated with eel grass meadows. They grow to 200 mm in one year and reach the maximum length of about 90 cm in about 12 years.

Formerly an important commercial fish species in the local pound net fisheries, today most of the tautog that reach the Massachusetts market come from lobstermen and the hook-and-line fishery. Tautog are a very important recreational species. Their inshore availability, gaminess, and excellent flavor make them a favorite fish of the small boat angler. Recent years have seen the advent of a significant hook and line commercial fishery developing for both scup and tautog in Buzzards Bay. They are also a favorite target for growing numbers of spear fishermen.

Tautog are represented in the modern segment of the Buzzards Bay finfish data base by 223 records that represent 3,321 individual fish. The monthly catch is dominated by those taken in May when the fish are actively moving to the spawning grounds and are accessible to the trawl samples of the Massachusetts Division of Marine Fisheries semi-annual stock assessment program. A second peak in the catch is noted in September (Figure 18). For the past ten years, the annual catch of tautog reported in the data base has

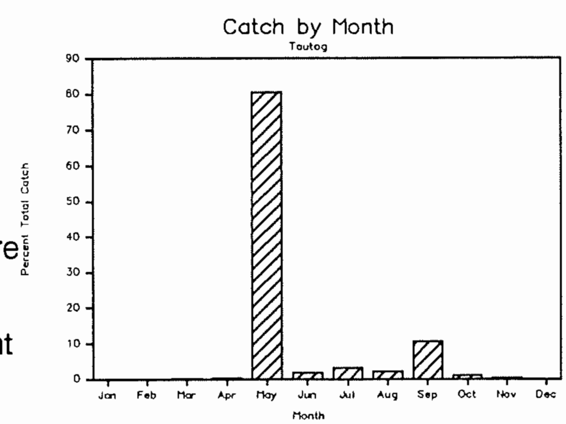

Figure 18. Occurrence by month of tautog in the post-1960 data base.

increased, more or less steadily (Figure 19). The amount and quality of the data, however, are insufficient to determine if this represents a trend.

Because tautog are fish resident in Buzzards Bay, and because they feed on organisms (blue mussels) that are known for their ability to concentrate organic and inorganic pollutants, one might predict that this species could be a fairly sensitive indicator of deteriorating environmental conditions. The information in the data base, however, does not suggest a serious decline in the population of this species.

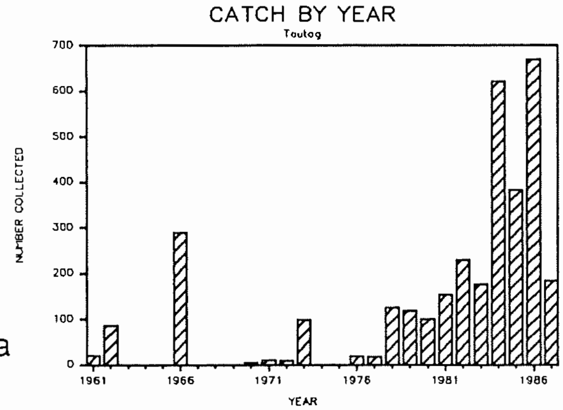

Figure 19. Yearly abundance of tautog in the post-1960 data base.

Winter flounder - Pseudopleuronectes americanus

The winter flounder is a benthic species that generally inhabits the soft mud, clay, and sandy bottoms of bays, estuaries, and shallow coastal waters from Labrador to Georgia. Areas of high populations in southern New England include Nantucket Shoals, Georges Bank, Cape Cod Bay, Block Island Sound, and Long Island Sound. The inshore populations are generally found in depths of less than 55 meters, and these inshore stocks have local and seasonal spawning migrations. Winter flounder south of Cape Cod migrate from bays and estuaries offshore to cooler coastal waters in late spring. When fall cooling occurs the fish move inshore and concentrate in the estuaries between December and March.

Winter flounder spawn from mid-winter through early spring. Spawning occurs principally in the upper estuaries in waters from 2 to 6 meters deep. Buzzards Bay and its embayments (such as the Westport, and Weeweantic Rivers) are important spawning areas for this fish. Early larval stages are most abundant in the upper estuary and follow the adults out of the estuary in their second year. Winter flounder become sexually mature when two to three years old.

Winter flounder feed only during the day and their diet consists of polychaetes, bivalves, gastropods and crustaceans. Since the winter flounder populations consists of many discrete stocks, typical species growth analyses are not feasible.

The winter flounder is a species of considerable importance to both the commercial and recreational fisheries of southern New England. It is taken in commercial quantities from Nova Scotia to New Jersey. The commercial catch is taken chiefly by otter trawlers in spring and autumn. It is probably the most important commercial fish species that regularly inhabits Buzzards Bay. In addition, it is a popular sport fish, providing rowboat and bridge anglers with sport and food during the fall and spring spawning migrations into and out of the estuaries. It also

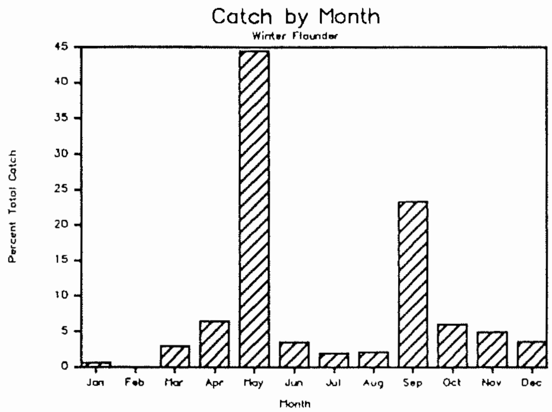

Figure 20. Occurrence by month of winter flounder in the post-1960 data base.

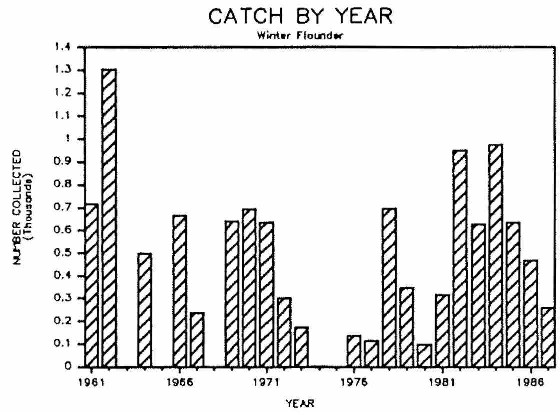

Figure 21. Yearly abundance of winter flounder in the post-1960 data base.

is a principle source of food for the growing population of ospreys in our local waters.

