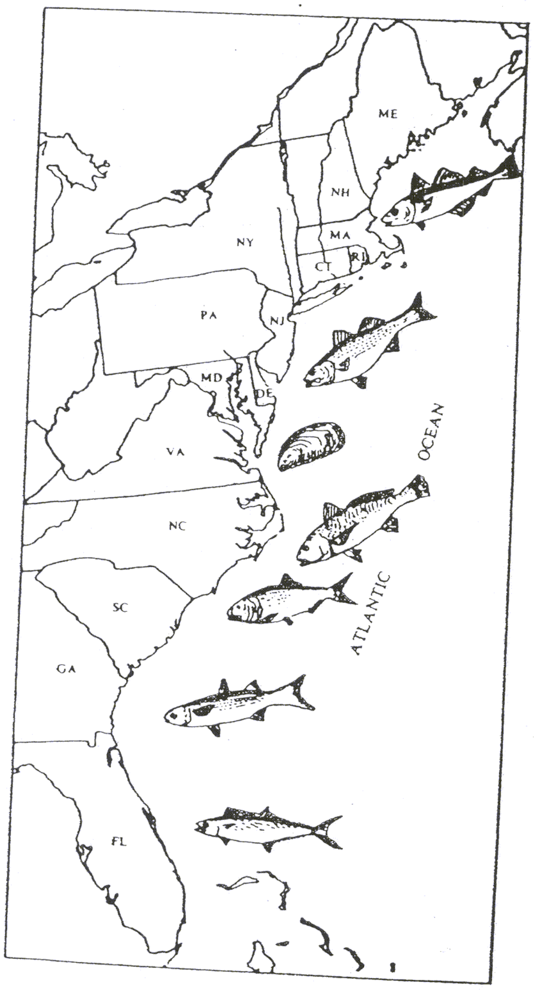
Fisheries Management Report No. 2

of the

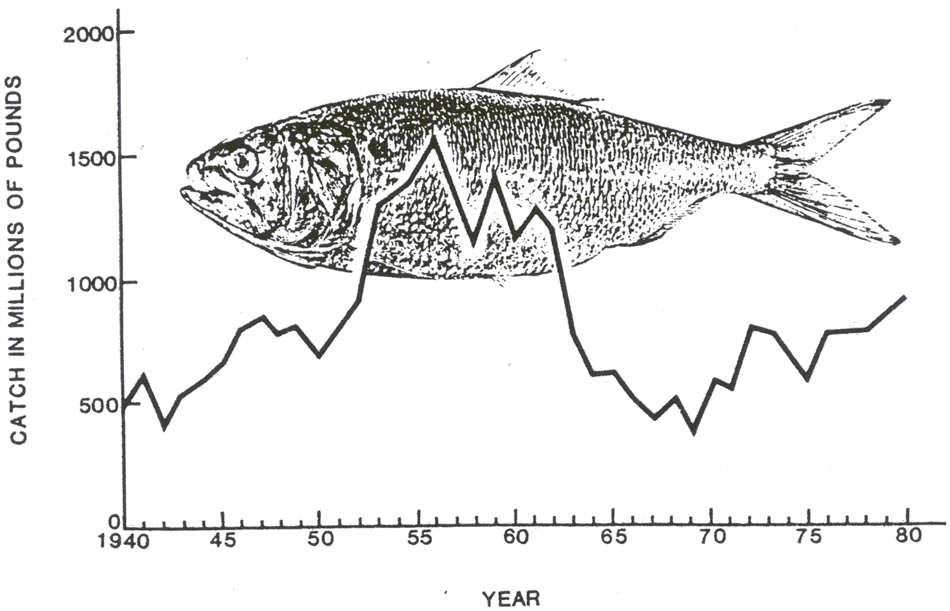
ATLANTIC STATES MARINE FISHERIES COMMISSION



FISHERY MANAGEMENT PLAN FOR ATLANTIC MENHADEN

August 1981

FISHERY MANAGEMENT PLAN for ATLANTIC MENHADEN BREVOORTIA TYRANNUS (LATROBE)



by the

ATLANTIC MENHADEN MANAGEMENT BOARD
JOHN M. CRONAN
CHAIRMAN

AUGUST 1981

FISHERY MANAGEMENT PLAN FOR ATLANTIC MENHADEN

BREVOORTIA TYRANNUS (LATROBE)

Prepared by the

ATLANTIC MENHADEN MANAGEMENT BOARD

JOHN M. CRONAN

CHAIRMAN

(as part of the Interstate Fishery Management Program administered by the Atlantic States Marine Fisheries Commission.)

August 1981

Funds, manpower and support services for plan preparation over the 5 year history of the Atlantic Menhaden Program were provided by the coastal states (most notably, Commonwealth of Virginia, State of New Jersey, State of North Carolina), co-operating menhaden companies (especially Standard Products, Inc., Zapata Haynie Corp., Seacoast Products, Inc.), and National Marine Fisheries Service (in particular the Beaufort Laboratory and the State Federal Fisheries Management Program). The Interstate Fisheries Management Program is supported by funds provided by Northeast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration under Cooperative Agreement No. NA-80-FA-H-00017.

EXECUTIVE SUMMARY

Atlantic menhaden represent a significant renewable Territorial Sea fishery resource which is distributed from Maine through Florida. Menhaden and other pelagic plankton feeding fishes serve as important foods of major predatory fishes of commercial and recreational importance. Atlantic menhaden occur in the coastal and estuarine waters at an abundance level which is adequate to support their share of the food needs of the predatory fish populations as well as the largest Atlantic coast commercial fishery by volume.

Atlantic menhaden have sustained a large and important fishery since colonial times. The fishery originated in New England waters and extended into the Chesapeake Bay and coastal North Carolina after the Civil War. Following World War II, the fishery expanded rapidly. Currently most of the commercial catch comes from the Territorial Sea and estuarine waters from eastern Long Island to northern South Carolina. Landings have varied over the decades. In 1980 catches by purse seine vessels were unloaded at reduction plants from Maine to Florida.

Analyses of the data base show that the Atlantic menhaden resource and fishery is based upon one stock which shows extensive coastwide migration. The resource is distributed by age and size along the coast with smaller and younger fish concentrating in the South Atlantic and Chesapeake Bay areas, and larger and older fish concentrating in the Middle and North Atlantic areas. All age groups occur in the North Carolina Fall fishery. Environmental factors play a major role in the determination of Atlantic menhaden year class success.

Landings by the purse seine fishery have always been high, making this fishery the largest on the Atlantic coast. The commercial operations provide significant numbers of jobs, and produce useful fishery products for domestic use and export. While social and economic aspects are important to management considerations, the health and well-being of the resource is of prime concern for both commercial and recreational interests.

During the August 1980 Philadelphia meeting, the Atlantic Menhaden Sub Board (=Atlantic Menhaden Management Board) concluded that as a minimum, 10% 3-year old and older fish (spawners) should be represented in the landings. They felt that this index would represent the minimum number of spawners required to maintain the stock, year to year. Further, if this minimum were maintained, the resource as well as commercial and recreational interests would be better protected in the event of consecutive year class failures.

The Atlantic Menhaden Management Board has given due consideration to the magnitude of the menhaden resources, the useful products derived therefrom, and the current diverse management authorities vested in the several states from Maine to Florida in development of this management plan. The plan provides for annual reviews that will permit a gradual increase in application of current knowledge and collection of additional information as the management program progresses.

Short-term (1980's) Objective:
Achieve for the entire Atlantic coast (not by any one state or geographic area) an age composition comprised of at least 10% of the landings in the purse seine fishery by number at age 3 or older (spawners) by the close of the 1983 season.

Long-term Objective:
Achieve the greatest continuing yield for each area by determining the age at which menhaden should be harvested and eliminating other restrictions which do not contribute to the management goal.

Achieving these objectives will require that selected projects be initiated so that the necessary information will be available as needed. Several review and action groups were created:

1) Atlantic Menhaden Advisory Committee (AMAC)
Technical membership by state, industry and NMFS to review status, suggest projects and recommend options to the Atlantic Menhaden Implementation Subcommittee.

2) Atlantic Menhaden Implementation Subcommittee (AMIS)
Three chief state fishery management administrators and three industry executives to evaluate options from AMAC and develop implementation strategies for options and to make recommendations to the Atlantic Menhaden Management Board.

3) Atlantic Menhaden Management Board (AMMB)
Six state administrators, six industry executives, and one NMFS representative who give final approval to management proposals, provide policy and guidance to AMIS and appoint members to AMIS and AMAC.

4) National Marine Fisheries Service - Southeast Fisheries Center (SEFC)
Continuation of the SEFC, Beaufort Laboratory Research and Stock Assessment Program with new data types and analyses as appropriate.

This management program will be a constituent part of the Atlantic States Marine Fisheries Commission's Interstate Fisheries Management Program.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

This document was drafted by the Atlantic Menhaden Scientific and Statistical Committee. The efforts of all present and former Committee members are gratefully acknowledged. Without their unrelenting attention to the tasks assigned by the Sub-Board this plan would not likely contain the rounded perspective gained by inputs from the diverse technical and industrial backgrounds represented on the Committee. Draft contributions to the plan by government and industry specialists for topical areas not represented on the Committee were made by Dr. Michael Orbach, Mr. Harry Kriegel and Mr. Thomas Ford. The contributions of state, industry, and academic members on the Population Dynamics I and II Subcommittees and Economic Subcommittee which were essential to the deliberations of the S&S Committee and preparation of this plan are deserving of special thanks. Technical and support services of the NMFS-Beaufort Laboratory and Virginia Institute of Marine Science greatly facilitated analyses, graphics, and typescript preparation and are acknowledged.

A limited number of copies of this document are available for distribution. Persons desiring a copy should forward a request to:

Mr. Robert Chapoton
NMFS-SEFC-Beaufort Laboratory
Beaufort, NC 28516-9722

or

Atlantic State Marine Fisheries Commission
ISFMP
1717 Massachusetts Ave., NW
Washington, DC 20036

SECTION 1. DESCRIPTION OF THE STOCK COMPRISING THE MANAGEMENT UNIT

A. Description and Distribution of Menhaden

Atlantic menhaden, *Brevoortia tyrannus* (Latrobe) 1802, belong to the herring family, Clupeidae, and are similar in appearance to the alewife and shad. It is distinguished from other Clupeidae by a large head, absence of teeth, pectinated scales, the location of the dorsal fin over the interval between the pelvic and anal fins and a compressed body with bony scutes. Other features include long gill rakers, and muscular pyloric stomach or gizzard. The body is bluish above and sides are silvery with a reddish luster. A conspicuous scapular spot is usually followed by two rows of smaller, secondary spots or blotches on the sides. The fins are tinged with pale yellow and edged in black.

Atlantic menhaden adults are found from Nova Scotia, Canada to West Palm Beach, Florida. It is an euryhaline species that occurs in the Atlantic Ocean and inland tidal waters along the eastern coast of the United States and Canada (Hildebrand 1948, 1964, Reintjes 1960, 1964).

Juveniles and adults occupy bays, sounds, and estuaries to the uppermost limits of brackish water. In the ocean they generally are confined to, or at least closely associated with, the waters overlying the Continental Shelf and never have been observed far from land. Gusev (1964) reported a catch of menhaden by a Soviet trawler about 130 km (80.8 mi) south of Cape Cod-- about the maximum distance from land that schools have been sighted by scouting aircraft, and farther offshore than the seaward limit of American purse seine operations.

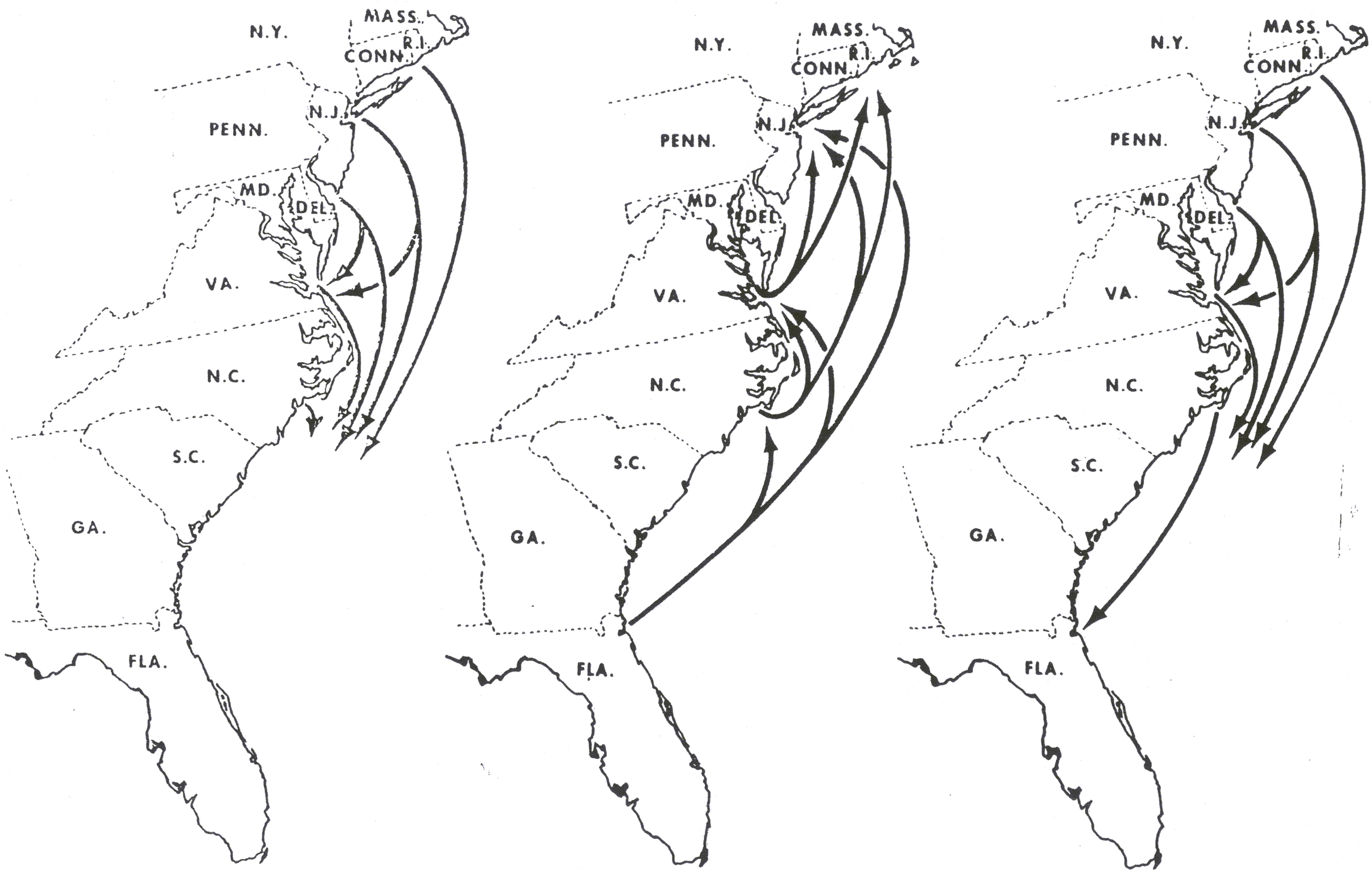
Hildebrand (1948) conjectured that each section of the Atlantic coast has its own population or race. June (1958) concluded from a study of the meristic characters of juveniles that at least two sub-populations occur, one north and one south of Long Island, N.Y., and Sutherland (1963) examined juveniles of four successive year classes-- 1956-59 with the same conclusions. June (1965) further supported the hypothesis by reporting significant differences in vertebral counts for maturing or nearly ripe adults of different spawning populations. More complete information, mostly from tagging studies (Nicholson 1978), demonstrate that Atlantic menhaden as now structured can be considered one population or stock which shows nearly complete intermingling from Maine to Florida.

Studies of the distribution of age and length groups in the catches, combined with information on the amount and distribution of fishing effort by the purse seine fleet, have demonstrated that the fish undertake extensive migrations. There is a northward movement along the coast in spring. During the summer, the smaller and younger fish are found in the southern part of the range, while progressively larger and older fish occur in more northerly latitudes. Further, there is a tendency for fish of similar size and age to occur together in a given locality, but to remain distinct from those of overlapping sizes and ages in adjacent localities. Thus, a north-south gradient in size and age becomes established, with larger and older fish found farther northward (June and Reintjes 1959; McHugh et al. 1959).

A southward withdrawal of fish from the summer grounds takes place in autumn. Prior to their southward migration, the fish congregate in large schools, which sometimes cover a surface area of many square kilometers. The fishing fleet follows the large schools as they migrate southward in October, but frequently the schools travel in deep water offshore where they cannot be caught. However, the schools are intercepted again as they pass close inshore along the coast of North Carolina in November. The large, migrating schools are last seen off the North Carolina coast in December or January (June 1961; Nicholson 1971 and 1972; Kroger and Guthrie 1973; Dryfoos et al. 1973; Roithmayr 1963; Reintjes 1969). Young-of-the-year (age 0) as well as older (age 1 and 2) and mature Atlantic menhaden (age 3+) undertake extensive migrations along the Atlantic coast of the United States (Figure 1.1).

In 1963, Roithmayr reported the distribution of fishing by purse seine vessels for the five-year period, 1955-1959. He estimated that during the five seasons surveyed, some 158,000 sets were made between April and January (Figure 1.2 and 1.3). From these data and other information early investigators concluded that Atlantic menhaden do not occur in equal abundance throughout the range, but are concentrated in certain localities during certain periods of the year. During the warmer months, the fish congregrate in schools in the near surface waters overlying the inner half of the Continental Shelf. While variations in the amount and distribution of fishing effort occurred from year to year, the area of concentration remained nearly the same over the 5 years for which such information was available. During the colder months, the fish rarely are seen in the surface waters. There is evidence that during this period they occur in loose aggregations in deeper water over the Continental Shelf. In Chesapeake Bay, however, menhaden have been taken at all times of year (McHugh, et al. 1959).

The observations and conclusions drawn by Roithmayr regarding the place and time that Atlantic menhaden appear in fishable quantities along the coast still hold true today, but distribution of fishing effort has changed. In recent years, purse seine fishing has concentrated in Chesapeake Bay and North Carolina. Fishing efforts in New England and Florida waters have been reduced from former years depicted in Figures 1.2 and 1.3.



FALL AND WINTER

JUVENILE

SPRING AND SUMMER

ADULT

FALL AND WINTER

ADULT

Figure 1.1. Juvenile and adult migrations of Atlantic menhaden.

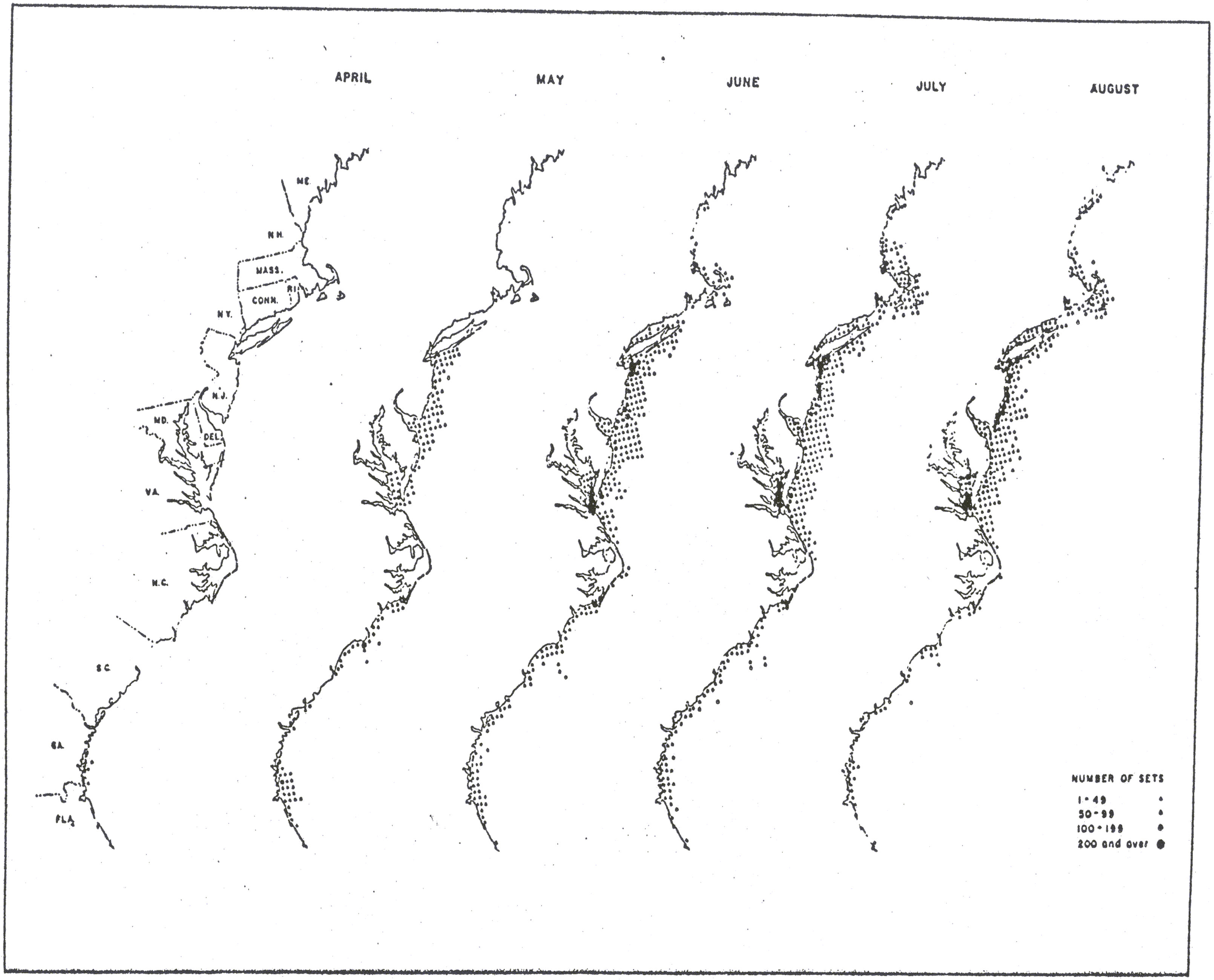


Figure 1.2. Distribution of the mean number of purse seine sets, April through August, 1955-59.

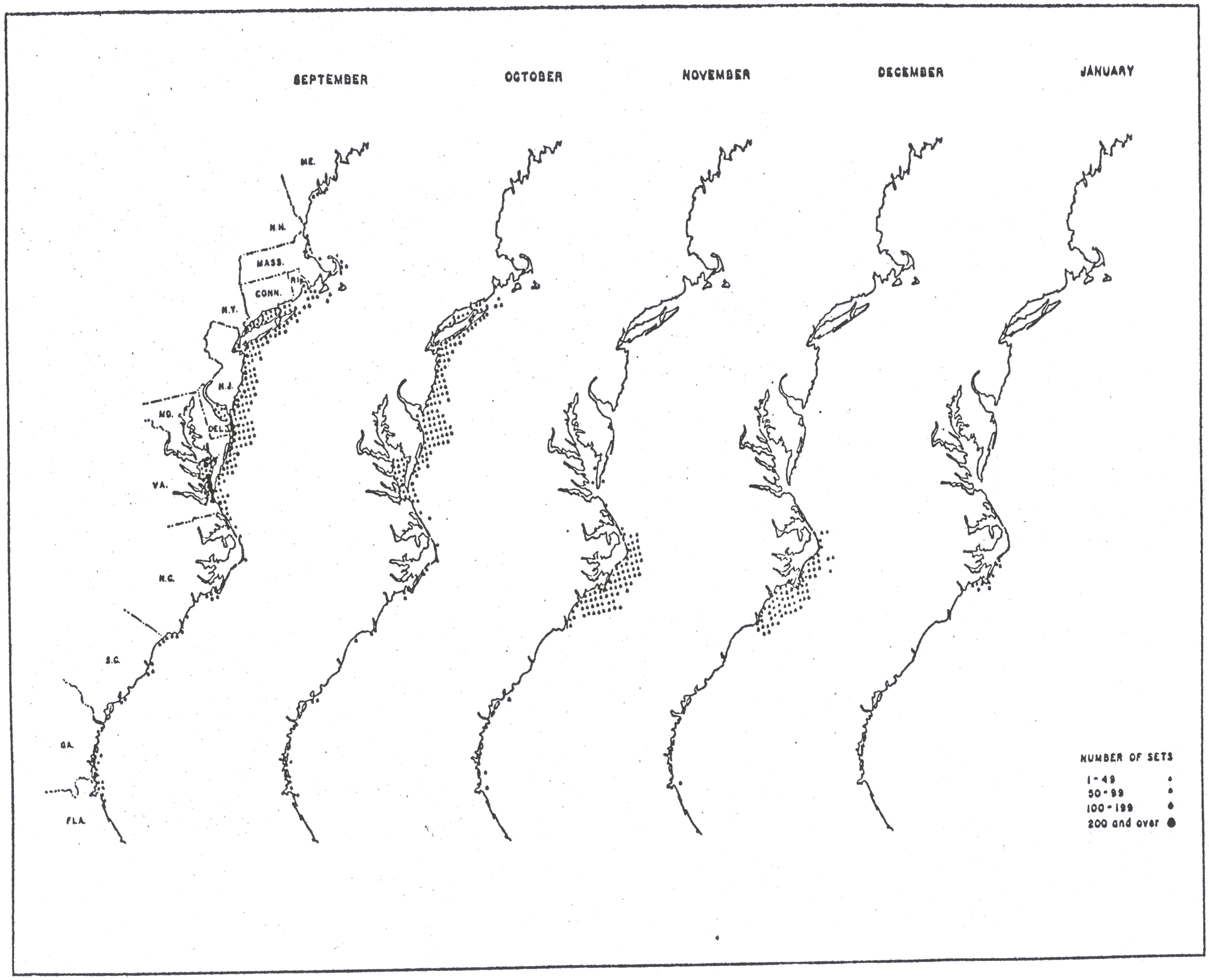


Figure 1.3. Distribution of the mean number of purse seine sets, September through January, 1955-60.

B. Present Stock Condition and Abundance

Several types of information are summarized in this appraisal of the present condition and abundance of the Atlantic menhaden population supporting the purse seine fishery, as well as the other minor fisheries, along the East Coast of the United States. The information types are 1) the amount and distribution of recent purse seine landings, 2) number and location of processing plants, 3) number of vessels and their nominal fishing effort, 4) estimates of the number and age of Atlantic menhaden, 5) estimates of MSY (see section 1D), 6) spawner-recruit relationship, 7) yield-per-recruit, 8) weight of fish in landings, 9) catchability, 10) current recruitment levels of young fish into the fishery, and 11) forecasts of purse seine landings.

1. Purse Seine Landings - Table 1.1 lists the landings of Atlantic menhaden made by purse seine during the forty-one year period, 1940-1980. Of particular importance, however, are the landings of the last ten years or so. Since 1969, landings have increased in seven years and decreased in four. They have increased in each of the last 5 years, 1976-1980. Landings in 1980 amounted to 401,000 metric tons (MT)[1], 2.5 times larger than 1969 landings of 161,000 MT which were the lowest since before World War II. While total landings have increased in recent years, landings in the five major fishing areas along the Coast have not improved equally. Landings in the North Atlantic area (New England) were slightly less than 7,000 MT in 1969, reached a peak of about 36,000 MT in 1974 and have fluctuated between 15,000 to 31,000 MT since then. In 1980, New England landings accounted for 7.4% of the total purse seine landings of Atlantic menhaden (see Figures 4.2 and 4.3).

Landings in the Chesapeake Bay - Middle Atlantic area since 1969 have ranged from about 150,000 MT in 1975 to a recent high of 283,000 MT in 1980. Landings in the last five years were about equal and averaged 240,000 MT. Purse seine landings in this area during 1980 accounted for 70.4% of the total Atlantic menhaden landings.

Landings in the South Atlantic area during 1969 were moderate at 33,000 MT and did not show the drastic decline observed in other areas that year. Since then, landings have fluctuated between 37,000 MT (1973) and 62,000 MT (1979). Landings were 53,000 MT in 1980 and have trended upward during the last five years. Landings in the South Atlantic area were 13.3% of the total Atlantic menhaden catch in 1980.

1/ Metric Ton = 2204.6 lbs.

Table 1.1. Atlantic menhaden purse seine landings by area, 1940-1980.

Year	North Atlantic	Middle Atlantic	Chesapeake Bay	South Atlantic	North Carolina Fall Fishery	Total
	Thousands of metric tons					
1940	16.8	91.1	35.3	37.9	36.6	217.7
1941	33.5	104.1	60.2	45.2	34.9	277.9
1942	14.6	77.7	21.9	32.9	20.1	167.2
1943	9.8	96.8	42.1	59.7	28.8	237.2
1944	27.5	122.6	32.2	46.9	28.7	257.9
1945	34.0	136.4	35.1	58.5	31.9	295.9
1946	42.9	183.8	57.6	40.8	37.3	362.4
1947	44.2	185.8	81.2	34.2	32.9	378.3
1948	44.4	137.4	68.3	55.8	40.6	346.5
1949	52.2	149.8	62.8	59.3	39.7	363.8
1950	49.3	143.0	63.1	20.0	21.8	297.2
1951	51.0	168.6	56.1	54.6	31.1	361.4
1952	58.1	193.7	45.7	86.0	26.4	409.9
1953	59.7	363.2	77.8	52.8	39.7	593.2
1954	64.9	335.7	126.0	39.6	41.9	608.1
1955	83.3	317.6	132.7	43.4	64.4	641.4
1956	98.5	378.3	94.0	68.6	73.7	712.1
1957	83.5	304.5	126.0	36.4	52.0	602.8
1958	36.0	211.1	151.3	41.3	70.3	510.0
1959	66.0	250.9	196.8	63.1	82.3	659.1
1960	66.4	256.0	108.5	36.7	62.2	529.8
1961	58.6	274.6	128.7	44.1	69.9	575.9
1962	64.7	249.9	155.1	42.2	25.8	537.7
1963	35.2	111.7	104.0	34.2	61.8	346.9
1964	15.0	35.2	134.1	46.5	38.4	269.2
1965	11.9	45.8	126.1	36.7	52.9	273.4
1966	1.8	6.0	115.6	24.5	71.7	219.6
1967	0.0	17.1	91.1	34.1	51.2	193.5
1968	6.7	26.2	115.5	33.6	52.8	234.8
1969	2.9	12.4	72.0	32.8	41.3	161.4
1970	4.3	11.5	182.9	42.4	18.3	259.4
1971	10.4	23.0	170.7	38.3	7.9	250.3
1972	14.5	54.6	245.5	45.9	5.4	365.9
1973	29.9	277.4 1/		37.2	2.4	346.9
1974	35.8	194.8		45.9	15.7	292.2
1975	23.1	149.8		59.5	17.8	250.2
1976	28.4	243.3		50.7	18.1	340.5
1977	15.0	244.1		49.8	32.2	341.1
1978	31.4	214.1		60.3	38.2	344.0
1979	29.4	230.7		61.6	54.0	375.7
1980	29.7	282.8		53.2	35.8	401.5

1/ Combined to retain confidentiality of landings data.

The North Carolina Fall fishery has proportionately undergone the greatest change in landings of any area since 1969, when landings amounted to 41,000 MT. Landings progressively decreased over the next 4 years and in 1973 catches amounted to only 2,400 MT. Since then, landings increased in most years reaching a high of 54,000 MT in 1979. In 1980, landings were 36,000 MT and accounted for 9.0% of total Atlantic menhaden purse seine landings.

2. Processing Plants - In 1980, Atlantic menhaden were landed and processed at 11 plants located in six coastal states from Maine to Florida (Figure 1.4). Seven plants processed only Atlantic menhaden. The other plants processed fish and fish parts of other species although Atlantic menhaden were an important part of the fishery products handled by them.

Landings of Atlantic menhaden in 1980 were concentrated in three coastal states; New Jersey, Virginia, and North Carolina which accounted for 90.3% of total landings. This is essentially the same as the five-year average of 90.9% for the years 1975-1979.

3. Number of Purse Seine Vessels and Nominal Fishing Effort - The number, type, location and intensity of effort of purse seine vessels engaged in the Atlantic menhaden fishery for the 1955-1980 seasons has varied considerably (see Table 1.2 and 1.3). The number of vessels engaged in fishing in each of the five major fishing areas since 1955 has changed significantly (Table 1.3). 1) In the North Atlantic area the number of vessels decreased from 40 in 1956 to zero in 1967, gradually built back up to around a dozen in the late 1970's, but only 5 vessels fished in 1980. 2) In the Middle Atlantic area, the number of vessels decreased from 48 in 1955 to 1 in 1970. Since 1976, there have been between four and six vessels. 3) In Chesapeake Bay, the number of purse seine vessels has remained more stable than in other areas, from 31 in 1959 to 18 in 1970. The number of vessels fishing in this area since 1976, has ranged from 21 to 24 and in 1980, there were 24 vessels. 4) In the South Atlantic area the number of vessels has decreased from 34 in 1955 to 10 in 1977. In 1980, 12 purse seine vessels reported landings of Atlantic menhaden in this area. 5) The number of purse seine vessels in the North Carolina Fall fishery ranged from 64 in 1957 to 4 in 1973. The number of vessels increased from 12 in 1974 to 19 in the 1980 fishing season.

While the total number of vessels was significantly less in 1980 than twenty to thirty years ago, the present day vessels are much more efficient than their earlier counterparts (see section 4B). This modernized fleet has permitted the purse seine fishery to be more efficient and price competitive in the provision of manufactured products. Changes in the number of vessels and vessel characteristics have also made it more difficult to define and estimate an effective unit of

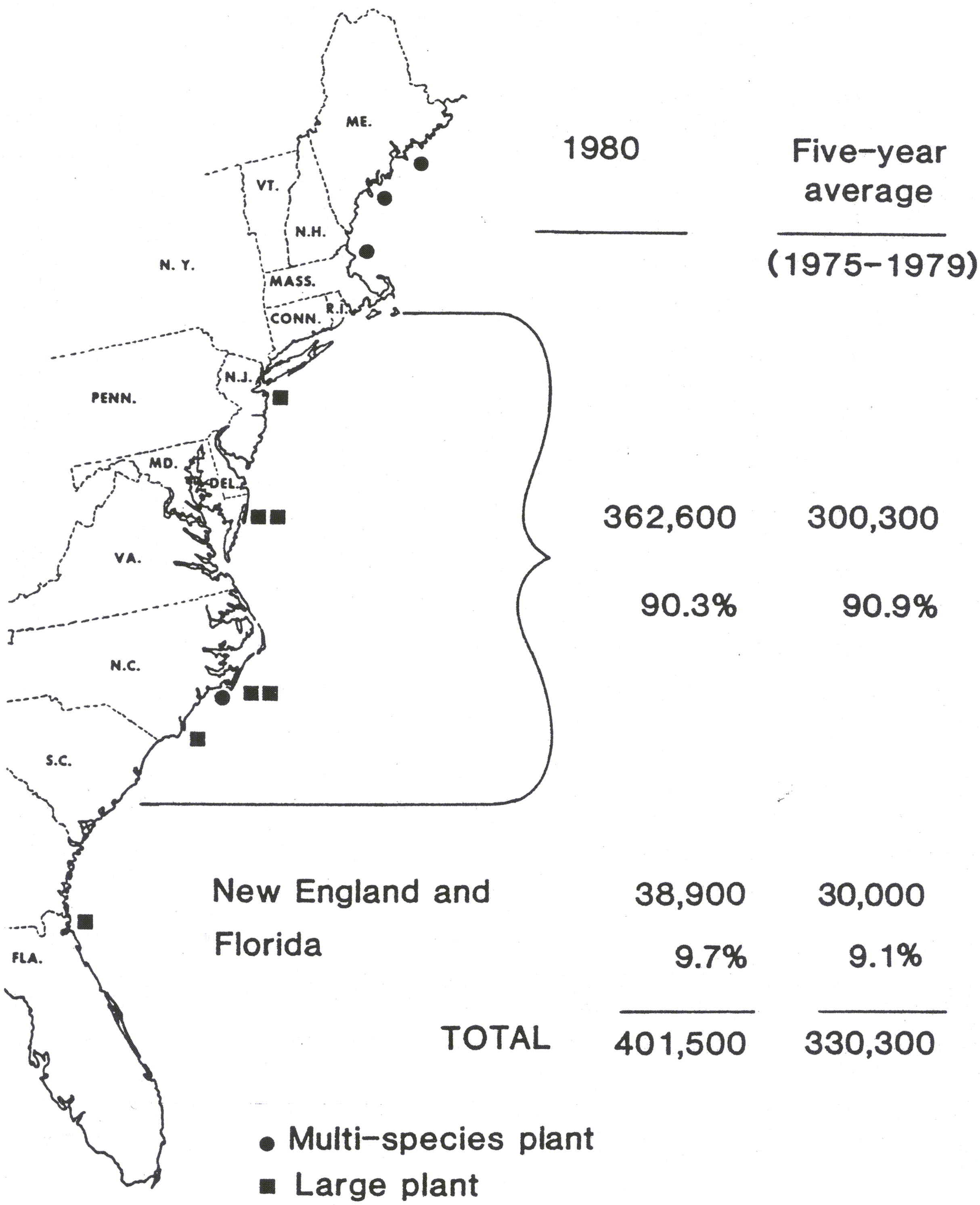


Figure 1.4. Locations of Atlantic menhaden processing plants and purse seine landings (MT) by landing area.