Because winter flounder utilize the upper ends of estuaries and spawning and nursery grounds, and because their habit of burrowing into sediments that can be pollutant-laden, this species lives at considerable risk to increasing pollution loads. Correlations of fin rot and hepatic carcinoma incidences with heavily polluted environments manifest this risk.

Winter flounder are represented in the post-1960 data base by 335 records totaling 11,492 fish. They have been taken in every month except February, with the peak catches occurring in May and September (most of these in the DMF stock assessment program samples) (Figure 20). The annual catch records (Figure 21) show no clear trends.

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Smith, H.M. 1898. Fishes found in the vicinity of Woods Hole. Bull. U.S. Fish. Comm. Vol XVII, 1897. pp. 85-111. Washington, D.C.

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APPENDIX A
List of Data Sources

TABLE I - DATA SOURCES

Reference Number	Citation (Annotation)*

1. Govoni, J.J. 1973. The distribution of some marine fish eggs and larvae in the Acushnet and Westport River Estuarine Systems,Massachusetts. M.S. Thesis. Southeastern Massachusetts University.

   (larval fish study. no species abundances. 22 records, 12 species. Season = winter, spring. Quality = 2)

2. Hoff, J.G., F.X. O'Brien and J.L. Cox. 1972. A biological assessment of the Acushnet River estuary. Unpublished. 20 pp.

   (24 records, 10 species, 508 total abundance. Season = winter, spring, fall. Quality = 1)

3. Fiske, J.D., J.R. Curley, and R.P. Lawton. 1968. A study of the marine resources of the Westport River estuary. Monograph Series No. 7. Div. Mar. Fish.

   (142 records, 33 species, 31,082 total abundance. Season = winter, spring, summer, fall. Quality = 1)

4. Hoff, J.G. 1976. A first record of Gobionellus boleosoma (Jordan and Gilbert) for New England. Chesapeake Sci. 17(1):65.

   (1 record, 1 species, 1 specimen. Season = fall. Quality = 2)

5. Edgar, R.K. and J.G. Hoff. 1976. Grazing of freshwater and estuarine benthic diatoms by adult Atlantic menhaden Brevoortia tyrannus. Fish. Bull. 74(3): 689-693.

   (1 record, 1 species, 150 total abundance. Season = fall. Quality = 2)

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* - Relative quality of data set is indicated by the following:
1 = high quality in terms of coverage, amount of information, authoritativeness.
2 = limited in scope or missing important data element
usually abundance estimate).
3 = limited data reported, or questionable in quality.
Usually of historical interest only.
"winter" = December, January, February
"spring" = March, April, May
"summer" = June, July, August
"fall" = September, October, November

6. Moss, S.A. 1972. Tooth replacement and body growth rates in the smooth dogfish, Mustelus canis (Mitchill). Copeia 1972(4): 808-811.

(1 record, 1 species, 36 total abundance. Season = spring. Quality = 2)

7. Hoff, J.G. 1971. Mass mortality of crevalle jack, Caranx hippos (Linnaeus) on the Atlantic coast of Massachusetts. Chesapeake Sci. 12(1): 49.

(1 record, 1 species, 55 total abundance. Season = fall. Quality = 2)

8. Moss, S.A. 1973. The responses of planehead filefish, Monocanthus hispidis (Linnaeus) to low temperature. Chesapeake Sci. 14(4): 299-303.

(1 record, 1 species, 24 total abundance. Season = fall. Quality = 2)

9. Hoff, J.G. 1976. Contribution to the biology of the seaboard goby, Gobiosoma gingsburgi. Copeia 1976(2): 385-386.

(1 record, 1 species, 200 total abundance. Season = spring. Quality = 2)

10. Hoff, J.G. and R.M. Ibara. 1977. Factors affecting the seasonal abundance composition and diversity of fishes in a southeastern New England estuary. Estuarine and Coastal Mar. Sci. 5: 665-678.

(224 records, 41 species, 17,751 total abundance. Season = winter, spring, summer, fall. Quality = 1)

11. Hoff, J.G. 1974. Fishes collected from Penikese Island in June 1972 and June 1973 (unpublished).

(24 records, 18 species, 2,596 total abundance. Season = summer. Quality = 1)

12. Moss, S.A. and J.G. Hoff. 1967-1984. R/V Corsair data sheets. Unpublished.

(793 records, 64 species, 19,348 total abundance. Season = winter, spring, summer, fall. Quality = 1)

13. Lux, F.E. and F.E. Nichy. 1971. Number and lengths, by season, of fishes caught with an otter trawl near Woods Hole, Mass. Sept. 1961 to Dec. 1962. SSR No. 622. : 1-15.

(170 records, 38 species, 11,438 total abundance. Season = winter, spring, summer, fall. Quality = 1)

14. Hoff, J.G. 1976-1985. Slocum River data sheets. Unpublished.

(418 records, 42 species, 37,441 total abundance. Season = winter, spring, summer, fall. Quality = 1)

15. Collins, W.S., Cooper-Sheehan, C., Hughes, S.C., and Buckley, J.L. 1981. The effects of power generation on some of the living marine resources of the Cape Cod Canal and approaches. Mass. Dept. of Fish., Wildl. & Rec. Vehich. Tech. Rpt

(larval fish study. 36 records, 35 species, 0 total abundance. Season = fall. Quality = 2)

16. Hoff, J.G. 1966., Vertebral anomalies in a humpbacked specimen of Atlantic silverside, Menidia menidia. Chesapeake Sci. 11(1): 64-65.

(1 record, 1 species, 200 total abundance. Season = fall. Quality = 2)

17. Hoff, J.G. 1972. Movements of adult tidewater silverside, Menidia beryllina (Cope), tagged in New England waters. Amer. Midl. Nat. 88(2): 499-502.

(2 records, 1 species, 1,675 total abundance. Season = summer. Quality = 2)

18. Musick, J.A. and J.G. Hoff. 1968. Vertebral anomalies in humpbacked specimens of menhaden, Brevoortia tyrannus. Trans. Amer. Fish Soc. 97(3): 277-278.

(1 record, 1 species, 338 total abundance. Season = summer. Quality = 2)

19. Baird, S.F. 1873. List of fishes collected at Woods Hole. Report U.S. Fish. Comm. 1871-72. pp. 823-827. Washington, D.C.

(124 records, 124 species, 0 total abundance. Season unknown. Quality = 3)

20. Fairbanks, R.B., W.S. Collings, and W.T. Sides. 1971. An assessment of the effects of electrical power generation on marine resources in the Cape Cod Canal. Mass. Dept. of Nat. Res. 48 pp.