Table 1.2. Number of purse seine vessels that landed Atlantic menhaden during the fishing year by area, 1955-1980.

Year	North Atlantic 1/	Middle Atlantic	Chesapeake Bay 2/	South Atlantic 3/	Total 4/	Fall Fishery
1955	39	48	20	34	150	51
1956	40	47	24	30	149	63
1957	33	46	25	31	144	64
1958	23	44	28	26	130	63
1959	34	45	31	25	144	59
1960	19	47	22	20	115	37
1961	21	47	23	20	117	44
1962	20	47	29	15	112	49
1963	10	46	36	16	112	46
1964	9	37	38	16	111	51
1965	6	13	38	19	84	46
1966	5	10	36	16	76	43
1967	0	4	32	16	64	46
1968	2	4	25	16	59	45
1969	3	4	22	16	51	36
1970	4	1	18	11	54	37
1971	5	2	20	11	51	32
1972	9	4	19	11	51	5
1973	10	6	23	11	58	4
1974	12	6	22	12	63	12
1975	9	5	22	14	61	17
1976	12	4	21	12	62	13
1977	12	5	24	10	64	16
1978	13	5	22	11	53	18
1979	11	4	22	13	54	18
1980	5	6	24	12	51	19

1/ Vessels fishing from New England ports in recent years are all trawlers that convert to purse seiners in summer. Some fish regularly and others sporadically.

2/ Vessels that fished only in regular season. Does not include vessels added in October or November.

3/ Includes only vessels that landed regularly in the summer fishery.

4/ Includes all vessels that landed fish during the year.

Table 1.3. Atlantic menhaden fishing effort (vessel-weeks) by area, 1955-1980. Area: North Atlantic (1); Middle Atantic (2); Chesapeake Bay (3); South Atlantic (4); and North Carolina Fall fishery (5).

Year	Area 1	2	3	4	5	Total
1955	523	990	467	484	328	2,792
1956	557	929	468	545	384	2,883
1957	417	1,056	533	476	295	2,777
1958	273	788	556	387	373	2,377
1959	411	953	668	509	306	2,847
1960	324	952	430	299	179	2,184
1961	302	1,031	498	391	226	2,448
1962	330	1,024	593	335	114	2,396
1963	255	843	685	295	280	2,358
1964	140	378	788	288	213	1,807
1965	96	300	797	354	258	1,805
1966	38	100	818	248	208	1,412
1967	0	131	763	259	222	1,375
1968	22	115	603	259	212	1,211
1969	38	120	514	166	152	990
1970	30	59	499	174	144	906
1971	86	79	505	171	54	895
1972	87	97	552	208	28	972
1973	135	118	630	208	13	1,104
1974	153	124	591	232	43	1,143
1975	143	95	614	282	81	1,215
1976	142	123	574	249	74	1,162
1977	116	130	667	197	129	1,239
1978	112	113	588	268	129	1,210
1979	98	95	579	271	155	1,198
1980	67	129	638	226	98	1,158

fishing effort. Nominal effort is the apparent or deployed amount of fishing effort in a fishery. Effective effort, however, is a direct measure of mortality imposed on the stock by that fishing unit. The overall trend in nominal fishing effort, expressed in vessel-weeks, declined from a high of 2,883 in 1956 to a low of 895 in 1971 (Table 1.3). Effort has averaged about 1200 vessel-weeks over the last eight years. Nominal effort has decreased in four of the five fishing areas during the 25-year period of record. In the Chesapeake Bay area nominal fishing effort has remained between 552 and 667 vessel-weeks/year since 1972.

4. Ages and Number of Atlantic Menhaden Landed, 1955-1980 - The estimated age composition of Atlantic menhaden purse seine landings, 1955-1980 (Table 1.4) shows several points of significance: 1) in the 1950's, a fairly large catch of older menhaden (4 to 8+ years old) were present in the landings; 2) 1-, 2- and 3- year old fish were caught in considerable numbers throughout the 26-year period; 3) the total estimated number of Atlantic menhaden landed per season was greatest in the 1950's, decreased during the 1960's, and increased during the late 1970's to levels near that of the 1950's and 4) the catch in recent years has been mostly 1 and 2 year old menhaden (an average of 79.1% of the total estimated number of fish landed during the five year period, 1976-1980). In 1959, the dominant 1958 year class entered the fishery and contributed a record 4.039 billion 1 year old fish. In 1980, the large 1979 year class entered the fishery as 1 year olds and contributed 1.433 billion fish.

Young-of-the-year menhaden (age 0) have been landed throughout the 1955-1980 period. Their estimated numbers have fluctuated from a low of 250,000 in 1961 to a high of 1.435 billion in 1979 (Table 1.4). Age 0 fish have been more consistently landed in recent years and averaged about 12.5% of the total estimated number of fish caught in the 1974-1978 seasons. In 1979, a record 1.435 billion Age 0 fish were landed, and represented 38% of the total estimated number of Atlantic menhaden caught that year. Their contribution to the purse seine landings decreased to 3% in the 1980 season.

During the last decade the estimated number of sexually mature menhaden (ages 3+) in the landings has declined. By inference, this indicates a reduced number of spawners in the population (Table 1.5). The estimated number of age 3 fish in the Atlantic menhaden population has only exceeded 200 million once since 1962; the estimated number of age 4 fish has not exceeded 40 million since 1963; and the estimated number of age 5 fish in the population has not exceeded 10 million since 1964. These reduced numbers of spawning aged fish combined with poor environmental conditions would result in a reduced number of recruits into the fishery and bring about fluctuations in year-to-year landings.

Table 1.4. Estimated number (in thousands) of Atlantic menhaden landed by purse seine by age and total weight landed (in thousands of metric tons), 1955-1980.

	AGE								TOTAL	
	0	1	2	3	4	5	6	7	8+	Number	Weight
1955	761,010	674,150	1,057,680	267,310	307,210	38,070	10,530	1,840	640	3,118,440	641.4
1956	36,370	2,073,260	902,720	319,600	44,780	150,680	28,700	6,720	1,990	3,564,820	712.1
1957	299,580	1,599,980	1,361,770	96,730	70,800	40,520	36,930	4,260	1,100	3,511,670	602.8
1958	106,060	858,160	1,635,350	72,050	17,250	15,940	9,090	4,880	430	2,719,210	510.0
1959	11,400	4,038,720	851,290	388,270	33,410	11,870	12,360	4,550	1,770	5,353,640	659.1
1960	72,170	281,010	2,208,630	76,370	102,200	23,770	7,950	2,360	650	2,775,110	529.8
1961	250	832,420	503,600	1,209,570	19,180	29,380	810	810	240	2,598,310	575.9
1962	51,580	514,110	834,520	217,250	423,370	30,750	24,600	2,980	700	2,099,860	537.7
1963	96,890	724,230	709,200	122,530	44,970	52,380	10,420	3,330	560	1,764,510	346.9
1964	302,590	703,950	604,980	83,500	17,940	7,850	6,620	1,310	320	1,729,060	269.2
1965	249,120	739,280	417,550	77,750	12,170	1,810	1,220	740	70	1,499,710	273.4
1966	349,460	550,830	404,110	31,700	3,880	370	110	110	40	1,340,610	219.6
1967	6,950	633,200	265,680	72,760	5,090	490	10	0	0	984,180	193.5
1968	114,154	415,348	549,029	70,811	13,045	1,030	140	0	0	1,163,417	234.8
1969	373,412	355,497	288,470	43,013	6,632	336	20	0	0	1,067,360	161.4
1970	31,140	963,646	490,763	38,741	4,877	649	0	0	0	1,529,816	259.4
1971	73,311	262,411	530,582	84,135	18,377	2,397	0	0	0	971,213	250.3
1972	93,902	1,034,277	509,429	154,328	15,570	1,032	0	0	0	1,808,538	365.9
1973	30,392	577,784	1,104,068	61,351	15,704	1,348	0	0	0	1,790,647	346.9
1974	326,055	653,614	966,010	49,513	2,296	1,021	0	0	0	1,998,509	292.2
1975	334,201	749,716	1,033,767	47,762	7,993	253	100	0	0	2,173,792	250.2
1976	271,796	1,467,030	1,211,312	46,047	8,105	53	0	0	0	3,004,343	340.5
1977	459,420	998,329	2,084,536	81,113	17,326	1,318	97	0	0	3,642,109	341.1
1978	323,270	619,670	1,695,090	256,980	31,760	3,490	0	0	0	2,930,260	344.0
1979	1,435,185	610,807	1,593,939	126,119	21,331	1,320	0	0	0	3,792,300	375.7
1980	93,080	1,433,300	1,467,470	222,530	69,360	14,480	1,130	0	0	3,305,340	401.5

Table 1.5. Estimated number of Atlantic menhaden spawners, number of eggs produced, and number of fish recruited at age 1 for the 1955-1975 year classes.[1/]

Year Class	Estimated No. of Spawners (in thousands)	Estimated No. of Eggs Produced (in trillions)	Number of Recruits at Age 1 (in thousands)
1955	1,619,999	181.60	5,342,764
1956	1,214,417	142.22	6,645,566
1957	580,361	78.80	3,070,584
1958	437,673	48.60	13,906,034
1959	1,108,727	87.43	2,021,986
1960	626,859	71.91	2,827,775
1961	2,788,975	152,85	2,093,833
1962	1,162,970	110.71	2,113,109
1963	375,225	45.82	1,651,159
1964	180,752	19.28	1,802,819
1965	126,957	11.40	1,308,699
1966	59,863	4.59	1,836,736
1967	121,183	10.97	1,186,185
1968	188,187	17.00	1,583,598
1969	125,693	16.87	2,556,678
1970	143,751	15.97	1,386,416
1971	195,856	22.88	3,349,700
1972	272,175	26.58	2,551,916
1973	111,289	11.36	2,804,031
1974	95,375	12.97	3,348,487*
1975	107,633*	8.88*	7,214,126*
1976	143,084*	7.10*	

* Preliminary estimates.

1/Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

5. Spawner-Recruit Relationship - Female Atlantic menhaden spawn for the first time as they approach or reach age 3 (Higham and Nicholson 1964). Thereafter they spawn each year and produce larger numbers of ova (eggs) as they grow older and larger. The number of potential spawners in the Atlantic menhaden population fluctuates as the larger year classes, like 1958, attain spawning age. However, a small spawning stock has produced large numbers of recruits, such as in 1969 and 1974 (Table 1.5).

The present data do not indicate a strong spawner-recruit relationship during the period 1955-1975 for Atlantic menhaden (Figure 1.5). There are years in which large spawning stocks produced high (1956) as well as low numbers (1961) of age 1 fish; medium numbers of spawners produced low (1959) and high (1958) numbers of recruits; and low spawning stock produced low (1970), medium (1971 and 1974) and high numbers (1975) of age 1 menhaden.

Environmental conditions are known to have a major influence on the survival of young fish (Nelson et al. 1977). Thus, a large number of spawning-age menhaden does not guarantee production of a large year class. There is a potential for recruitment failure but it appears unlikely on the basis of historical observation. The Atlantic menhaden resource has demonstrated large year classes in the 1950's, poor abundance in the 1960's, and relatively large broods again in the 1970's.

6. Weight of Atlantic Menhaden in Landings - The mean weight of age 1, 2, and 3 Atlantic menhaden sampled during 1955 to about 1970 increased slightly (Figure 1.6). Since then mean weight of each age group decreased during the period 1971 to 1977. Age 1 fish averaged only 64 grams in 1977 yet they had averaged 165 grams in 1970. Age 2 fish averaged 128 grams in 1977 and 239 grams in 1970. Age 3 menhaden averaged 518 grams in 1970 and declined to 362 grams by 1977.

This change in average weight by age may be the result of three interacting factors: environment, migration and recruitment behavior into the purse seine fishery, and density dependent growth. During the protracted spawning season environmental factors may contribute to increased spawning success in the spring rather than in the fall or winter, thus there would be a shorter growing season and smaller fish. Young fish, mostly 1's and 2's, may be entering the fishery earlier in the year and therefore at a reduced size. Since the proportion of total purse seine landings from Chesapeake Bay and South Atlantic waters has increased in recent years, the menhaden from these areas have historically been smaller than the more-northerly counterparts in the Middle Atlantic fishing grounds.

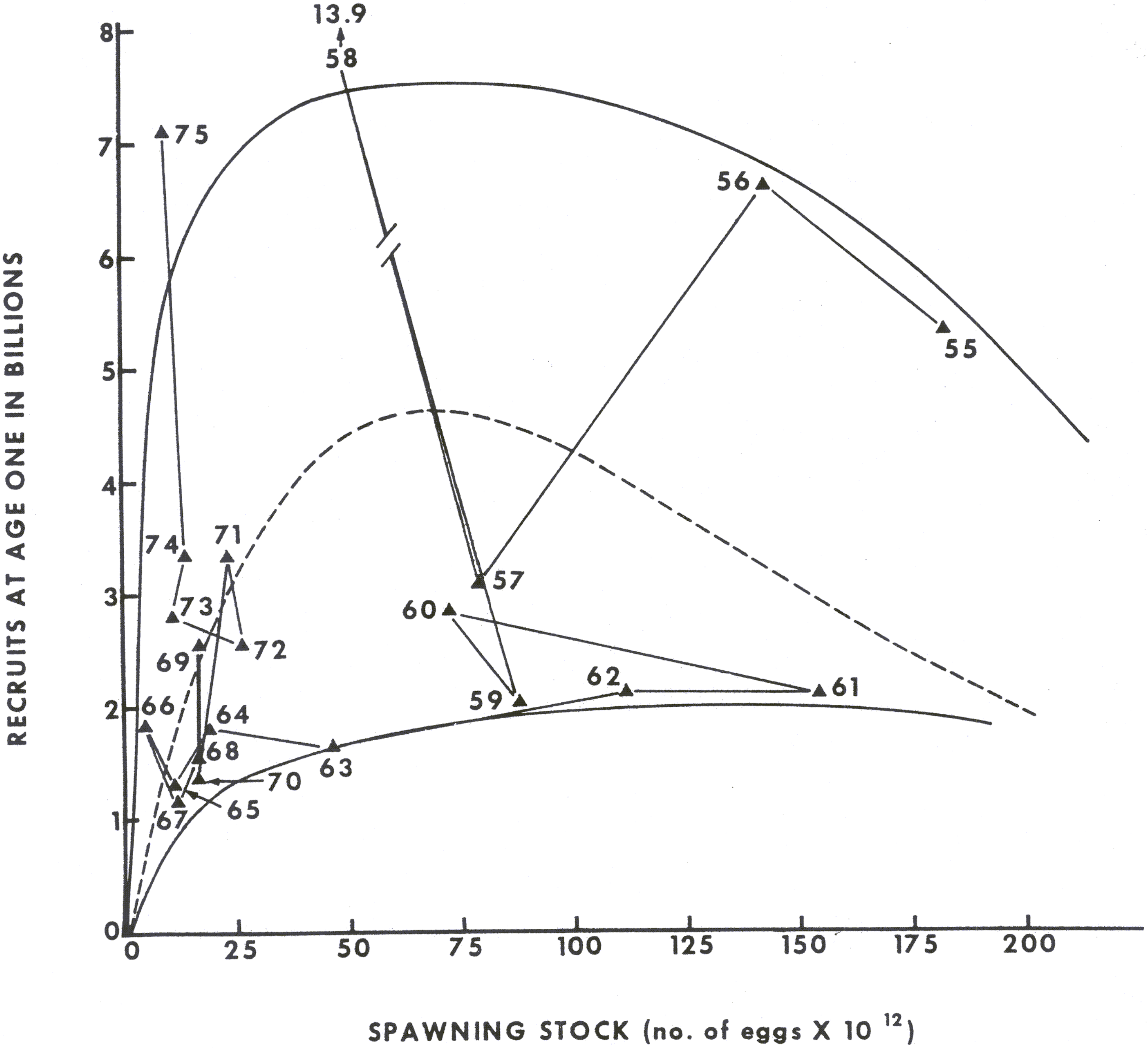


Figure 1.5. Atlantic menhaden spawner-recruit relationship, 1955-1975[1/].

[1/] Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

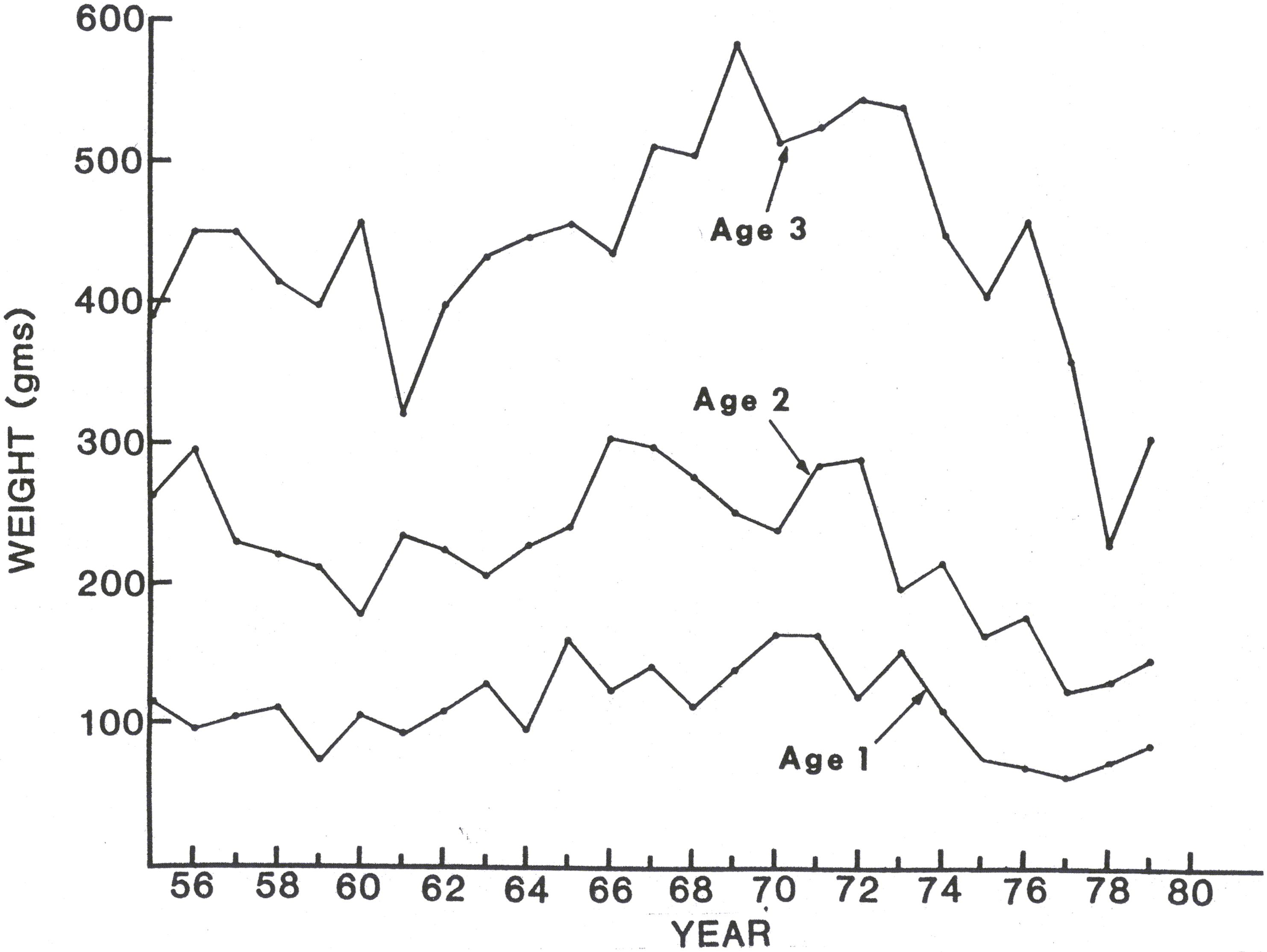


Figure 1.6. Atlantic menhaden mean weight (weighted) at ages 1, 2, and 3, 1955-1979.[1/]

1/ Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

Atlantic menhaden show density dependent growth: the large year classes of the 1970's have produced the smallest average size fish at a given age since 1955. The consequence of these smaller size menhaden entering the fishery is that while numbers of individuals have been sizable (Table 1.4) their combined contribution in weight is significantly less than if they were older or larger. Relatively high fishing pressure apportioned among the fishing areas in the manner of recent years would also tend to yield progressively younger and smaller fish in the catch during each successive year.

7. Forecasts of Catches - The NMFS menhaden research staff at the Beaufort Laboratory has made annual forecasts of purse seine landings since 1973. The forecasting method uses multiple regression equations which relate catch in a given year to catch and effort in the previous years. The technique accounted for 86 percent of the annual variation of catches during the 16 year period 1955 to 1973. Observed catches deviated from this forecast catch by an average of 14 percent for the period 1973-1980 and ranged from a high of 27 percent in 1974 to a low of 1 percent in 1978 (Figure 1.7).

The preliminary forecast is made annually before the close of the current fishing season (November) and an updated forecast is issued in April. These forecasts are based upon the projected amount of fishing effort in the next year (nominal effort in this case). Separate forecast estimates are made for the expected effort as well as 10 percent greater or lesser effort (Figure 1.8).

8. Recruitment Levels - Atlantic menhaden recruitment has fluctuated greatly since sampling of the purse seine fishery was initiated in 1977 (Table 1.5). There were large year classes in 1955, 1956, and 1958. Low abundance was the rule from 1959 through 1968. Abundance again increased in 1969 and has been moderately large through 1974. The 1975 brood was exceptional at 7.2 billion fish and may be the second largest since 1958. The 1958 year class recruited 13.9 billion fish into the fishery at age 1. Lack of a strong spawner-recruit relationship (Figure 1.5) makes calculation of the benefits to the fishery of maintaining a larger number of spawners to ensure an adequate number of recruits to perpetuate the stock and fishery tenuous.

9. Age Structure of Spawners - The spawning stock is currently composed mostly of late age 2 fish (80 to 90% of the total spawners) (Figure 1.9). The heavy dependency of the stock on young spawners has continued since about 1965. Before then, the contribution of late age 2 spawners in the population was as low as 40% in 1955 and 35% in 1962. These low contributions of age 2 spawners represent both the presence of older dominant year classes and shifts in fishing pressure. Ages 3+ composed most of the spawners in the

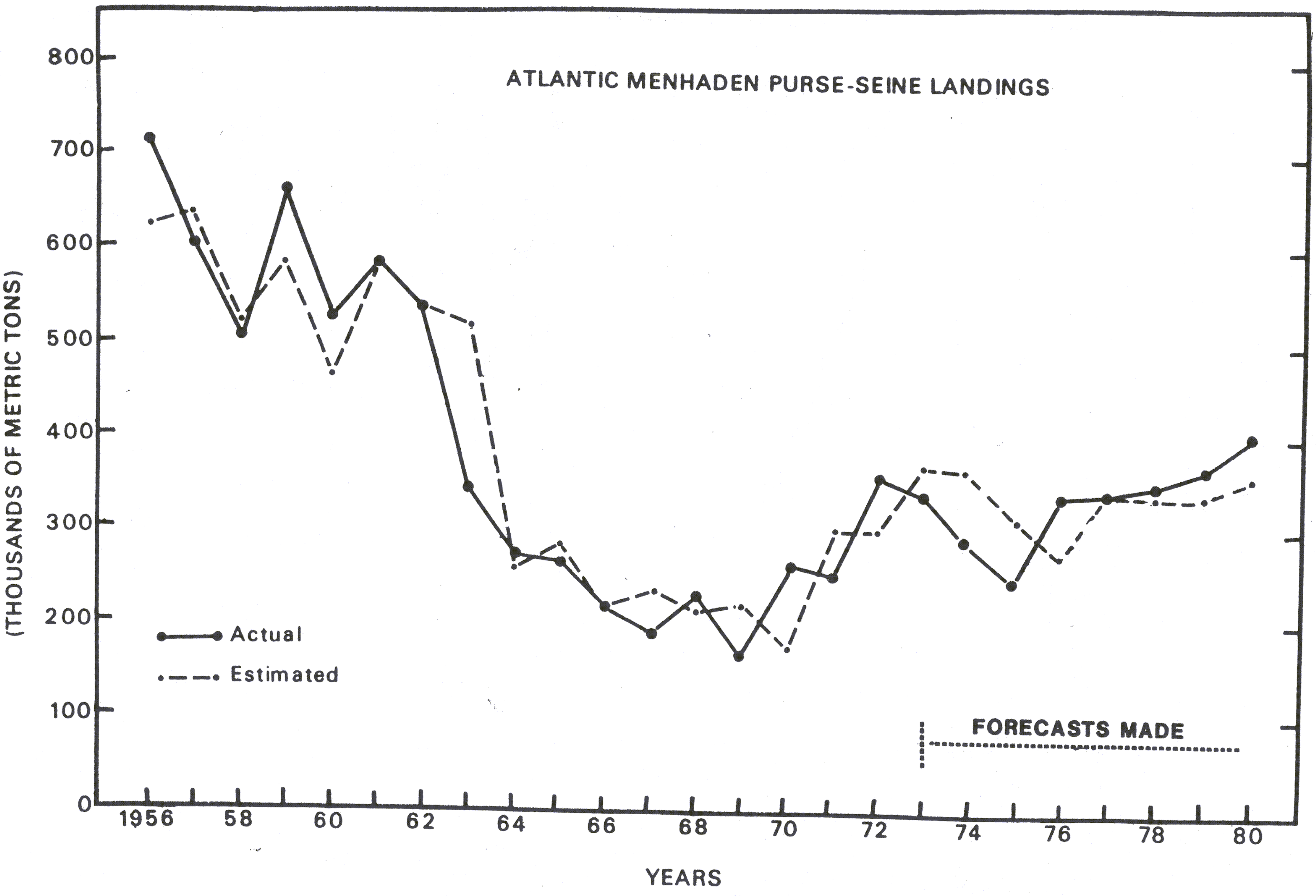


Figure 1.7. Atlantic menhaden purse seine landings and forecasts.

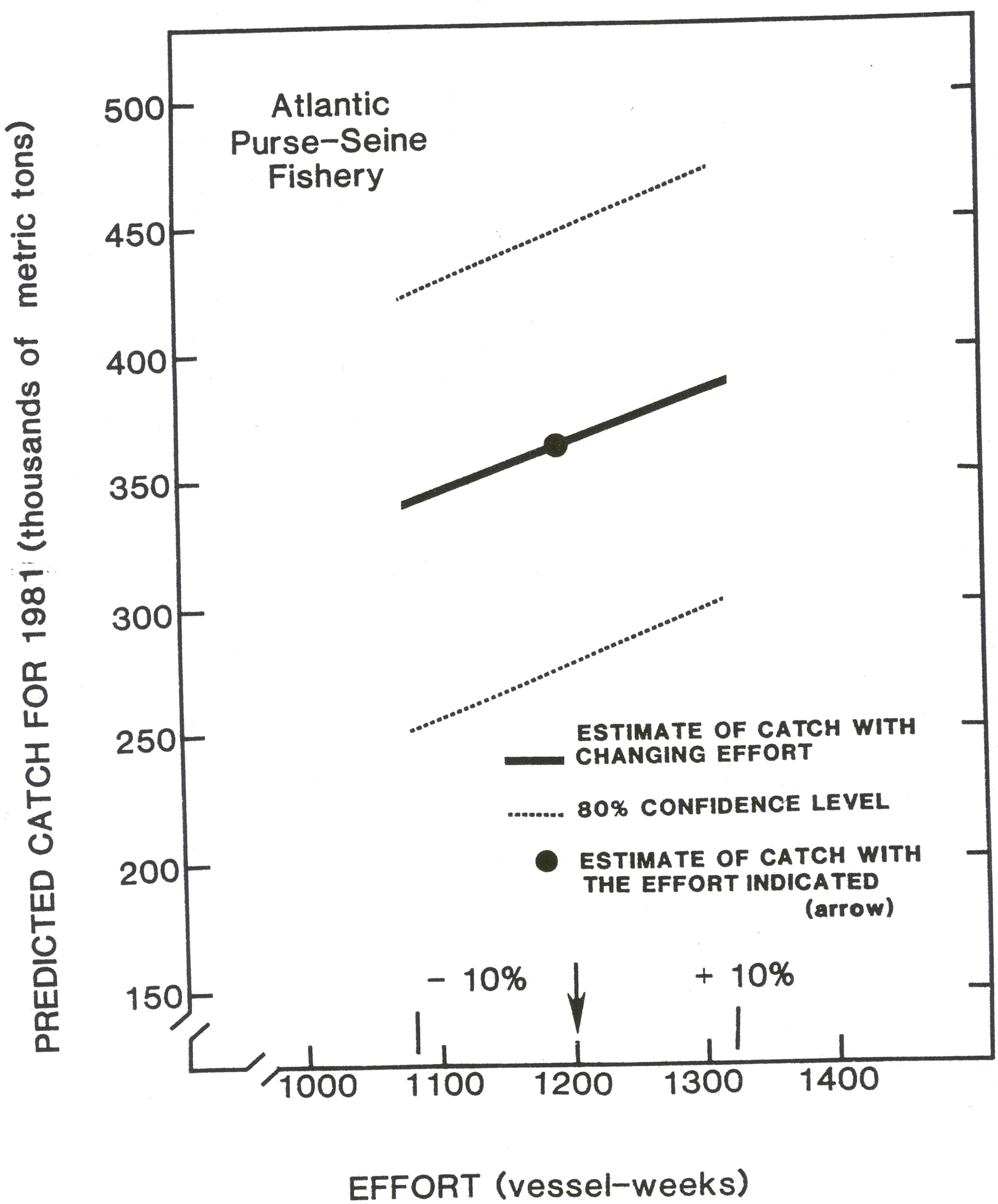


Figure 1.8. Forecast of Atlantic menhaden purse-seine catches for 1981 season.

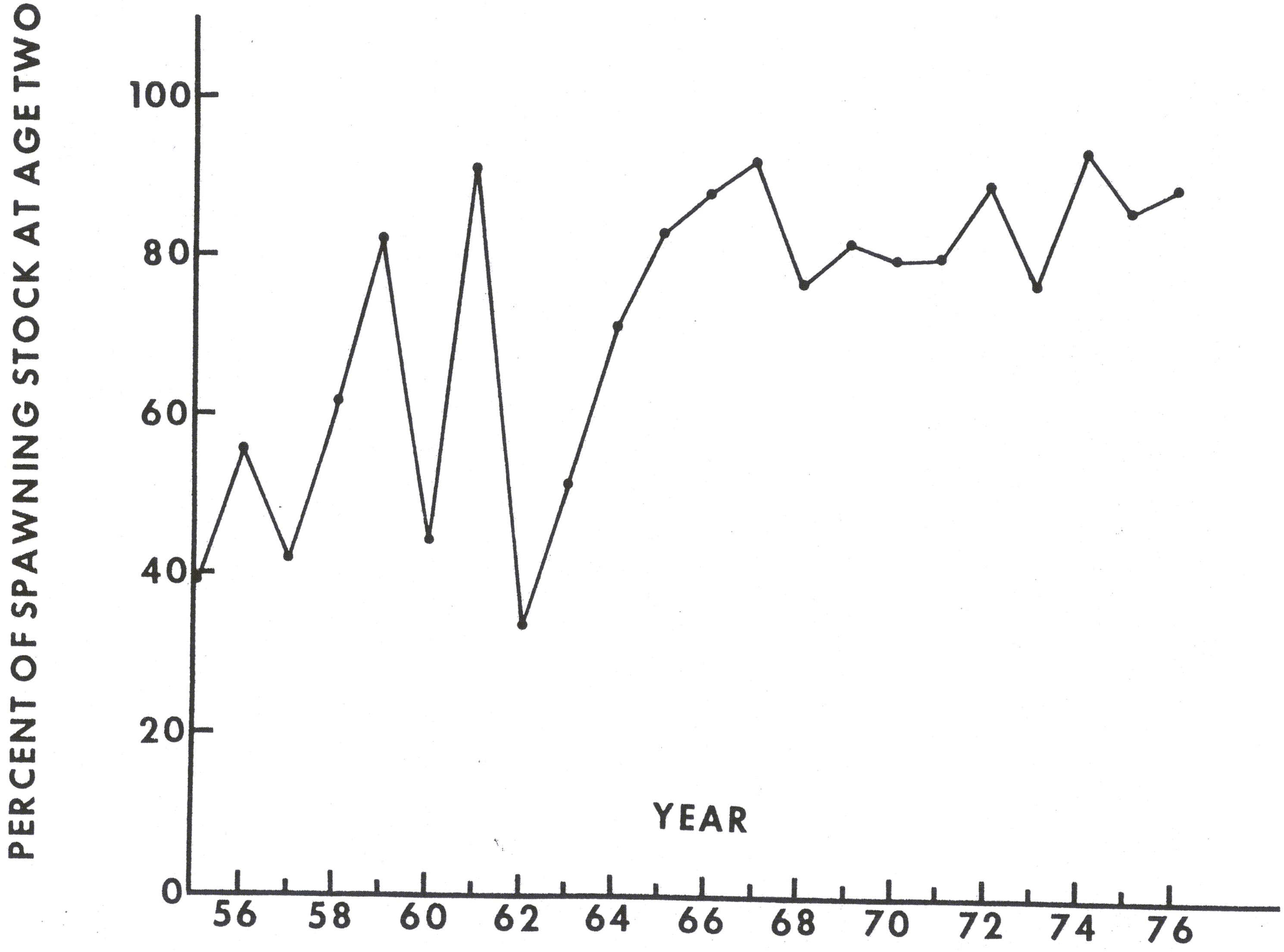


Figure 1.9. Contribution of late age 2 spawners (%) to total spawning stock of Atlantic menhaden, 1955-1976.1/

1/ Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

1950's and early 1960's. From a biological basis, rebuilding of the stock of Atlantic menhaden to include a greater proportion of the spawners at age 3+, would serve to ensure against precipitous population declines from recruitment failures and tend to stabilize the fishery.

10. Catchability - Catchability of Atlantic menhaden by purse seine increased for all ages in the period 1955-1976 (Figure 1.10). The mortality caused by a purse seine vessel operating for 1 week changed from less than 0.0005 in the 1950's to a peak of 0.0023 in 1973. Since then, the catchability declined to about 0.0010 for fish of ages 1-5 and about 0.0018 for fish of ages 2-3. The increase in fishing mortality per vessel week indicates that the effectiveness of an average vessel increased by a factor of about four between 1955 and 1976. While the number of vessels in the Atlantic menhaden fleet has been reduced since 1955, there has been a substantial increase in efficiency of the menhaden vessels in the present day fishery.

11. Fishing Mortality - Fishing mortality on age 0 fish has fluctuated from 0 to 13% over the years. Most of the fishing mortality inflicted on this age group (about 80%), has occurred in the North Carolina Fall fishery.

Fishing mortality of age 1 and older Atlantic menhaden has fluctuated widely since 1955 depending on the size of the year class as well as the amount and distribution of fishing effort. Overall fishing mortality averaged about 50% from 1955-1961. It increased to over 70% during the mid 1960's when small year classes entered the fishery. In the late 1960's and early 1970's fishing mortality declined to about 60% as a result of the smaller fleet. Thereafter, fishing mortality for ages 1 and older increased and has averaged over 75% in recent years. The estimated fishing mortality rate in the period 1973-1976 averaged about 90% for age-2 fish. Fishing mortality rates for fish of ages 2-3 which were fully recruited followed similar trends as for ages 1 and older but averaged over 60% in the 1950's, declined only slightly during the 1960's and increased to about 90% during the early and mid 1970's.