(14 records, 12 species, 1,469 total abundance. Season = winter, spring, summer. Quality = 2)

22. Hoff, J.G. 1968. Occurrence of Liparis atlanticus in Aquipecten irradians in Buzzards Bay, Massachusetts. Trans. Am. Fish. Soc. 97(2): 277-278.

(1 record, 1 species, 1 total abundance. Season = fall. Quality = 2)

23. Bean, T.H. 1884. List of fishes collected by the U.S. Fish Commission at Woods Hole, Mass., during the summer of 1881. pp. 339-344. Washington, D.C.

(32 records, 32 species, 0 total abundance. Season unspecified. Quality = 3)

25. Massachusetts Division of Marine Fisheries. 1977. Summarization of Massachusetts Marine Sport Fishery Statistics for 1975. Unpublished report # 11517-100-42-9/79-CR.

(12 records, 12 species, 0 abundance, no locations. Season unspecified. Quality = 3)

26. Kolek, A. and T. Currier. 1980. Feasibility of a pot fishery for scup. Mass. Div. Mar. Fish., Publ. No. 11986-26-100-7-80-CR. Boston, Ma. 24 pp.

(10 records, 8 species, 2,600 total abundance. Season unspecified. Quality = 2)

27. Kendall, W.C. 1908. Fauna of New England. 8. List of fishes. Occasl. Paps. Boston Soc. Nat. Hist. 7(8): 1-152.

(13 records, 13 species, 0 total abundance. Season unspecified. Quality = 3)

28. Smith, H.M. 1898. Fishes found in the vicinity of Woods Hole. Bull. U.S. Fish. Comm. Vol XVII, for 1897. pp. 85-111. Washington, D.C.

(144 records, 144 species, 0 total abundance. Season unspecified. Quality = 3)

31. Smith, H.M. 1901. Notes on the subtropical fishes observed in 1900. Biological Notes 21(2): 32-33.

(1 record, 1 species, 0 total abundance. Season unspecified. Quality = 3)

32. Sumner, F.B., R.C. Osburn and L.J. Cole. 1913. A biological survey of the waters of Woods Hole and vicinity. Part 2, Sect. 3 - A catalogue of marine fauna. Bull. U.S. Bur. Fish 3(2): 549-794.

(178 records, 170 species, 1,227 total abundance. Season = winter, spring, summer, fall. Quality = 2)

33. Topp, R.W. 1967. Biometry and related aspects of the biology of young winter flounder, Pseudopleuronectes americanus (Walbaum) in the Weweantic River estuary.
M.S. Thesis. University of Massachusetts. Amherst. 65pp.

(10 records, 9 species, 505 total abundance [some records missing abundance] Season = spring. Quality = 2)

34. Serchuk, F.M. 1972. The ecology of the cunner, Tautogolabrus adspersus (Walbaum) in the Weweantic River estuary, Wareham, Massachusetts. M.S. Thesis, University of Massachusetts, Amherst. 111pp.

(4 records, 4 species, 219 total abundance [some missing] Season = summer. Quality = 2)

35. Storer, D.H. 1839. Report on the fishes, reptiles and birds of Massachusetts. Comm. Zool. & Botan. Survey of the State (Fishes): 1-202. Boston.

(6 records, 6 species, 0 total abundance. Season unspecified. Quality = 3)

37. Howe, A. et. al. 1978-1987. Buzzards Bay trawl logs. Unpublished. Massachusetts Division of Marine Fisheries.

(1,453 records, 65 species, 303,791 total abundance. Season = spring, fall. Quality = 1)

38. Board of Commissioners on Fisheries and Game. 1917. Special Report of the Board of Commissioners on Fisheries and Game Relative to the Fish and Fisheries of Buzzards Bay. House No. 534. 30 pp.

(541 records, 46 species, 452,705 total abundance. Season = spring, summer, fall. Quality = 1)

39. Goode, G.B. 1887. The Fisheries and Fishery Industries of the United States. Section V, Vol. I. History and Methods of the Fisheries. Washington, D.C .

(33 records, 23 species, 0 abundance. Season = spring, summer, fall. Quality = 3)

40. Sherwood, G.H. and V.N. Evans, 1901. Notes on migration, spawning, abundance of certain fishes in 1900. In: Biological Notes, # 2. Bull. U.S. Fish. Comm. XXI. Washington, D.C.

(1 record, 1 species, 0 abundance. Season unspecified. Quality = 3)

41. Storer, 1843. Cited in Sumner, reference # 32 above in which no bibliographic reference is given.

(4 records, 4 species, 38 total abundance. Season unspecified. Quality = 3)

42. Moss, S.A., 1985. River herring reproductive energetics. Unpublished manuscript.

(7 records, 1 species, 92 total abundance. Season = spring. Quality = 2)

43. Rusek, T., 1986. Data records, Acushnet River gill net collections. Unpublished.

(38 records, 7 species, 186 total abundance. Season = summer, fall. Quality = 1)

44. Moss, S. A., 1986-87. Data records, Westport River seine collections. Unpublished

(10 records, 10 species, 508 total abundance. . Season = fall. Quality = 2)

45. Stolgitus, J.A., 1970. Some aspects of the biology of the tautog, Tautoga onitis (Linnaeus), from the Weweantic Estuary, Massachusetts, 1967. M.S. Thesis, UMass (Amherst). 48 pp.

(41 records, 1 species, 261 total abundance, . Season = spring, summer, fall. Quality = 2)

46. Howe, A.B., 1971. Biological investigation of the Atlantic tomcod, Microgadus tomcod (Walbaum), in the Weweantic River Estuary, Massachusetts, 1967. M.S. Thesis, UMass (Amherst). 81 pp.

21 records, 1 species, 319 total abundance. . Season = winter, spring, summer, fall. Quality = 2)

47. Lebida, R.C., 1969. The seasonal distribution, abundance and distribution of eggs, larvae, and juvenile fishes in the Weweantic River Estuary, Massachusetts. 1966. M.S. Thesis, UMass (Amherst). 59 pp. Report 47 species of juvenile fish collected; however, collection data are only summaries.

(386 records, 38 species, 0 total abundance. Season = winter, spring, summer, fall. Quality = 3)

48.Crestin, D.S., 1973. Some aspects of the biology of adults and early life stages of the rainbow smelt, Osmerus mordax (Mitchill), from the Weweantic River Estuary, Wareham-Marion, Massachusets, 1968. M.S. Thesis, UMass (Amherst). 108 pp.

(13 records, 1 species, 429 total abundance. Season = summer. Quality = 2)

49. Smith, R.M. and C.F. Cole, 1970. Chlorinated hydrocarbon residue in winter flounder, Pseudopleuronectes americanus, from the Weweantic River Estuary. J. Fish. Res. Bd. Canada 27(12):2374-2380.