12. Yield-Per-Recruit (Y/R) - The overall average yield-per-recruit of Atlantic menhaden under current conditions (1974-1976 seasons) where fish enter the fishery at age 0.5 years and are subject to average fishing mortality (F of 1.0) is 77 grams (Figure 1.11). As the age of entry into the fishery and survival of the younger ages increase, the population biomass and the yield-per-recruit increase. In the hypothetical case of no fishing, maximum biomass of Atlantic menhaden would occur at about

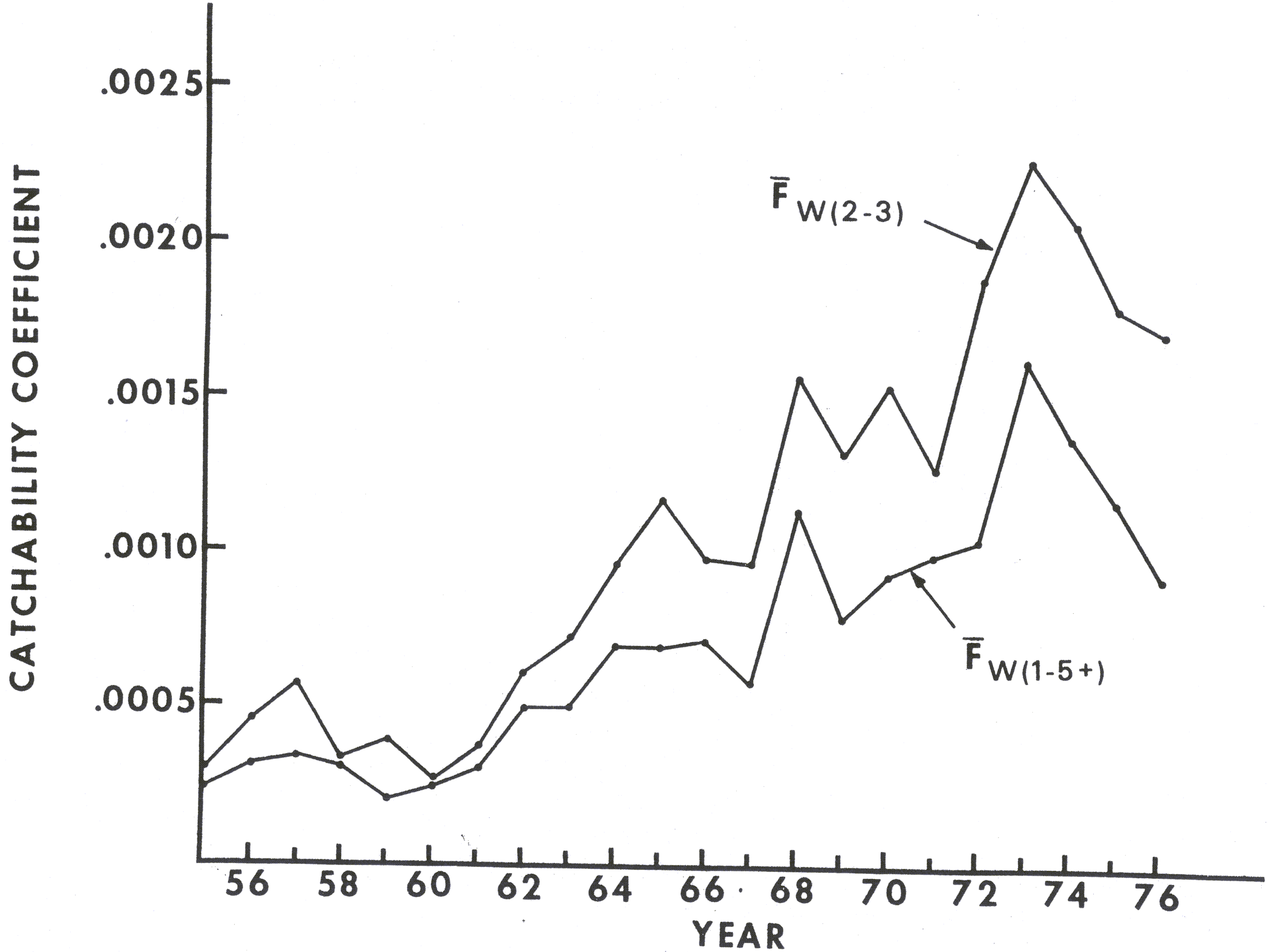


Figure 1.10. Catchability coefficient (fishing mortality per vessel-week) of Atlantic menhaden at ages 1 and older, and ages 2 and 3 by year, 1955-1976[1/].

1/ Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

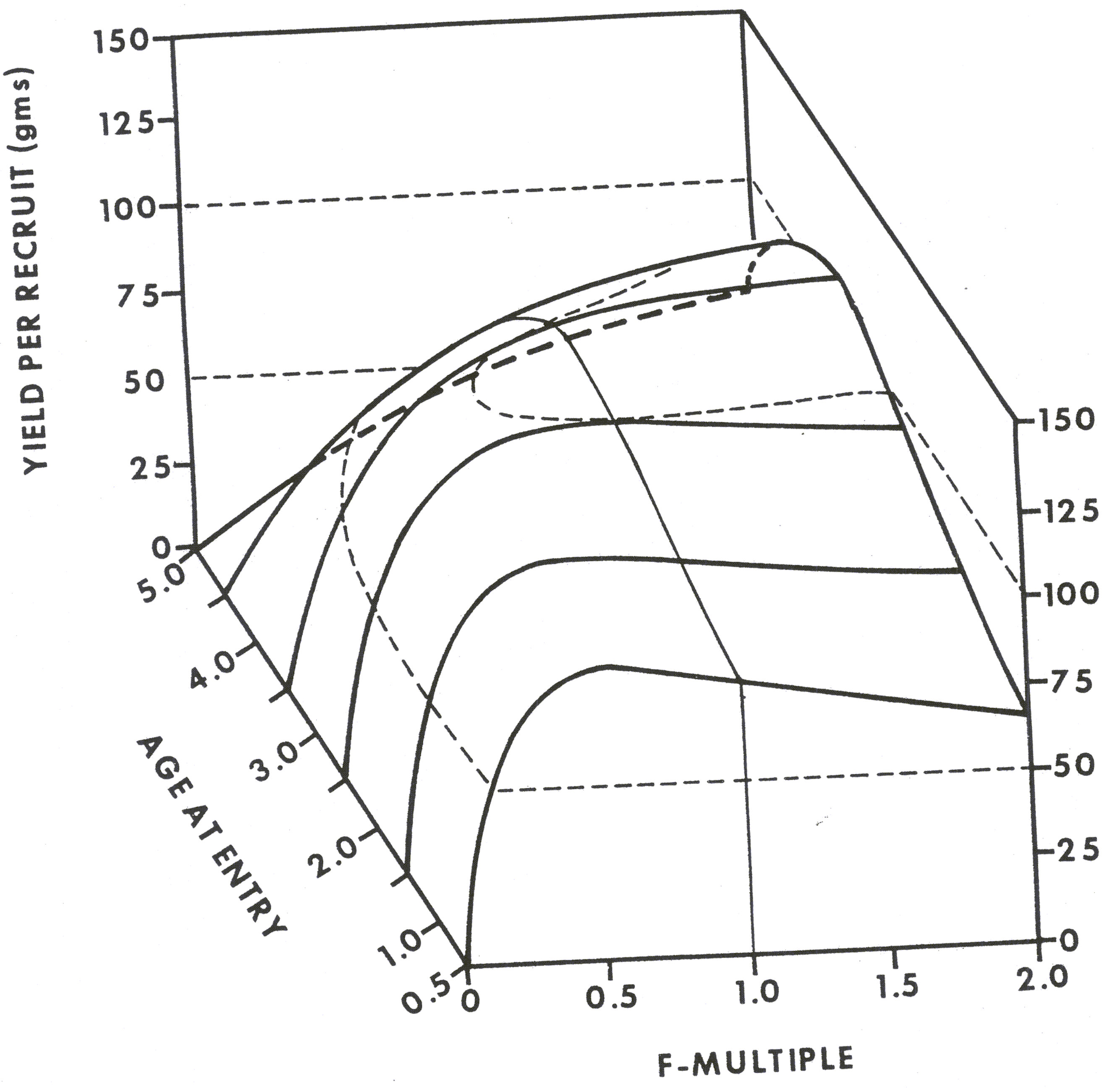


Figure 1.11. Overall yield-per-recruit of Atlantic menhaden under current conditions (F-multiple of 1.0, and age at entry of 0.5) using average fishing mortality values by quarter and area for the 1974-1976 fishing seasons.1/

1/ Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

age 3.25. The biomass of the population would decline beyond age 3.25 because natural mortality would exceed the gain due to the combined growth of the individual fish. Thus, increase in the yield-per-recruit from the present level will require a reduction in fishing mortality, a reallocation of fishing effort or a combination of the two.

The estimated changes in yield-per-recruit which would result from changes in fishing mortality and age at entry relative to current conditions are presented in Table 1.6. The current yield of 77.57 grams would increase 7% with a reduction of fishing mortality to one-half the current average rate. If the age of entry is increased to age 1.0, then the net gain in Y/R is 10%, and if raised to age 1.5, the net gain is 13%.

Changes in the age at entry would change the current allocation of the yield-per-recruit as well as the catch in the five fishing areas (Table 1.7). The distribution of the current Y/R (77 grams) is 9.66 grams in the North Atlantic (Area 1), 12.07 grams in the Middle Atlantic Area (Area 2), 37.53 grams in Chesapeake Bay (Area 3), 13.80 grams in the South Atlantic Area (Area 4), and 4.11 grams in the North Carolina Fall Fishery (Area 5). Increasing the age at entry for Atlantic menhaden from 0.5 to age 1.0 would result in Y/R increases of 6% each in areas 1, 2, 3, and 4 and conversely result in a 30% decrease in Y/R in Area 5. The overall net increase in Y/R would be 4%.

C. Ecological Relationships

Predator-Prey Relations. Sykes and Manooch (1979) recently summarized the available literature and the following is modified after their report.

The effects of predation are complicated with regard to the structure of aquatic communities. Scientists believe that predation plays an important role in evolution and ecology. Predators may alter prey populations by (1) reducing and even eliminating prey species or (2) regulating prey population levels so that carrying capacities are not exceeded. Though many researchers have investigated the effect of predation on community structure, the subject remains controversial and difficult to analyze.

In recent years, there has been a trend toward development of mathematical models to describe predator-prey relationships and thereby attempt to quantify energetics, population dynamics, and structure of estuarine and marine ecosystems. To apply models to field conditions, basic parameters must be obtained, such as biomass of predator and prey populations, specific growth rate of prey, and specific death rate of predators. The estuarine system is so dynamic and complex that we barely have

Table 1.6 Yield-per-recruit for the Atlantic menhaden fishery based on average fishing mortality (F-multiple = 1.0) for the 1974-1976 fishing seasons at an array of ages of entry, expressed as percentages of current yield-per-recruit. 1/

	Percent Y/R at F - multiple				
Age of Entry	.50	.75	1.0	1.25	1.50
2.0	16	18	16	14	13
1.5	13	13	11	8	6
1.0	10	8	4	0	-3
0.5	7	5	(77.57g)*	-4	-8

* Base value for calculation of percentage change

1/ Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

Table 1.7 Percent change in yield-per-recruit by area and for the overall Atlantic menhaden fishery at ages of entry of 1.0, 1.5, and 2.0, compared with yield-per-recruit(g) under the current age of entry (0.5), at average fishing mortality rates for the 1974-1976 fishing seasons. 1/

Area	Age of Entry			
	0.5	1.0	1.5	2.0
	Current (g)	Change (%)		
North Atlantic	9.66	6	24	45
Middle Atlantic	12.07	6	24	45
Chesapeake Bay	37.53	6	11	12
South Atlantic	13.80	6	0	3
N.C. Fall Fishery	4.11	-30	-19	-51
Total	77.57*	4	11	16

* The sum of area is slightly different from the overall total due to the nature of the yield/recruit program, which calculates Y/R for each individual area and then calculates overall Y/R instead of simply summing the areas. Thus, differences are due to rounding.

1/ Source: Population Dynamics Subcommittee II. Communication to Atlantic Menhaden Scientific and Statistical Committee, August 1980.

an understanding of the basic food chains and actually know little of predator and prey populations in terms of structure, biomass, movements, and mortality.

Food habit studies have shown repeatedly that one species of fish is seldom totally dependent upon another. Should prey populations decline, predators either select other closely related species or the predator population decreases accordingly. In either case, the result is often a gradual recovery phase of the prey animals. Slobodkin (1968) reported on the optimal strategy by predators to maintain population levels; his work may be useful to fisheries scientists investigating current predator-prey interactions.

Predator-prey interactions in a relatively closed system, such as a farm pond, a lake, and in some instances a reservoir, are reasonably well understood. Estuaries, however, are more dynamic environments, continually generating arrays of aquatic life. They are the nurseries of thousands of species, and numerous studies have shown them to be necessary for the hatching or rearing of many coastal fish species. Estuarine fishes move into and out of the estuary for reproduction, feeding, and growing. The complexity of the estuary is a major obstacle to the fisheries scientist attempting to evaluate who eats what, when, where, how much, and under what conditions. Resident species are in the minority. Among the major sojourners are striped bass (Morone saxatilis), Spanish mackerel (Scomberomorus maculatus), bluefish (Pomatomus saltatrix), seatrout (Cynoscion), croaker (Micropogonias undulatus), spot (Leiostomus xanthurus), anchovy (Anchoa), mullet (Mugil), red drum (Sciaenops ocellata), shrimp (Penaeus), and menhaden (Brevoortia). Because the major estuarine species are seasonal visitors, their roles as feeders or food are not sufficiently defined for us to be able to assess interdependence between them and other species, except in a few research documents. Neither is it possible at this time to determine how changes in abundance of predators or prey alter the existing structure of an estuarine ecosystem.

Prey animals have morphological and behavioral adaptations, which reduce their susceptability to predation. Thompson (1976) listed several mechanisms used by fish to avoid predators, such as protective coloring, spines, poisonous tissue, rapid agile movements, and schooling. Menhaden are renown for their schooling behavior and the successful purse seine fishery is highly dependent upon this attribute. Shaw (1978) gave a thorough review of the phenomenon of fish schools, their attributes, and advantages of a school versus solitary existance.

Food habit studies and subsequent construction of simplified food chains have received the most attention by researchers. Although vital to an understanding of estuarine ecology, food studies usually fail to contend with seasonality, predator size, prey selection, or specifically answer what would happen to a given predator species if "preferred" foods were not available. Variables which may affect predator-prey relationships are often not evaluated (Hilborn 1975, McHugh 1967, Paloheimo and Dickie 1970). Field experiments with predator exclusion cages have shown that predation can have a pronounced effect on prey populations by altering species diversity and biomass (Commito 1976, Guida 1976, Menzel et al. 1976, Virnstein 1976, Young and Young 1977). Predation by fishes on eggs and larvae of other species has not been studied extensively, although it may be very important.

One area of recurring concern is between hook and line bluefish fishermen and menhaden purse seine fishermen. Groups of bluefish recreational fishermen, particularly on the Atlantic coast from Long Island Sound northward, have objected to menhaden fishing because they believe menhaden are the major source of food for bluefish stocks. They also object to nets fished close to shore in areas preferred for recreational fishing. The bluefish fishermen have advocated regulation of the menhaden fishery. Therefore, there is need to evaluate the degree of dependence that one species or group of species has upon another. A quantitative assessment of the predator-prey role could be useful in reaching agreement between the debating factions.

For many years it has been known that bluefish feed heavily on menhaden (Goode 1879). Various authors have cited menhaden as a major food of bluefish, and also mentioned mackerels, herrings, alewives (Alosa), and other species as prey for bluefish. Studies by Walford and his associates (personal communication) show that bluefish feed throughout the water column on a large variety of fishes: butterfish (Peprilus), menhaden, round herring (Etrumeus teres), sand lance (Ammodytes), silversides (Menidia), mackerel, anchovy, Spanish sardine, gray and spotted seatrouts, croaker, and spot. These and other studies have shown that bluefish feed on menhaden, but they also show numerous other species in the diet. These data are helpful when considering social confrontations arising from fishery disputes ostensibly based upon predator-prey interactions, but they are too limited in a quantitative sense to allow technical decision making.

Oviatt (1977) discussed the predator-prey relations of bluefish and striped bass with menhaden and the resulting problems with fishermen in Narragansett Bay, RI. Recreational fishermen said that a large portion of the biomass of menhaden is taken annually in the bay by commercial fishermen, leaving insufficient food for predator species. Oviatt approached the matter from a quantitative viewpoint. The occurrence of menhaden in stomachs of bluefish and striped bass in the bay ranged between 41 and 46% over a two-year study period. She found that bluefish and striped bass have diversified feeding habits and when offshore, both species feed mainly on sand lance. She concluded that, inasmuch as both striped bass and bluefish are generalized feeders, they utilize the most abundant prey in their locality. The major conclusion of her study was that even with increased fishing effort for menhaden over a 20-year period, these catches have had no serious impact on the striped bass or bluefish population in the area. She emphasized, however, that research should be carried out annually over the total range of the fisheries to increase the accuracy of information on relative abundance and year class strength.

Menhaden are preyed upon by several other recreationally caught species of great popularity. Manooch (1973) reported that menhaden were a major item in the diet of striped bass in Albemarle Sound, NC occurring in 54% of the stomachs. Weakfish (Cynoscion) also eat menhaden but exhibit flexibility in prey selection in different geographical areas (Merriner 1975). The full ecological value of the menhaden resource in addition to its important use in the commercial production of fish meal, oil, and solubles may be realized only when its contribution as a food item for other valuable finfish species is considered.