(9 records, 1 species, 65 total abundance. Season = winter, spring, summer, fall. Quality = 2)

51. Frame, David W., 1972. Biology of young winter flounder, Pseudopleuronectes americanus (Walbaum): Feeding habits, metabolism and food utilization. M.S. Thesis, UMass (Amherst).

(2 records, 1 species, 40 total abundance. Season = summer. Quality = 2)

52. Howe, A.B. and P.G. Coates, 1975. Winter flounder movements, growth, and mortality off Massachusetts. Trans. Amer. Fish. Soc. 104(1):13-29. Exact dates and numbers not given, extracted from tables.

(6 records, 1 species, 499 total abundance. Season = winter, spring. Quality = 2)

53. Pierce, D.E. and A.B. Howe, 1977. A further study on winter flounder group identification off Massachusetts. Trans. Amer. Fish. Soc. 106(2):131-139. Exact dates inferred.

(18 records, 1 species, 1,800 total abundance. Season = fall. Quality = 2)

54. Lux, F.E., 1984. Fishes caught in neuston samples in Buzzards Bay, Massachusetts, in 1979.
Woods Hole Laboratory Reference Doc. No. 84-01
NOAA, NMFS, NEZFC, Woods Hole. 3 pp.

(No exact dates (May - November, 1979), no abundances or locations. Season = spring, summer, fall . Quality = 3)

APPENDIX B

Fish Species in Data Base with their common, scientific names and NODC codes

common name	scientific name	NODC code
1. sea lamprey	Petromyzon marinus	008603010301
2. sand tiger	Eugomphodes taurus	008707030101
3. white shark	Carcharodon carcharias	008707040101
4. thresher shark	Alopias vulpinus	008707040401
5. shortfin mako	Isurus oxyrinchus	008707040501
6. tiger shark	Galeocerdo cuvieri	008708020201
7. smooth dogfish	Mustelus canis	008708020401
8. dusky shark	Carcharhinus obscurus	008708020501
9. sandbar shark	Carcharhinus plumbeus	008708020503
10. blacktip shark	Carcharhinus limbatus	008708020507
11. blue shark	Prionace glauca	008708020601
12. smooth hammerhead	Sphyrna zygaena	008708030102
13. spiny dogfish	Squalus acanthias	008710010201
14. Atlantic angel shark	Squatina dumerili	008711010102
15. Atlantic torpedo	Torpedo nobiliana	008713030102
16. clearnose skate	Raja eglanteria	008713040113
17. little skate	Raja erinacea	008713040114
18. barndoor skate	Raja laevis	008713040115
19. winter skate	Raja ocellata	008713040116
20. thorny skate	Raja radiata	008713040134
21. roughtail stingray	Dasyatis centroura	008713050104
22. smooth butterfly ray	Gymnura micrura	008713050202
23. bullnose ray	Myliobatis freminvillei	008713070201
24. cownose ray	Rhinoptera bonasus	008713070301
25. shortnose sturgeon	Acipenser brevirostris	008729010104
26. Atlantic sturgeon	Acipenser oxyrhynchus	008729010105
27. ladyfish	Elops saurus	008738010101
28. tarpon	Megalops atlanticus	008738020201
29. bonefish	Abula vulpes	008739010101
30. American eel	Anguilla rostrata	008741010101
31. conger eel	Conger oceanicus	008741120101
32. American shad	Alosa sapidissima	008747010101
33. blueback herring	Alosa aestivalis	008747010102
34. hickory shad	Alosa mediocris	008747010103
35. alewife	Alosa pseudoharengus	008747010105
36. Atlantic herring	Clupea harengus	008747010201
37. Atlantic menhaden	Brevoortia tyrannus	008747010401
38. round herring	Etrumeus teres	008747010601
39. Atlantic thread herring	Opisthonema oglinum	008747010701
40. Spanish sardine	Sardinella aurita	008747011001
41. striped anchovy	Anchoa hepsetus	008747020201
42. bay anchovy	Anchoa mitchilli	008747020202
43. flat anchovy	Anchoviella perfasciata	008747020304

common name	scientific name	NODC code
44. Atlantic salmon	Salmo salar	008755010305
45. brook trout	Salvelinus fontinalis	008755010404
46. rainbow smelt	Osmerus mordax	008755030302
47. Atlantic argentine	Argentina silus	008756010203
48. inshore lizardfish	Synodus foetens	008762020101
49. snakefish	Trachinocephalus myops	008762020401
50. gafftopsail catfish	Bagre marinus	008777180101
51. oyster toadfish	Opsanus tau	008783010201
52. goosefish	Lophius americanus	008786010101
53. Atlantic cod	Gadus morhua	008791030402
54. Atlantic tomcod	Microgadus tomcod	008791030602
55. pollock	Pollachius virens	008791030901
56. red hake	Urophycis chuss	008791031001
57. spotted hake	Urophycis regia	008791031002
58. white hake	Urophycis tenuis	008791031003
59. haddock	Melanogrammus aeglefinus	008791031301
60. fourbeard rockling	Enchelyopus cimbrius	008791031501
61. silver hake	Merluccius bilinearis	008791040101
62. striped cusk-eel	Ophidion marginatum	008792010613
63. ocean pout	Macrozoarces americanus	008793011601
64. Atlantic flyingfish	Cypselurus melanurus	008803010114
65. ballyhoo	Hemiramphus brasiliensis	008803010201
66. halfbeak	Hyporhamphus unifasciatus	008803010301
67. flat needlefish	Ablennes hians	008803020101
68. Atlantic needlefish	Strongylura marina	008803020201
69. agujon	Tylosurus acus	008803020301
70. Atlantic saury	Scomberesox saurus	008803030201
71. sheepshead minnow	Cyprinodon variegatus	008804040101
72. banded killifish	Fundulus diaphanus	008804040202
73. mummichog	Fundulus heteroclitus	008804040203
74. striped killifish	Fundulus majalis	008804040205
75. rainwater killifish	Lucania parva	008804040301
76. inland silverside	Menidia beryllina	008805020301
77. Atlantic silverside	Menidia menidia	008805020302
78. threespine stickleback	Gasterosteus aculeatus	008818010101
79. blackspotted stickleback	Gasterosteus wheatlandi	008818010102
80. ninespine stickleback	Pungitius pungitius	008818010201
81. fourspine stickleback	Apeltes quadracus	008818010301
82. bluespotted cornetfish	Fistularia tabacaria	008819020101
83. northern pipefish	Syngnathus fuscus	008820020103
84. lined seahorse	Hippocampus erectus	008820020201
85. redfish or ocean perch	Sebastes marinus	008826010139
86. spotted scorpionfish	Scorpaena plumieri	008826010614
87. northern searobin	Prionotus carolinus	008826020101
88. striped searobin	Prionotus evolans	008826020102
89. sea raven	Hemitripterus americanus	008831021503
90. grubby	Myoxocephalus aenaeus	008831022207
91. longhorn sculpin	Myoxocephalus octodecemspinosus	008831022209
92. shorthorn sculpin	Myoxocephalus scorpius	008831022210
93. alligatorfish	Aspidophoroides monopterygius	008831080304

Appendix B (cont.)

common name	scientific name	NODC code
94. seasnail	Liparis atlanticus	008831090826
95. striped seasnail	Liparis liparis	008831090828
96. lumpfish	Cyclopterus lumpus	008831091501
97. flying gurnard	Dactylopterus volitans	008832010101
98. white perch	Morone americana	008835020101
99. striped bass	Morone saxatilis	008835020102
100. black sea bass	Centropristis striata	008835020301
101. snowy grouper	Epinephelus niveatus	008835020411
102. bigeye	Priacanthus arenatus	008835170101
103. short bigeye	Pristigenys alta	008835170201
104. bluefish	Pomatomus saltatrix	008835250101
105. cobia	Rachycentron canadum	008835260101
106. marlinsucker	Remora osteochir	008835270102
107. remora	Remora remora	008835270103
108. spearfish remora	Remora brachyptera	008835270104
109. sharksucker	Echeneis naucrates	008835270201
110. rough scad	Trachurus lathami	008835270202
111. whitefin sharksucker	Echeneis neucratoides	008835280102
112. African pompano	Alectis ciliaris	008835280202
113. yellow jack	Caranx bartholomaei	008835280301
114. crevalle jack	Caranx hippos	008835280303
115. blue runner	Caranx crysos	008835280306
116. leatherjacket	Oligoplites saurus	008835280501
117. bigeye scad	Selar crumenophthalmus	008835280601
118. lookdown	Selene vomer	008835280701
119. greater amberjack	Seriola dumerili	008835280801
120. banded rudderfish	Seriola zonata	008835280804
121. yellowtail	Seriola lalandei	008835280806
122. Florida pompano	Trachinotus carolinus	008835280901
123. permit	Trachinotus falcatus	008835280902
124. palometa	Trachinotus goodei	008835280903
125. Atlantic moonfish	Selene setapinnis	008835281001
126. mackerel scad	Decapterus macarellus	008835281201
127. round scad	Decapterus punctatus	008835281202
128. pilotfish	Naucrates ductor	008835281501
129. gray snapper	Lutjanus griseus	008835360102
130. mutton snapper	Lutjanus analis	008835360103
131. schoolmaster	Lutjanus apodus	008835360104
132. dog snapper	Lutjanus jocu	008835360109
133. tripletail	Lobotes surinamensis	008835380101
134. silver jenny	Eucinostomus gula	008835390101
135. spotfin mojarra	Eucinostomus argenteus	008835390102
136. scup	Stenotomus chrysops	008835430101
137. pinfish	Lagodon rhomboides	008835430201
138. sheepshead	Archosargus probatocephalus	008835430301
139. weakfish	Cynoscion regalis	008835440104
140. spot	Leiostomus xanthurus	008835440401
141. banded drum	Larimus fasciatus	008835440501
142. northern kingfish	Menticirrhus saxatilis	008835440603
143. Atlantic croaker	Micropogonias undulatus	008835440701

common name	scientific name	NODC code
144. red drum	Sciaenops ocellatus	008835440901
145. red goatfish	Mullus auratus	008835450201
146. Bermuda chub	Kyphosus sectatrix	008835510102
147. Atlantic spadefish	Chaetodipterus faber	008835520101
148. spotfin butterflyfish	Chaetodon ocellatus	008835550101
149. foureye butterflyfish	Chaetodon capistratus	008835550103
150. striped mullet	Mugil cephalus	008836010101
151. white mullet	Mugil curema	008836010102
152. fantail mullet	Mugil trichodon	008836010105
153. northern sennet	Sphyraena borealis	008837010102
154. guaguanche	Sphyraena guachancho	008837010103
155. great barracuda	Sphyraena barracuda	008837010104
156. tautog	Tautoga onitis	008839010101
157. cunner	Tautogolabrus adspersus	008839010201
158. wrymouth	Cryptacanthodes maculatus	008842120905
159. snakeblenny	Lumpenus lumpretaeformis	008842122001
160. radiated shanny	Ulvaria subbifurcata	008842122101
161. rock gunnel	Pholis gunnellus	008842130209
162. American sand lance	Ammodytes americanus	008845010102
163. darter goby	Gobionellus boleosoma	008847010501
164. naked goby	Gobiosoma bosci	008847010601
165. seaboard goby	Gobiosoma ginsburgi	008847010602
166. Atlantic cutlassfish	Trichiurus lepturus	008850020201
167. little tunny	Euthynnus alletteratus	008850030102
168. Atlantic bonito	Sarda sarda	008850030202
169. chub mackerel	Scomber japonicus	008850030301
170. Atlantic mackerel	Scomber scombrus	008850030302
171. albacore	Thunnus alalunga	008850030401
172. bluefin tuna	Thunnus thynnus	008850030402
173. Spanish mackerel	Scomberomorus maculatus	008850030502
174. cero	Scomberomorus regalis	008850030503
175. frigate mackerel	Auxis thazard	008850030702
176. swordfish	Xiphias gladius	008850040101
177. sailfish	Istiophorus platypterus	008850060101
178. longbill spearfish	Tetrapterus pfluegeri	008850060304
179. butterfish	Peprilus triacanthus	008851030103
180. harvestfish	Peprilus alepidotus	008851030106
181. bigeye squaretail	Tetragonurus atlanticus	008851040102
182. gulfstream flounder	Citharichthys arctifrons	008857030104
183. smallmouth flounder	Etropus microstomus	008857030202
184. summer flounder	Paralichthys dentatus	008857030301
185. fourspot flounder	Paralichthys oblongus	008857030305
186. windowpane	Scophthalmus aquosus	008857030401
187. witch flounder	Glyptocephalus cynoglossus	008857040502
188. American plaice	Hippoglossoides platessoides	008857040603
189. yellowtail flounder	Limanda ferruginea	008857040903
190. Atlantic halibut	Hippoglossus hippoglossus	008857041902
191. winter flounder	Pseudopleuronectes americanus	008857042001
192. hogchoker	Trinectes maculatus	008858010101
193. orange filefish	Aluterus schoepfi	008860020101

Appendix B (cont.)