McHugh (1967) took issue with social-political pressure brought to bear in recent years on the commercial fishing constituencies by recreational fishing interests. That pressure has usually been based on the assumption that commercial fishing gear over-exploits the food supply of sport fishes or actually kills large numbers of sport species. McHugh could find no scientific evidence to support the allegations. He countered the argument of recreational fishermen by suggesting that menhaden may consume large quantities of other valuable estuarine nekton species. Further, he raised the question of relationships between menhaden abundance and abundance of shrimp, blue crabs, and other resources. The inference is that although menhaden serve as prey for commercial and recreationally sought species, they may in turn prey upon the early planktonic life stages of other valuable species.

D. Estimates of MSY.

Since there is not a well defined unit of effective fishing effort for the Atlantic purse seine fishery, the maximum sustainable yield or catch (MSY) cannot be estimated by the usual methods (Schaefer 1954, 1957). Through various adjustments, estimates of virtual population, and catchability, an MSY of 380,000 to 500,000 metric tons was estimated (Schaaf and Huntsman 1972). One basic requirement of the Schaefer model is that recruitment, the entry of young fish into the fishery, must be stable. As shown earlier, the Atlantic menhaden resource has undergone drastic changes in number of recruits since 1955 so estimates of MSY by this method are of limited value and should be used only as very rough approximations. They are not appropriate for use in the 1980's.

E. Future

The future of the Atlantic menhaden resource and fishery is essentially unknown. No one can predict with any degree of precision the changes in the resource or fishery if the open, competitive common-property policy continues. The resource and landings could continue to increase, as they have since about 1970, or they could turn down once again and decline as they did between 1962 and 1969. Many factors acting together determine the actual number, age and size of menhaden in the resource and the subsequent harvest. These include environmental conditions, the number of vessels and the amount and distribution of effort, availability of menhaden to fishing, and market conditions. Other events, some outside the fishery help influence the final outcome as evidenced by landings in past years (Schaaf, et al 1975). The fish population in the next five years or so will no doubt fluctuate but the degree of change and its direction are largely unknown.

The history of the fishery provides some clues to life history and habits of the Atlantic menhaden and provides some insight into the future. The following items or considerations should help establish some lower as well as upper limits in answer to the retorical question: "Can the resource and fishery collapse?". Biological features that appear of major importance include; spawning, estuarine habitat, landings, recruitment, schooling, and migrations.

- Spawning of Atlantic menhaden occurs from Florida to Maine in every month although most spawning appears to be from North Carolina to Delaware during the Fall and Winter. Spawning also occurs from 110 miles offshore to along the coast and in some of the larger bays and sounds (Chesapeake Bay, Narragansett Bay, Delaware Bay and others) (Chapoton 1972, Dietrich 1979, Reintjes 1961, Kendall and Reintjes 1975). Dispersal of the eggs along the coast protects any one year class from 100% mortality although adverse local conditions could kill small segments of any brood. The negative effects of several years of adverse conditions combined with other non-fishing related mortalities is acknowledged (Hoss, et al 1974).

- Larvae of Atlantic menhaden enter the estuaries along the coast at an age of 1 to 2 months. No coastwide movement of larvae appears to occur (Nelson, et al 1977, Reintjes 1969, Wilkens and Lewis 1971). Presently, most estuaries appear to be in fair condition and some areas have shown improvement in overall quality in recent years. Menhaden can and do inhabit essentially every major estuary along the United States East Coast from Florida to Massachusetts and at times even those in Maine (Pacheco and Grant 1965).

  Thus, the estuarine habitat of the Atlantic coast is presently capable of supporting large numbers of young Atlantic menhaden. No sudden changes in this essential habitat are likely. Adequate estuarine habitat (area and quality) is essential, however, for the continuation of Atlantic menhaden.

- Based on purse seine landings since 1940 (Table 1.1), landings would not fall much lower than 150,000 MT even with a series of poor spawning years, and high fishing pressure. The lowest landings since 1940 occurred in 1969 (161,000 MT). Landings fell below 200,000 MT only one other time since before World War II (193,000 in 1967) (Nicholson 1975). Other factors, mostly of economic origin would come into play to protect the resource or reduce fishing (as in 1969), thus the Atlantic menhaden resource should not face biological extinction. Catastrophies in fishery resources do occur, even for species under some form of management, if the essential biological information is given secondary consideration in decisions. Fishing by man does have a major impact on the population.

- Recruitment of Atlantic menhaden into the purse seine fishery is well known (Huntsman and Chapoton 1973, Nicholson 1975, McHugh et al. 1959, Nicholson and Higham 1964). In most areas, young-of-the-year fish do enter the fishery to some degree. Only in the North Carolina Fall fishery are these young fish landed in significant numbers (Nicholson 1975). Recent changes in the fishing season and mesh regulations of Virginia in 1976 have significantly reduced the catch of young of the year fish in Virginia waters. In addition to fish of North Carolina origin, the North Carolina Fall fishery in December and January (Kroger and Guthrie 1973) takes migrating fish, some of which had been protected in Virginia. In waters north of Virginia these fish are either avoided, not retained by the seine mesh used, or do not occur on the usual purse seine fishing grounds.

Age 1 Atlantic menhaden are only partly available and recruited into the fishery. Although an appreciable number of age 1 fish enter the fishery from Chesapeake Bay to Florida, their true abundance (quantity as well as size) is not indicated by catches made in the purse seine fishery (Schaaf and Huntsman 1972).

Thus, as with age 0 Atlantic menhaden, age 1 fish are protected in large part from the total fishery and, to differing degrees from year to year are able to avoid capture. This tends to assure that a certain quantity of menhaden attain at least age 2.

At age 2, Atlantic menhaden are fully recruited into the Atlantic coast purse seine fishery. This age group supports most of the current fishery from Florida to Massachusetts and sometimes even in Maine (June and Reintjes 1959, Nicholson 1975). The great bulk of coast wide landings have been age 2 fish in recent years. They represent an average of about 60 percent of all purse seine landings.

Age 3 through 8+ menhaden are fully recruited to the purse seine fishery and can support sizable catches depending on location and year. These fish are the principal spawning stock and account for the bulk of egg production and spawning activity from Florida to Maine. Most catches of age 3 through 8+ menhaden currently are made in New England waters during the summer fishery. A few of these older fish are taken in the North Carolina Fall fishery from November through January. They have contributed 15 to 20% of the total NC Fall fishery landings in recent years.

Thus, the age 3 through 8+ segment of the Atlantic menhaden population is more-or-less completely vulnerable to the purse seine fishery either during the summer fishery in New England waters or as they migrate to or from the Middle and South Atlantic waters in the spring and fall. During the 1960's, some evidence suggested that the production of young fish (age 0) was low because the spawning stock (age 3+ females) was reduced (Nelson, et al. 1977). Therefore, the fishery may be able to catch excessive numbers of potential spawners near the time of first spawning (age 3) or at times prior to successive spawnings (age 4+) when egg production increases with increasing age (Higham and Nicholson 1964, Dietrich 1979).

- Schooling of Atlantic menhaden is a biological feature of utmost importance to the purse seine fishery. This habit is shown by all ages and sizes of menhaden and permits the successful use of purse seine fishing gear during daylight hours. At high population levels, schools tend to be large and numerous. At lower population levels, the schools are generally smaller and less numerous. When the population is at low abundance, those few existing schools represent a proportionately larger amount of the entire population than would a single school in a period of high abundance. Since the purse seine usually captures an entire school, continued heavy fishing could exert considerable impact on the residual population and further reduce an already reduced stock. There appears to be no fish species of sufficient numbers or size to adequately replace the Atlantic menhaden (Pristas and Cheek 1973).

When the abundance is low, as in the late 1960's, fishing becomes less profitable and fishing effort decreases after a lag of one or more years. Companies usually plan the next year's fishing operations based on the current year's catch, thus experience and poor catches one year will be reflected in company activity during the next year. Poor catches and financial losses reduce the attractiveness of continued fishing before the "last" fish is captured.

Schooling of fishes is generally considered a species-protective mechanism (Guthrie and Kroger 1974, Brock and Differburgh 1953, Breder 1967, Shaw 1978). Under natural conditions the schools will be composed of individuals of similar size. Fish in a school will be less likely to be eaten by predators and aided in locating food (June 1972, Shaw 1978).

- The present purse seine fishery relies on the migrations of Atlantic menhaden to provide a supply of fish for capture. Fishing on the southern (Georgia and Florida) and northern fishing grounds (New England) depend in large measure on migrating fish which move into their fishable waters during the summer. The central fishing grounds (Virginia to New York) receive additional fish from North Carolina and more southern waters. Fish migrating south in the fall, contribute to catches off New Jersey, Delaware, Virginia and North Carolina. In fact, most of the catch in the North Carolina Fall fishery has been historically fish migrating from more northern waters (Dryfoos et al. 1973, Pristas and Willis 1973, Parker 1973, Nicholson 1978, Kroger, et al 1971, Kroger and Guthrie 1973, Kroger, et al. 1974).

Migrations of Atlantic menhaden along the coast at almost all times of the year tend to expose the fish to several different parts of the purse seine fishery within the same season. Thus, fish that escape capture in one area are often subjected to capture in another area later and possibly in several areas before the fishing season is over. Thus, multiple exposure adds to the likelihood of Atlantic menhaden being captured by man. This feature reduces the chance that large segments of the total population will remain undetected for very long periods during any one fishing season and certainly not for several seasons.

In summary, the answer to the question posed "Can the resource and fishery collapse?" appears to be "yes" on the basis of the biological factors. The collapse would take several years, however, and this might permit time for corrective action. Such action, no matter the form or degree, might not be sufficient to prevent a total collapse. The Atlantic menhaden resource would probably persist at an abundance level well below that required for efficient, cost effective purse seining.

SECTION 2. DESCRIPTION OF HABITAT OF THE STOCK COMPRISING THE MANAGEMENT UNIT.

A. Condition of the Habitat

The ecosystem may be compartmentalized into abiotic (non-living) substances; autotrophic organisms (primary producers) which are able to use abiotic material to store solar energy in the form of organic matter; and decomposers which break down organic matter, using its stored energy to release inorganic constituents. Most ecosystems also have consumers which convert organic material to another form, using some of the stored energy of the organic material for maintenance. The rate of transfer of material and energy between parts of the ecosystems is affected by the amount, type, or condition of abiotic and biotic material (factors) in the system.

The nekton (including menhaden) are distinguished from other biological components of the ecosystem by their ability to distribute themselves over the continental shelf and in the estuaries independent of the water circulation of the region (although some species may use currents for transportation or orientation). This ability to move from one location to another or to maintain a desired location allows groups of individuals of a particular species to obtain a desired breeding location with some consistency year after year. Such groups are called stocks, and although they may mix with other stocks during parts of their life cycle, they are generally isolated from other members of their species during the breeding season.

The Middle Atlantic - Southern New England Region is relatively uniform physically, and is influenced by many large coastal rivers and Chesapeake Bay (the largest estuary in the United States). Additional significant estuarine influences are Narragansett Bay, Long Island Sound, the Hudson River estuary, Delaware Bay, and the nearly continuous band of estuaries behind barrier beaches along southern Long Island, New Jersey, Delaware, Maryland and Virginia. The southern edge of the region includes the significant estuarine complex of Currituck, Albemarle, and Pamlico Sounds behind the outer banks of Cape Hatteras.

The paucity of oceanographic data on the continental shelf and in the estuaries south of Cape Hatteras, North Carolina hinders attempts to document the oceanographic conditions. In general data are more available and conditions better understood in the estuaries than on the continental shelf.

At Cape Hatteras, the continental shelf extends seaward approximately 33 km (20 miles) then widens gradually to 113 km (70 miles) off New Jersey and Rhode Island and then broadens to 193 km (120 miles) off Cape Cod forming Georges Bank. The substrate of the shelf in this region is predominantly sand interspersed with large pockets of sand-gravel and sandshell. Beyond 200 m, the substrate becomes a mixture of silt, silt-sand, and clay.

On the continental shelf north of Cape Hatteras, surface circulation is generally southwesterly during all seasons, although this may be interrupted by coastal indrafting and some reversal of flow at the northern and southern extremities of the area. Speeds of the drift are on the order of five nautical miles per day. There may be a shoreward component to this drift during the warm half of the year and an offshore component during the cold half. This drift, fundamentally the result of temperature-salinity distribution, may be made final by the wind. A persistent bottom drift at speeds of tenths of nautical miles per day extends from beyond midshelf toward the coast and eventually into the estuaries.

A southerly flowing coastal current such as that prevalent north of Hatteras is transient to the south of Hatteras. During winter a cross shelf thermal gradient causes a northerly set to the coastal waters. In summer the cross shelf thermal gradient is nearly non-existent, so a general southerly movement is found over most of the shelf.

Circulation in the western North Atlantic is profoundly influenced by the Gulf Stream, an intense western boundary current. Transport by the Gulf Stream off Cape Hatteras has been estimated to be $63 \times 10^6 m^3/sec$, and surface currents as high as 200 cm/sec have been measured.

The salinity cycle results from stream flow and the intrusion of slope water from offshore. The salinity maximum of winter is reduced to a minimum in early summer by large volumes of spring river runoff. Inward drifts of offshore saline water throughout the autumn eventually counterbalance the fresh water outflow and return the region's salinity distribution to the winter maximum. Due to the proximity of the Gulf Stream and the low amount of runoff per unit length of coast, the shelf water south of Hatteras is relatively saline when compared to coastal waters farther north. Shelf salinity here is lower during summer. Water salinities near shore average 32 ‰, increase to 34-35 ‰ along the shelf edge, and exceed 36.5 ‰ along the main lines of the Gulf Stream.

Most, if not all, of the coastal waters and estuaries from New England to central Florida are utilized by juvenile menhaden as nursery areas. The association of menhaden with the rich inshore waters during the first year of life is often described as a dependency for successful rearing of the fish. Several aspects of this fish/water/food interaction were described in detail by Reintjes and Pacheco (1966) (their abstract is given below):

"Menhaden, genus Brevoortia, use estuaries along the Atlantic and Gulf coasts of the United States as nursery areas for more than half of their first year of life. The Atlantic menhaden, B. tyrannus, and Gulf menhaden, B. patronus, support the largest fishery in North America and observations reported concern mainly these species. Spawning occurs in the Atlantic Ocean and Gulf of Mexico. After hatching and early development the larvae move into estuaries. The time spent in the ocean before entering the estuaries is not known. Larvae move into the tributaries near the upstream limits of saline water. Water temperatures below 3 C deter entry into the estuaries, inhibit movements into the tributaries, and cause mass mortalities. Temperatures below 3 C killed larvae confined in the laboratory at salinities of 24 ‰ but effects varied somewhat with acclimation temperatures. Larvae and juvenile menhaden were collected in salinities of 1‰ or less along the Atlantic and Gulf coasts of the United States. Along the south Texas coast juveniles survived salinities up to 60 ‰ but were killed by 80 ‰. Other physical, chemical, and biological factors affecting young menhaden are mentioned but supporting data are few. Literature citations include most of the publications on the estuarine phase of the menhaden's life history."

A general account of estuarine biology was presented by Lauff (1967), Douglas and Stroud (1971), and Smith et al. (1966).

B. Habitat Areas of Particular Concern

Spawning areas include the open waters of the continental shelf off the East coast of the U.S. These areas are within the Fishery Conservation Zone (Figures 2.1 and 2.2).

Severely depleted oxygen concentrations and widespread mortalities of benthic organisms occurred in the section of New York Bight in 1976. It covered an area about 100 miles (160 km) long and 40 miles (64 km) wide during the most critical phases of the depletion. Normal O_2 levels in this region are greater than 4 ppm. Investigations to date indicate that this state was probably induced by a combination of meteorological and circulatory conditions in conjunction with a large-scale algal bloom (predominantly of

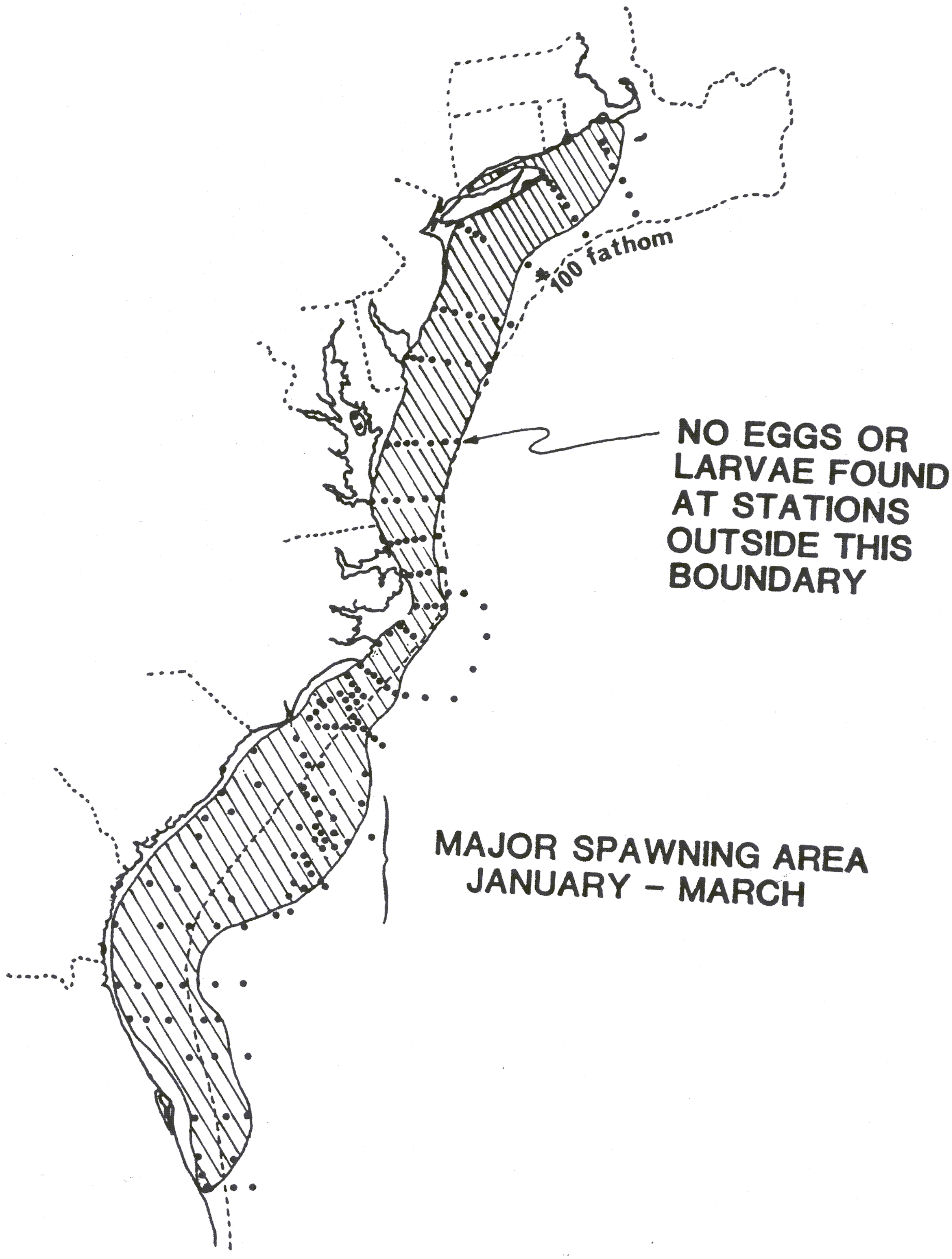


Figure 2.1. Spawning grounds of Atlantic menhaden based upon records of eggs and larvae (1917-1971). (Source NMFS 1973).