common name	scientific name	NODC code
194. unicorn filefish	Aluterus monoceros	008860020103
195. gray triggerfish	Balistes capriscus	008860020201
196. queen triggerfish	Balistes vetula	008860020202
197. planehead filefish	Monacanthus hispidus	008860020703
198. trunkfish	Lactophrys trigonus	008860030101
199. smooth trunkfish	Lactophrys triqueter	008860030103
200. smooth puffer	Lagocephalus laevigatus	008861010101
201. northern puffer	Sphoeroides maculatus	008861010201
202. bandtail puffer	Sphoeroides spengleri	008861010211
203. striped burrfish	Chilomycterus schoepfi	008861030101
204. web burrfish	Chilomycterus antillarum	008861030103
205. porcupinefish	Diodon hystrix	008861030201
206. ocean sunfish	Mola mola	008861040101

APPENDIX C

TOTAL FISH SPECIES

Because the physical and logical form of the data base has two separate sets of data (pre-1920 and post-1960), the master list of fishes included below is arranged in two sets of columns, each representing one of the database segments. For each segment the number of records in the data base for each of the 206 species is given in the first column and the total number of individuals of each species in the second.

SUMMARY OF SPECIES IN THE DATA BASE

PRE 1920 POST 1960
SPECIES

common name* scientific name	Pre-1920 records	#'s	Post-1960 records	#'s
1. sea lamprey (Petromyzon marinus)	2	-	1	1
2. sand tiger (Eugomphodes taurus)	20	126	1	0
3. white shark (Carcharodon carcharias)	4	3	0	-
4. thresher shark (Alopias vulpinus)	12	24	0	-
5. shortfin mako (Isurus oxyrinchus)	3	-	0	-
6. tiger shark (Galeocerdo cuvieri)	3	-	0	-
7. smooth dogfish (Mustelus canis)	36	2,786	130	1,454
8. dusky shark (Carcharhinus obscurus)	14	45	0	-
9. sandbar shark (Carcharhinus plumbeus)	2	4	1	1
10. blacktip shark (Carcharhinus limbatus)	3	20	0	-
11. blue shark (Prionace glauca)	2	1	0	-
12. smooth hammerhead (Sphyrna zygaena)	5	3	0	-
13. spiny dogfish (Squalus acanthias)	18	4,809	85	333
14. Atlantic angel shark (Squatina dumerili)	1	-	0	-
15. Atlantic torpedo (Torpedo nobiliana)	3	-	4	5
16. clearnose skate (Raja eglanteria)	2	-	0	-
17. little skate (Raja erinacea)	36	2,458	92	1,216
18. barndoor skate (Raja laevis)	16	292	0	-
19. winter skate (Raja ocellata)	15	1,035	29	332
20. thorny skate (Raja radiata)	2	-	0	-
21. roughtail stingray (Dasyatis centroura)	10	22	0	-
22. smooth butterfly ray (Gymnura micrura)	3	-	0	-
23. bullnose ray (Myliobatis freminvillei)	3	-	0	-
24. cownose ray (Rhinoptera bonasus)	3	-	0	-
25. shortnose sturgeon (Acipenser brevirostris)	2	-	-	-
26. Atlantic sturgeon (Acipenser oxyrhinchus)	3	-	-	-
27. ladyfish (Elops saurus)	2	-	0	-
28. tarpon (Megalops atlanticus)	3	-	0	-

* - Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1980. A list of Common and Scientific Names of Fishes from the United States and Canada. Amer. Fish. Soc. sp. publ. No. 12:1-174.

APPENDIX C (cont)

common name scientific name	Pre-1920 records	#'s	Post-1960 records	#'s
29. bonefish (Abula vulpes)	2	-	0	-
30. American eel (Anguilla rostrata)	16	1,167	68	422
31. conger eel (Conger oceanicus)	6	133	5	5
32. American shad (Alosa sapidissima)	10	9	9	33
33. blueback herring (Alosa aestivalis)	11	33,217	26	557
34. hickory shad (Alosa mediocris)	23	2,063	0	-
35. alewife (Alosa pseudoharengus)	28	42,411	68	1,132
36. Atlantic herring (Clupea harengus)	9	54	23	3,734
37. Atlantic menhaden (Brevoortia tyrannus)	22	2,096	51	5,338
38. round herring (Etrumeus teres)	4	5,834	2	3
39. Atlantic thread herring (Opisthonema oglinum)	3	-	0	-
40. Spanish sardine (Sardinella aurita)	3	-	0	-
41. striped anchovy (Anchoa hepsetus)	0	-	17	6,768
42. bay anchovy (Anchoa mitchilli)	3	-	25	32,652
43. flat anchovy (Anchoviella perfasciata)	2	-	0	-
44. Atlantic salmon (Salmo salar)	3	-	0	-
45. brook trout (Salvelinus fontinalis)	2	-	0	-
46. rainbow smelt (Osmerus mordax)	5	184	41	687
47. Atlantic argentine (Argentina silus)	2	22	0	-
48. inshore lizardfish (Synodus foetens)	1	-	2	3
49. snakefish (Trachinocephalus myops)	2	-	3	5
50. gafftopsail catfish (Bagre marinus)	1	-	0	-
51. oyster toadfish (Opsanus tau)	3	-	26	83
52. goosefish (Lophius americanus)	21	636	10	10
53. Atlantic cod (Gadus morhua)	5	2	32	269
54. Atlantic tomcod (Microgadus tomcod)	11	1,425	76	539
55. pollock (Pollachius virens)	5	74	28	460
56. red hake (Urophycis chuss)	3	-	46	378
57. spotted hake (Urophycis regia)	4	2	13	39
58. white hake (Urophycis tenuis)	3	-	37	176
59. haddock (Melanogrammus aeglefinus)	2	-	0	-
60. fourbeard rockling (Enchelyopus cimbrius)	4	-	25	129
61. silver hake (Merluccius bilinearis)	28	43,060	52	1,731
62. striped cusk-eel (Ophidion marginatum)	0	-	2	1
63. ocean pout (Macrozoarces americanus)	3	-	6	91
64. Atlantic flyingfish (Cypselurus melanurus)	3	-	0	-
65. ballyhoo (Hemiramphus brasiliensis)	1	1	0	-
66. halfbeak (Hyporhamphus unifasciatus)	1	-	0	-
67. flat needlefish (Ablennes hians)	1	1	0	-
68. Atlantic needlefish (Strongylura marina)	3	-	16	63
69. agujon (Tylosurus acus)	2	-	0	-
70. Atlantic saury (Scomberesox saurus)	2	-	0	-
71. sheepshead minnow (Cyprinodon variegatus)	3	-	31	7,021
72. banded killifish (Fundulus diaphanus)	1	-	30	1,399
73. mummichog (Fundulus heteroclitus)	-	-	96	19,736
74. striped killifish (Fundulus majalis)	3	-	81	5,523
75. rainwater killifish (Lucania parva)	2	-	5	2,014
76. inland silverside (Menidia beryllina)	2	-	28	3,560
77. Atlantic silverside (Menidia menidia)	3	-	142	32,870

APPENDIX C (cont)

common name scientific name	Pre-1920 records	#'s	Post-1960 records	#'s
78. threespine stickleback (Gasterosteus aculeatus)	3	-	35	403
79. blackspotted stickleback (Gasterosteus wheatlandi)	2	-	0	-
80. ninespine stickleback (Pungitius pungitius)	3	-	19	358
81. fourspine stickleback (Apeltes quadracus)	3	-	98	8,630
82. bluespotted cornetfish (Fistularia tabacaria)	3	-	2	2
83. northern pipefish (Syngnathus fuscus)	2	-	83	898
84. lined seahorse (Hippocampus erectus)	2	-	0	-
85. redfish or ocean perch (Sebastes marinus)	2	-	0	-
86. spotted scorpionfish (Scorpaena plumieri)	2	22	0	-
87. northern searobin (Prionotus carolinus)	16	2,052	146	3,670
88. striped searobin (Prionotus evolans)	7	32	57	159
89. sea raven (Hemitripterus americanus)	3	-	7	9
90. grubby (Myoxocephalus aenaeus)	-	-	3	8
91. longhorn sculpin (Myoxocephalus octodecemspinosus)	3	-	31	493
92. shorthorn sculpin (Myoxocephalus scorpius)	14	328	36	345
93. alligatorfish (Aspidophoroides monopterygius	0	-	1	-
94. seasnail (Liparis atlanticus)	0	-	3	1
95. striped seasnail (Liparis liparis)	2	-	0	-
96. lumpfish (Cyclopterus lumpus)	4	3	4	2
97. flying gurnard (Dactylopterus volitans)	3	-	2	2
98. white perch (Morone americana)	3	-	45	1,389
99. striped bass (Morone saxatilis)	7	46	28	49
100. black sea bass (Centropristis striata)	13	333	101	6,142
101. snowy grouper (Epinephelus niveatus)	2	-	1	1
102. bigeye (Priacanthus arenatus)	2	-	0	-
103. short bigeye (Pristigenys alta)	2	-	3	4
104. bluefish (Pomatomus saltatrix)	16	644	59	412
105. cobia (Rachycentron canadum)	3	1	0	-
106. rough scad (Trachurus lathami)	0	-	5	6
107. marlinsucker (Remora osteochir)	3	1	0	-
108. remora (Remora remora)	3	1	0	-
109. spearfish remora (Remora brachyptera)	3	-	0	-
110. sharksucker (Echeneis naucrates)	4	-	0	-
111. whitefin sharksucker (Echeneis neucratoides)	2	-	0	-
112. African pompano (Alectis ciliaris)	3	-	0	-
113. yellow jack (Caranx bartholomaei)	3	-	0	-
114. crevalle jack (Caranx hippos)	3	-	10	116
115. blue runner (Caranx crysos)	4	-	1	1
116. leatherjacket (Oligoplites saurus)	1	1	0	-
117. bigeye scad (Selar crumenophthalmus)	3	-	0	-
118. lookdown (Selene vomer)	4	-	1	41
119. greater amberjack (Seriola dumerili)	2	-	0	-
120. banded rudderfish (Seriola zonata)	4	-	0	-
121. yellowtail (Seriola lalandei)	2	-	0	-
122. Florida pompano (Trachinotus carolinus)	3	-	0	-
123. permit (Trachinotus falcatus)	3	-	3	8
124. palometa (Trachinotus goodei)	2	-	0	-
125. Atlantic moonfish (Selene setapinnis)	3	-	2	2
126. mackerel scad (Decapterus macarellus)	3	-	2	2

APPENDIX C (cont)

common name scientific name	Pre-1920 records	#'s	Post-1960 records	#'s
127. round scad (Decapterus punctatus)	3	4	1	2
128. pilotfish (Naucrates ductor)	3	2	0	-
129. gray snapper (Lutjanus griseus)	2	-	0	-
130. mutton snapper (Lutjanus analis)	1	4	1	1
131. schoolmaster (Lutjanus apodus)	1	-	0	-
132. dog snapper (Lutjanus jocu)	1	-	0	-
133. tripletail (Lobotes surinamensis)	3	-	0	-
134. silver jenny (Eucinostomus gula)	2	-	1	100
135. spotfin mojarra (Eucinostomus argenteus)	0	-	1	100
136. scup (Stenotomus chrysops)	23	23,043	192	218,331
137. pinfish (Lagodon rhomboides)	3	-	0	-
138. sheepshead (Archosargus probatocephalus)	4	-	0	-
139. weakfish (Cynoscion regalis)	20	153	17	72
140. spot (Leiostomus xanthurus)	3	-	0	-
141. banded drum (Larimus fasciatus)	2	-	0	-
142. northern kingfish (Menticirrhus saxatilis)	8	6	11	28
143. Atlantic croaker (Micropogonias undulatus)	2	1	0	-
144. red drum (Sciaenops ocellatus)	2	-	0	-
145. red goatfish (Mullus auratus)	2	5	4	4
146. Bermuda chub (Kyphosus sectatrix)	3	-	0	-
147. Atlantic spadefish (Chaetodipterus faber)	2	-	0	-
148. spotfin butterflyfish (Chaetodon ocellatus)	2	-	0	-
149. foureye butterflyfish (Chaetodon capistratus)	2	-	0	-
150. striped mullet (Mugil cephalus)	3	-	24	333
151. white mullet (Mugil curema)	3	-	0	-
152. fantail mullet (Mugil trichodon)	1	-	0	-
153. northern sennet (Sphyraena borealis)	2	-	0	-
154. guaguanche (Sphyraena guachancho)	3	-	2	4
155. great barracuda (Sphyraena barracuda)	2	-	0	-
156. tautog (Tautoga onitis)	34	1,553	223	3,321
157. cunner (Tautogolabrus adspersus)	10	205	139	3,267
158. wrymouth (Cryptacanthodes maculatus)	2	-	5	4
159. snakeblenny (Lumpenus lumpretaeformis)	0	-	4	-
160. radiated shanny (Ulvaria subbifurcata)	1	-	1	-
161. rock gunnel (Pholis gunnellus)	5	-	25	70
162. American sand lance (Ammodytes americanus)	4	-	35	4,106
163. darter goby(Gobionellus boleosoma)	0	-	1	1
164. naked goby (Gobiosoma bosci)	3	-	4	24
165. seaboard goby (Gobiosoma ginsburgi)	0	-	9	268
166. Atlantic cutlassfish (Trichiurus lepturus)	2	-	0	-
167. little tunny (Euthynnus alletteratus)	2	-	0	-
168. Atlantic bonito (Sarda sarda)	5	2	0	-
169. chub mackerel (Scomber japonicus)	1	-	0	-
170. Atlantic mackerel (Scomber scombrus)	39	209,046	12	131
171. albacore (Thunnus alalunga)	3	1	0	-
172. bluefin tuna (Thunnus thynnus)	2	-	0	-
173. Spanish mackerel (Scomberomorus maculatus)	3	-	0	-
174. cero (Scomberomorus regalis)	2	-	0	-
175. frigate mackerel (Auxis thazard)	1	-	0	-