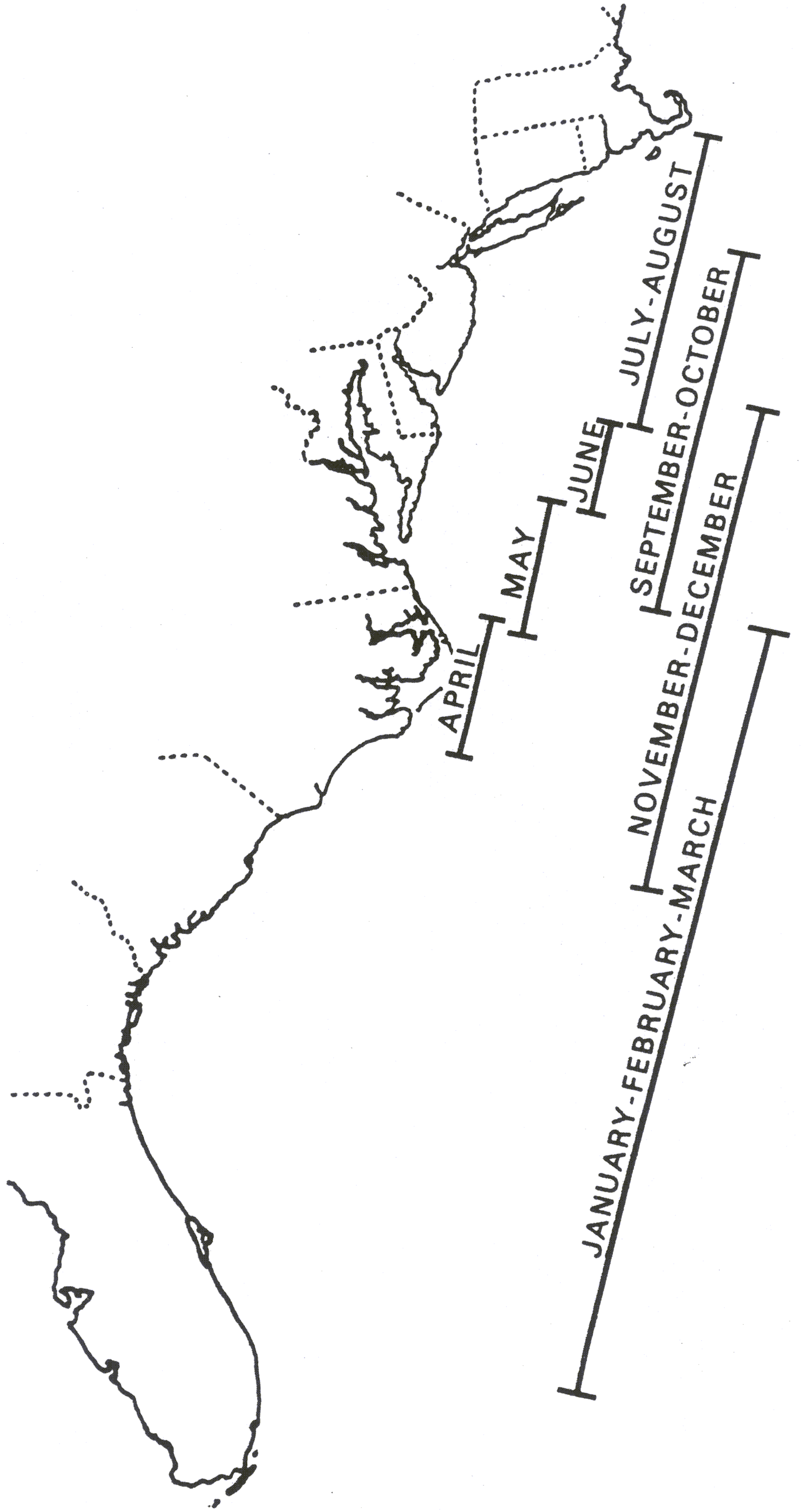


Figure 2.2 Principal spawning areas of Atlantic menhaden by months of the year. (Source NMFS 1973).

Ceratium tripos). It is not known to what degree the routine dumping of wastes (sewage sludge and dredge spoils) in the ocean contributed to the depletion.

The shelf will likely continue as a disposal area for sewage sludge, chemical wastes, radiological wastes, etc. over the near term (until the year 2000 at least). Oil exploration is now in progress in the Baltimore Canyon Trough area off New Jersey and Delaware.

Nursery areas and primary fishing areas are within the jurisdictional boundaries of the U.S. Most activities are within the 3-mile limit and thus are within the territorial sea of the individual states.

Location of industry in the coastal zone and continued urbanization and domestication of the shore areas by private home-owners create a series of stresses on the stability of the nursery zone. Douglas and Stroud (1971) cover some of the important inter-actions.

Chesapeake Bay is a major nursery area for menhaden. Figures 2.3-2.5 document the projected location and size of some of the major facilities affecting water quality and habitat quality within the inshore areas.

There have been several recent publications which address the future and fate of Chesapeake Bay and bear on the maintenance of habitat quality and effective menhaden nursery grounds (W.A.S. 1972 and C.R.C. 1977). Other states' waters face similar problems.

C. Habitat Protection Programs

No special habitat protection programs exist in the continental shelf habitat of Atlantic menhaden. Sampling for pollu-tion is carried out by the National Marine Fisheries Service and the Environmental Protection Agency. Habitat protection programs on the shelf and inshore waters are administered by a variety of Federal agencies including the Department of the Interior, the Coast Guard, and the Environmental Protection Agency (permits for siting, dredg-ing, discharge to water, etc.). State agencies individually admin-ister permit and water quality programs within their jurisdictions. With approval of Coastal Zone Management Programs the estuarine nursery areas may be designated critical areas for protection in most states.

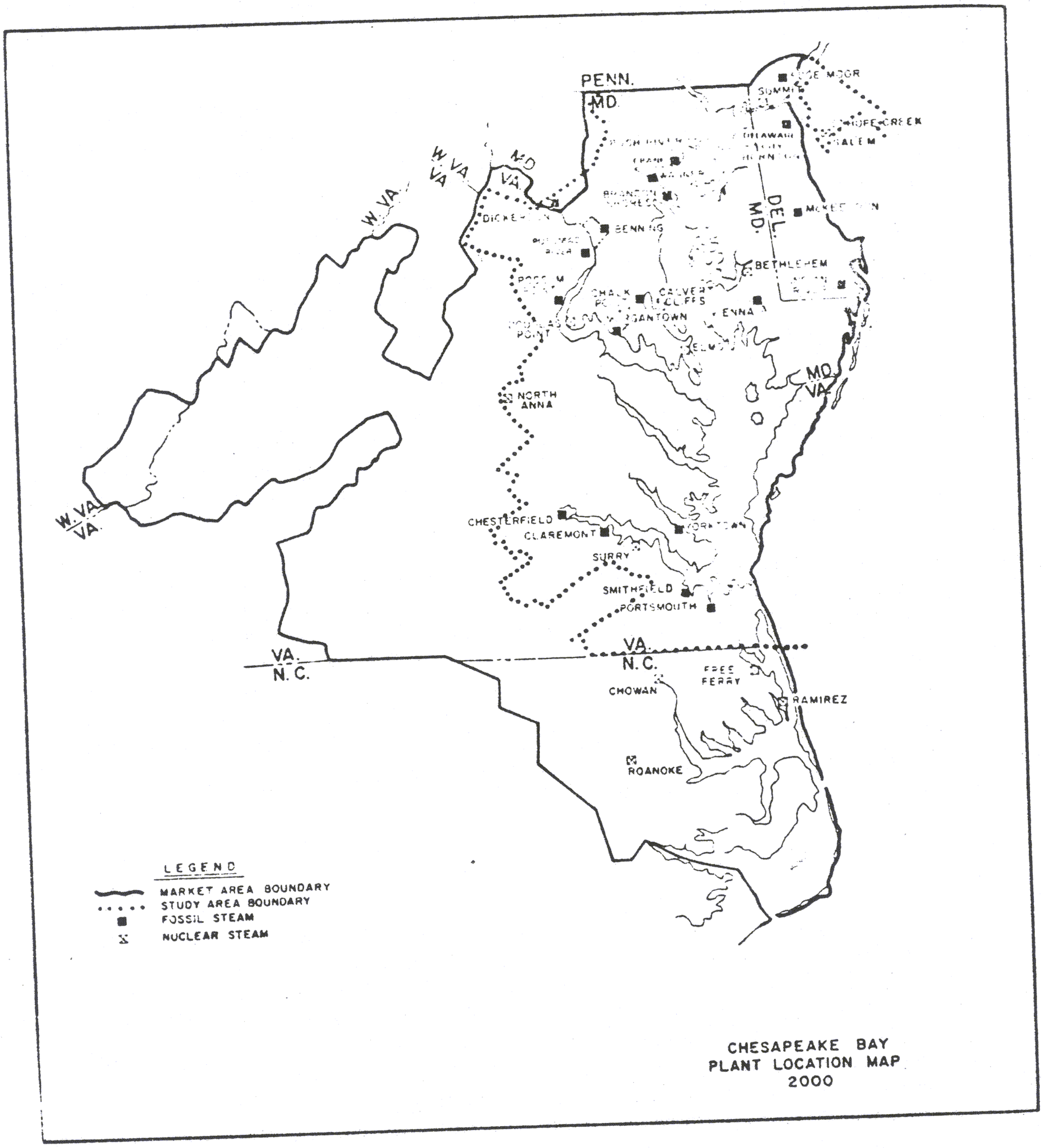
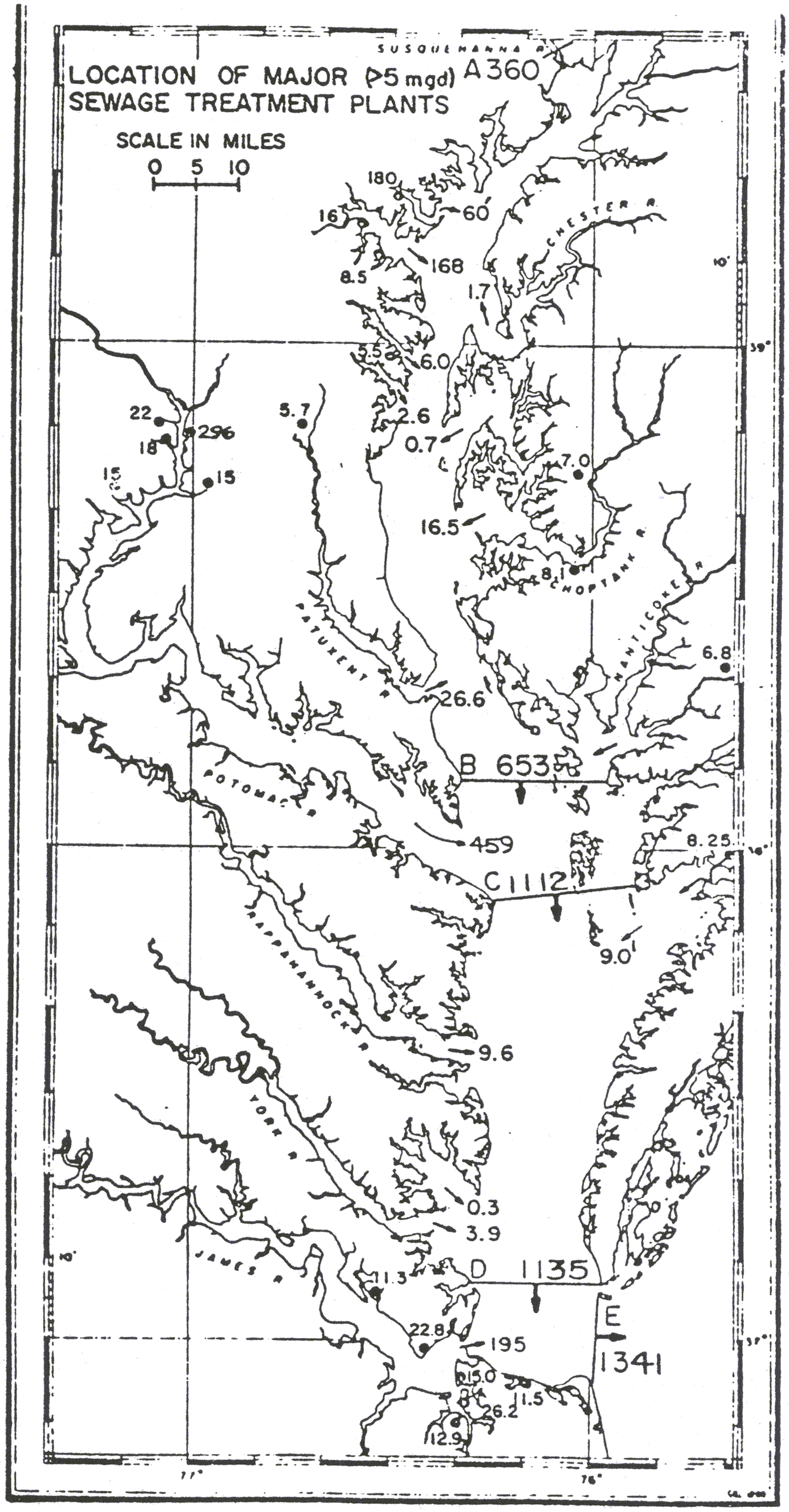


Figure 2.3. Power plant sites projected to meet demand in the year 2000. (Source COE 1977, Appendix 13, p. 56).



Note: Numbers are discharge rates in million gallons per day. Larger numbers are cumulative sums of inputs into the Bay. (After 20).

Figure 2.4. Major municipal sewage discharges in Chesapeake Bay. (Source COE 1977, Appendix 15, p. 375).

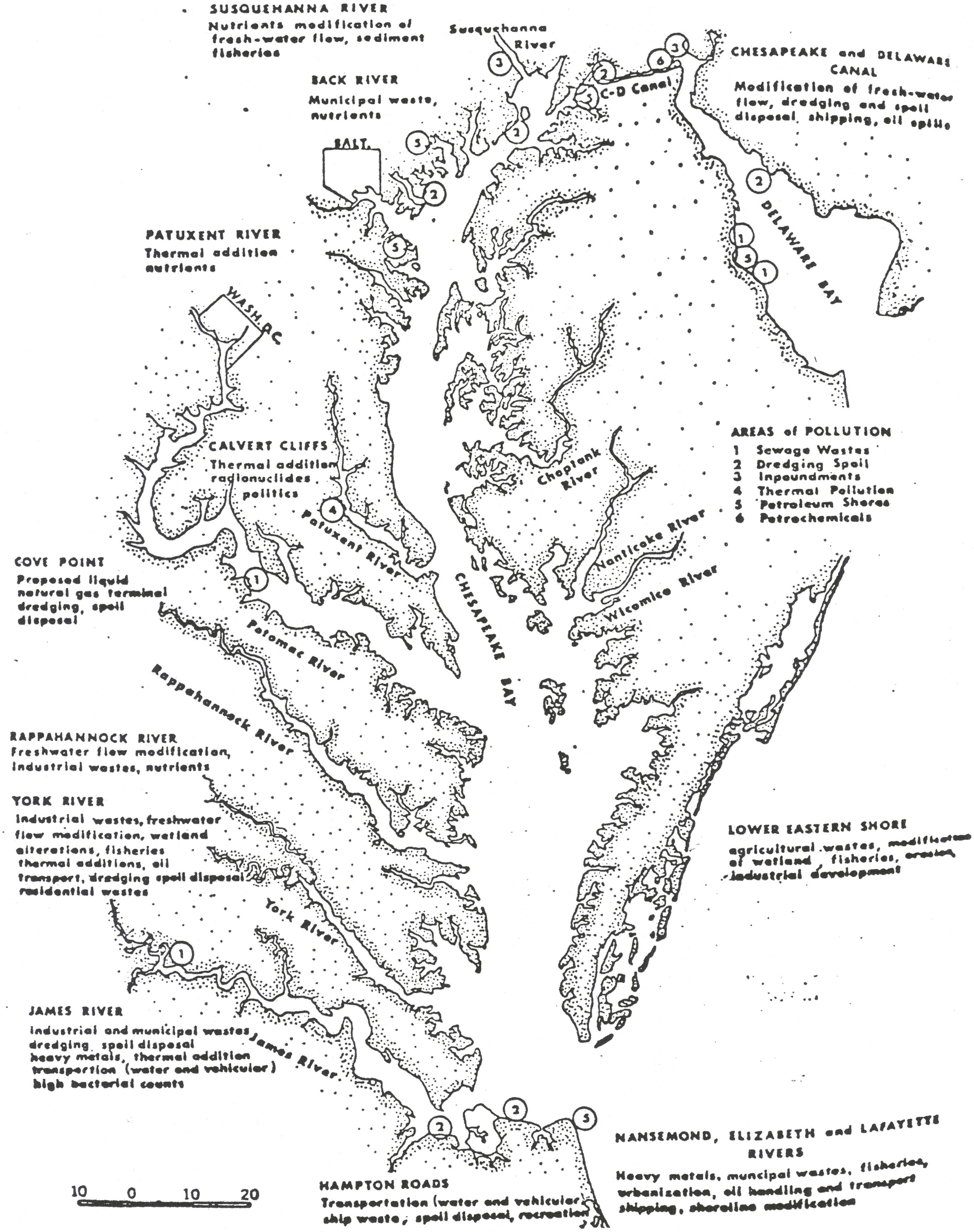


Figure 2.5. Major areas (types) of pollution in Chesapeake Bay. (Source COE 1977, Appendix 15, p. 400).