common name scientific name	Pre-1920 records	#'s	Post-1960 records	#'s
176. swordfish (Xiphias gladius)	1	-	0	-
177. sailfish (Istiophorus platypterus)	2	-	0	-
178. longbill spearfish (Tetrapterus pfluegeri)	3	-	0	-
179. butterfish (Peprilus triacanthus)	41	65,692	103	36,548
180. harvestfish (Peprilus alepidotus)	2	-	0	-
181. bigeye squaretail (Tetragonurus atlanticus)	2	-	0	-
182. gulfstream flounder (Citharichthys arctifrons)	0	-	5	6
183. smallmouth flounder (Etropus microstomus)	0	-	1	-
184. summer flounder (Paralichthys dentatus)	41	5,398	141	675
185. fourspot flounder (Paralichthys oblongus)	8	1,167	69	429
186. windowpane (Scophthalmus aquosus)	8	55	214	2,078
187. witch flounder (Glyptocephalus cynoglossus)	0	-	1	-
188. American plaice (Hippoglossoides platessoides)	4	-	1	5
189. yellowtail flounder (Limanda ferruginea)	4	-	3	-
190. Atlantic halibut (Hippoglossus hippoglossus)	1	-	0	-
191. winter flounder (Pseudopleuronectes americanus)	5	58	355	11,492
192. hogchoker (Trinectes maculatus)	3	-	27	74
193. orange filefish (Aluterus schoepfi)	3	-	3	5
194. unicorn filefish (Aluterus monoceros)	2	1	0	-
195. gray triggerfish (Balistes capriscus)	0	-	1	1
196. queen triggerfish (Balistes vetula)	3	1	0	-
197. planehead filefish (Monacanthus hispidus)	3	-	25	228
198. trunkfish (Lactophrys trigonus)	2	-	0	-
199. smooth trunkfish (Lactophrys triqueter)	2	1	0	-
200. smooth puffer (Lagocephalus laevigatus)	2	-	0	-
201. northern puffer (Sphoeroides maculatus)	7	58	37	120
102. bandtail puffer (Sphoeroides spengleri)	3	-	0	-
203. striped burrfish Chilomycterus schoepfi)	3	-	0	-
204. web burrfish (Chilomycterus antillarum)	2	1	0	-
205. porcupinefish (Diodon hystrix)	2	1	0	-
206. ocean sunfish (Mola mola)	3	-	0	-

APPENDIX D

INSTRUCTIONS FOR ACCESSING THE COMPUTER DATA BASE

Included with this report are diskettes that are formatted for use on IBM-PC microcomputers, or compatible machines using the MS-DOS operating system. Two of these diskettes contain the databases. They are marked BUZ1FISH (containing the post-1960 data set), and BUZ2FISH (containing the pre-1920 data set and the source data base). The third diskette, marked "PC-FILE:Db. Program Disk", contains the software needed to access and manipulate the data bases.

With the PC-FILE Db program disk in the logged drive, the program is started by entering "PCF" at the DOS prompt. With the online help screens (ALT-H) the menus in PCFILE Db it will be possible to search, select, sort, modify, delete, list, clone, merge, copy, export, or otherwise manipulate the finfish data base. Sorting and selecting from the source data base will allow the filtering and cloning of additional finfish data bases according to whatever criteria are deemed necessary. The data files are in a format compatable with the popular dBase application, and may be accessed from that application.

APPENDIX E

Description of the fields within a single database record.

The first field in each record, "Taxon_Number", occupies 12 columns and is filled with the NODC code for the species of that record. The NODC code numbers are generally assigned in phylogenetic sequence, so a sort of the data base for Taxonomic Number in ascending order will produce a list arranged in increasing taxonomic order.

The second field in each record is "date", an eight column field that contains the month (first two columns - 01 [January] to 12 [December], day (second two columns [01 - 31], and year (final four columns [e.g. 1978]). Although this field comprises three different elements, it may be sorted by any or all of the elements.

The third field is a two column one, "no" that contains the two digit keys to the source of the record being coded, and given in the annotated Data Sources in Appendix A.

The fourth and fifth fields contain latitude and longitude in degrees north and west (first two columns in each field), minutes (third and fourth columns), and seconds (fifth and sixth columns in each field).

Field number 6 contains five columns and describes the collection gear by which the fish were taken (trawl, seine, trap, etc).

The seventh field ("abund_a") is as single column one and provides an estimate of abundance (a = abundant, c = common, u = uncommon, r = rare) that is helpful where more quantitative measures of abundance were not reported. The eighth field ("abund#") is a five column one and reports the number of individuals found in the sample.

The ninth field ("p") is another single column one and reports the presence (y) or absence (n) of physical or chemical data that can be found in the source listed under reference number. Most often these data include water temperature, depth, and (sometimes) salinity and/or dissolved oxygen at the collection site. The final field, "notes," provides 23 columns to report any special notations that are important to the record. Most often this space contains the genus and species of the fish in question.

```
Record number 512                                                                F
================================================================================
taxon number[0087470101051]
       date [09101986]
reference no[14]
   latitude [413148]
  longitude [705836]
location cod[1 ]
       gear [seine]
 abund alfa [c]
 abundance# [3     ]
  pchem y_n [n]
 slocum sta [ ]
      notes [Alosa pseudoharengus]
                                                            →Q←== ←↑→↓ ==
                                                             D Delete
                                                             M Modify
                                                             S new Search
                                                             E End of file
                                                             B Beginning "
                                                             N Next record
                                                             P Prior record
                                                             R get by Rcd#
                                                             + browse down
                                                             - browse up
                                                             Q Quit finding
```

APPENDIX F

This appendix contains a complete copy of the entire database that is sorted in ascending NODC code sequence, and within a code, by date, again in ascending order.