SECTION 3. FISHERY MANAGEMENT JURISDICTION, LAWS AND POLICIES

Menhaden management at the present time is left mainly in the hands of the industry which harvests the resource on an economic basis. The states exercise few management controls other than setting of seasons and defining sanctuary areas in response to pressures generated by long-standing institutional conflicts. At present three states have an established season (Maine, New Hampshire and Virginia) and two have mesh sizes (Virginia, 1 3/4"; and South Carolina, 1 1/2" stretched mesh). This system has served well in the past but concern for the valuable Atlantic menhaden resource has increased since the decline in stocks.

The present system is not flexible enough to readily incorporate biological and other pertinent data into management procedures which suffer from political pressures generated by the public's adverse reactions to certain menhaden harvesting techniques. A continuing challenge of management has been to counteract the unwarranted reactions of the public.

A synoptic review of the states' management structures and other features pertinent to the Atlantic menhaden fishery is presented in the following compendium of regulations.

STATE DELEGATION OF AUTHORITY	LEGISLATIVE AUTHORIZATION	POSSIBLE REGULATIONS TO INSURE ADEQUATE CONSERVATION	LICENSES	SEASON	SPECIAL AREAS	PENALTIES
MAINE Department of Marine Resources	Section 3505 Subsection 4 Paragraph B	Commissioner may make regulations upon advice and consent of the advisory council. Method: time taken, method, number taken, weight taken, length and location, when a condition endangering any marine species exists as determined by a hearing.	None specifically for menhaden NRC - $200 RC - $10 (5.0) RC - $25 (C.)	May 15 to Dec. 1	Damariscotta and Georges River--in certain areas. June 1 to Dec. 31. Boats transporting are limited to 30,590 lbs, 437 bushels, or 25 hogheads, must be measured, plainly marked and sealed by State sealer. 1) no setting of purse seine within 1500 ft. of any stop seine. 2) no setting of seine within 2000 ft. of the mouth of any weir. 3) no use of purse, drag of stop seine in ports of Kennebec, Sheepscot, Damariscotta, and St. Georges Rivers.	Possible suspension of permit or where specific penalties are not provided . fine - $500 and/or jail for one year.
NEW HAMPSHIRE Fish and Game Department	R.S.A.211.65 Division of Marine Fisheries created R.S.A. 206.1 Commission created R.S.A. 206.10 Powers and Duties of Director	The director may make rules and regulations. Methods: size, number, quantity, areas, and manner of their taking	A.N.R. (for saltwater) by netting, dragging, or trawling is $150 regardless of the size of boat or vessel	No person shall use a purse seine June 1 to September 15.		General penalty misdemeanor
MASSACHUSETTS Division of Marine Fisheries Marine Fisheries Advisory Commission	Mass. Ann. Laws 2.5, SA; Chapter 130	The Division may promulgate regulations with approval of Marine Adivsory Commission. Method: taking fish, size, seasons and hours, and opening and closing of areas.	C. boats 100' - $100; boats 60' - 99' - $75; boats up to 59' - $50 This permit is valid for taking, landing, and selling finfish, and may be endorsed for shellfish. A special permit ($10) is required for	No closed seasons	Special permits are issued for areas designated as a regulated fishery area or as an inshore permit area. Specific regulations may apply by individual area.	NR transporting fish out of state waters are subject to a $50 fine and forfeiture of the catch. Violators are subject to fines of not less than $10 - not more than $1000, imprisonment not more than 1 month - or both.

RHODE ISLAND Division of Fish and Wild-life	Title 20-1 General Laws of Rhode Island Title 42 Chapter 17	Division may promulgate regulations manner of taking fish, size of fish, seasons and hours, numbers and quantities and opening and closing of areas 1)c. required to make monthly reports to Department 2) Equipment must be registered	Vessels 99' = \$100; vessels 59'-99' = \$75; vessels up to 59' = \$50	No closed seasons	See excepted areas	Fine up to \$500 and one year suspension of license. Fine of not less than \$500, no more than \$700 for violation of regulations 3
CONNECTICUT Department of Environmental Protection	C.G.S. Section 26.3	Commissioner is authorized to carry out administrative rather than management or protection of fishery resources.	Purse seine = \$300; gillnet, seine, scap, etc. for commercial purposes = \$10; individual license (personal use with seine less than 30' and scoop net no more than 36"--no license required)	No closed seasons	No fishing on weekends. No mesh size restrictions	Fine up to and not exceeding \$500 or imprisoned not more than 50 days or both
NEW YORK Department of Environmental Conservation	N.Y.E.C.L. Sections 3-0301, 11-0305	Commissioner of Environmental Conservation shall be authorized to, with the advice and approval of the State Environmental Board, adopt, amend or repeal environmental standards, criteria, rules, regulations and procedures	R.N.R. 30 gross tons (gt) or less = \$25; 30-100 gt = \$200 100-150 gt =\$500 150-200 gt =\$750 over 200 gt=\$1000 Licenses expire Dec. 31 following date of issue	No closed seasons	See excepted areas	Civil penalties of not less than \$250 nor more than \$1000 for each offense of Section 13-0333 or misdemeanor fine between \$25-\$100 for 1st offense, \$50-\$100 for 2nd offense, \$100-\$200 for 3rd offense, or imprisonment for 30-90 days.

NEW JERSEY Division of Fish, Game and Shellfisheries	New Jersey Stat. Ann.	Division of Natural Resources has the power to cooperate with other states, interstate and Federal departments and agencies to develop programs and policies for the conservation and protection of natural resources	R 30-100 gt=$125; 100-150 gt =$250; 150-175 gt =$400; 175-200 gt =$550; 200 + gt = $900; 20 tons or less used for taking menhaden for bait purposes only. 30-100 gt = $450; 100-150 gt =$700; 150-175 gt =$1000; 175-200 gt =$1150; 200 + gt = $1500; Residents who lease vessels from out of state shall pay fees same as N.R.	No closed seasons	None	Violations are misdemeanors - $1000 for each offense
DELAWARE Division of Fish and Wildlife	House Bill No.413, Section 919, Delaware Code, Title 7, "Menhaden Fishing"	Division has authority to protect, conserve and propagate the fisheries resources of the state. Further legislation regarding more powers pending.	Vessels over 65' in length shall obtain a license before fishing for menhaden. Fee - $100	No closed seasons	No menhaden fishing between Memorial Day and Labor Day on the weekends. No fishing for menhaden within 1 mile of populated beach or pier. Dead fish must be kept on vessel.	Violations are regarded as misdemeanors. $500 - first offense; $2500 - each offense thereafter.
MARYLAND Tidewater Fisheries Administration	M.D. N.R. Section 1-101, 4-202	Regulations may include, but are not limited to, provisions, enlarging, extending, restricting, or prohibiting the taking or catching of these resources	None issued for purse nets	Commercial menhaden fishery prohibited.	Commercial menhaden fishery prohibited from use of purse nets in Maryland waters	Violations are misdemeanors. Fine not less than $100 nor more than $1000; and shall stand committed to the Baltimore City Jail or to the County jail until such fines and costs are paid.

VIRGINIA Marine Resources Commission	Code of Virginia, Chapter 4. Fish and fishing generally, sections 28.1-58 to 28.1-81.1. Specifically Chapter 4, Art 2, Section 28.1-53 to 28.1-66 "fish for manufacture into fish meal, oil, etc.	Mesh size not less than 1-3/4" stretched	Duration 1/1 to 12/31. R. A) (Sail vessel) purse nets of not more than 400 meshes deep $21.50 B) (sail vessel) more than 400 meshes - $75 C) power boat or steam vessel: under 100 gt - $3/gt max. $150. over 100 gt - $5/gt. max $600. D) Power boat or steam vessel less than 20 HP - $37.50	Third Monday of May through third Friday of November, inclusive of each year.	See excepted areas.	All violations are misdemeanors Upon conviction shall be punished by a fine of not more than $1000 or imprisonment of not more than 12 months or both.
NORTH CAROLINA	North Carolina General Statutes. See G.S.113-152 113-156 113-163 113-182 113-185 113-186 1438-286	Marine Fisheries Commission power specifically includes the promulgation of rules and regulations implementing the provisions of Chapter 113 of the General Statutes	License must have name of man in command. Fees for mother ship are $1.60 per ton, g.t., customhouse measurements, and no license is required for a purse boat used in connection with a licensed mother ship. N.R. must pay $200 in addition.	No closed seasons	Buying or selling menhaden for reduction must be done by a measure of 22,000 cubic inches for every 1,000 fish. Specific requlations prohibiting fishing apply to Masonboro Inlet and Cape Lookout Bight. It is unlawful to fish in the ocean within 750 ft. of an ocean pier. Purse seines for menhaden fishing shall not take foodfish in excess of 1 percent of the total amount of fish on board.	Violation of Marine-fisheries regulations is a misdemeanor punishable by a fine of not less than $50 nor more than $250 for the first offense and not less than $100 nore more than $500 for any offense thereafter or imprisonment for not more than 30 days, or both.

SOUTH CAROLINA Wildlife and Marine Resources Commission	S.C.Code Section 28		Required for each boat used. Fee based on net tonnage determined at \$1 per net ton for R and \$2 per net ton for NR. Individual license of \$4 for individual NR. Purse seines licensed at \$5 each.	No closed seasons	Purse seine fishing allowed 300 yards or more beyond beach. Purse seine mesh must be at least 3/4 inch bar measured 1-1/2 inch diagonal.	Any person violating the provisions shall be guilty of a misdemeanor punishable as provided in paragraph 28-761 of South Carolina Title 28.
GEORGIA Game & Fish Division Section of Coastal Fisheries	Executive Reorganization Act of 1972 Section 1527	Board of Natural Resources and Commissioner of Natural Resources may fix open and closed seasons for all wildlife regulating manner, method and devices of hilling, taking, capturing and consuming wildlife as otherwise provided by law.	Personal- RC - \$2 NRC - \$5 Vessel - trawler up to 18' - \$25 trawler more than 18' - \$25, plus 50¢/ft over 18'. All other boats - \$5 - up to 18' All other boats 50¢ over 18' or fraction thereof.	No closed seasons	1,000 ft. restricted area from shore for Jekyll Island St. Simon Sea Island Tynee No purse seines inside rivers, creeks & sounds.	Loss of license for a period of six months
FLORIDA Department of Natural Resources, Division of Marine Resources. All Rules & regulations through the Executive Director & must be approved by the Governor and cabinet	Chapter 370 Florida Statutes Annotated. Allows for local laws and "General Bills of Local Application"	Power to regulate the taking or possession of saltwater fish.	Purse seine -\$25 Non-resident - \$25 Purse Boat - \$31 Carrier Vessel -\$76 Dealer Classification - \$10 Wholesale Dealer: Resident - \$100 Non Resident-\$150 Alien - \$500	None set	No menhaden by purse seine along designated areas of west coast.	Violations of Chapter 370 - not more than \$500 and/or imprisonment of 1 year. Other sections specify seizure of fishing gear, vessels, catch and vehicles.

Terms used: NR = non resident; R = resident; C = commercial

SECTION 4. DESCRIPTION OF THE FISHERY

A. History of the Fishery

Atlantic menhaden have supported the United States' largest fishery since colonial times. Except for a short period in the 1930s, more menhaden have been landed annually than any other fish. Since 1963, the harvest of Gulf menhaden has exceeded that of Atlantic menhaden. Landing records indicate that over 32.7 billion pounds (14,838,752 metric tons-MT) of Atlantic menhaden have been caught by fishing fleets operating from Maine to Florida since 1940.

American Indians may have used menhaden for fertilizer before the settlement of North America by the white man. Colonists soon recognized the value of whole menhaden for fertilizer, and local seine fisheries gradually developed from New York to Maine. From 6,000 to 8,000 fish were used on each acre (Harrison 1931). The use of whole fish for fertilizer continued into the nineteenth century. Frye (1978) described the beginning of the menhaden oil industry in Rhode Island in 1811. The fishery grew steadily during the first half of the nineteenth century, with significant mechanization, including boilers for rendering the raw fish and presses for removing the oil. Oil was used as fuel and for industrial processes, while the solids remaining after oil removal (scrap) were used for fertilizer. Numerous small factories were located along the coast of the northeastern states. However, their supply was limited to fish that could be captured by the traditional shore-based seines. About 1845, the purse seine was introduced, and scarcity of raw material was no longer a problem.

Union soldiers returning home from North Carolina and Virginia after the Civil War reported on the abundance of menhaden in Chesapeake Bay and coastal North Carolina. By about 1870, several plants were operating in the two areas (Whitehurst 1973 for North Carolina).

The industry gradually developed during the late 1800s and early 1900s and was described in considerable detail just before World War I by Greer (1914). One plant had developed a method to reduce odors by treating waste gases, a sort of "scrubber". During this period, the number of factories and vessels varied according to the supply of menhaden. The principal use for scrap was fertilizer, with different companies each producing their own formulation. A small amount was used to feed cattle and chickens.

Harrison (1931) described the uses of menhaden during the late 1920s (p. 41): "... much is being used in mixed feeds for poultry, swine, and cattle, and the amount going to fertilizer is steadily decreasing. Menhaden oil is used primarily in the manufacture of soap, linoleum, water proof fabrics, and certain types of paints."

Following World War II, the industry grew rapidly and reached peak production during 1953-62. Sharp declines in landings resulted in factory closings and fleet reductions during 1962-72. The industry has been fairly stable since then, although landings have fluctuated. Frye (1978) described the history of the fishery in great detail, citing many contemporary descriptions of fishing and processing activities.

Nearly the entire catch of menhaden is now used in the manufacture of meal and solubles for animal feed, and oil is used in the manufacture of margarine as well as in a wide variety of industrial products and processes. A small portion of the total catch (amount unknown) is used for bait by commercial and recreational fishermen.

B. Fishing Vessels and Gear

The early purse seine fishery utilized sailing vessels. Coal-fired steamers were introduced after the Civil War. In the 1930s, diesel-powered vessels began to replace the steamers, although a few sailing vessels were still in use.

Reintjes (1969) described modern menhaden vessels and purse seines, and summarized significant technological developments since World War II:

- 1946: Use of spotter aircraft; setting on a school is now directed by the spotter pilot via radio communications with the purse boats.
- 1946: Use of pumps to transfer fish from the nets to the carrier vessel resulted in shorter transfer time and more fishing time.
- 1954: Use of synthetic net material rather than cotton twine.
- 1957: Use of hydraulic power blocks in the purse boats to haul in the purse seine allowed a reduction in crew size and speeded up retrieval of the net. Synthetic net material, much stronger than cotton, was able to stand the increased strain from the power blocks.
- 1958: Introduction of aluminum purse seine boats to replace wooden boats.

During this same period the fleet of carrier vessels underwent significant changes, with larger, faster vessels replacing the older members of the fleet. These changes in the fleet after

World War II are discussed in Section 5. Today, menhaden vessels range from about 70 ft (21m) to 195 ft (60m). Most menhaden vessels carry two purse seine boats about 36 ft (11m) in length (a few small vessels have only one purse boat). The purse seine has a stretched mesh of 1 1/4 in (3cm) to 2 3/8 in (6.3 cm) and ranges in length from about 1000 ft (305 m) to about 1400 ft (427m), and in depth from about 65 ft (20m) to about 90 ft (27m).

Over the years, vessels participating in the Atlantic menhaden purse seine fishery have varied considerably in size, fishing methods, gear, and intensity of effort. Most of the purse seine vessels fishing in Chesapeake Bay and Middle Atlantic areas have been devoted to the fishery for the duration of the season (~ 26 weeks/year). These are generally large conventionally-rigged vessels which carry two smaller purse seine boats. However, several smaller vessels utilizing only one purse seine boat ("snapper rigs") have fished in these regions, often in areas not available to the larger vessels. The catches of the "snapper rigs" (a very small fraction of the total) are often sold for bait (sport fishery, crab pots, etc.) as well as being processed into meal, oil, and solubles. Few conventional menhaden vessels have ever been based in the North Atlantic because of the variability of occurrance of menhaden in that region. Rather, trawlers and draggers convert for purse seine operation in a manner similar to the "snapper rigs" farther south. They fish for menhaden as long as it pays to do so. If the season begins poorly, most of these vessels leave the fishery for more profitable pursuits. If more menhaden appear later in the year, some of those vessels may re-enter the fishery. Conventional vessels from the middle Atlantic area often fish in the New England area if the long run is justified by significant quantities of fish in the area, especially if fishing is relatively poor nearer their home ports. The South Atlantic fleet is composed of vessels of a wide size range, with some smaller vessels using two purse boats. All of the vessels, however, fish exclusively for menhaden throughout the summer and fall seasons.

The number of purse seine vessels fishing for menhaden has varied widely, depending principally on availability of fish. Greer (1914) reported 147 vessels in 1912. During the fishery's peak (1953-1962), about 115-130 vessels fished during the summer, while about 30 to 60 participated in the North Carolina Fall fishery. As the fishery declined during the 1960s, fleet size decreased by more than 50%; from 108 full-time menhaden vessels in 1963 to 47 in 1968 (Nicholson 1971). Since 1972, from 35 to 43 full-time menhaden vessels have fished during the summer season, while 15 to 23 boats have fished in the North Carolina Fall fishery.

The number of full-time vessels in the fishery has not changed appreciably since 1972, but the "quality" of those vessels has changed significantly as shown by increases in capacity and refrigeration. The initial purpose of refrigeration was to deliver better quality raw material to the processing plant. An added benefit has been that vessels can remain on the fishing grounds for up to several days, if necessary to make an acceptable catch. Because of the reduction in number of vessels, the prospective fishing grounds can no longer be simultaneously covered as thoroughly as in the past. Vessels may fail to find fish in their chosen fishing area, whereas in the past, the larger fleet almost guaranteed that some fish would be taken. However, when fish are encountered today, the increased average hold capacity permits large catches to be landed. The ability to take advantage of peak availability of fish is critical for the maintenance of the industry in the face of a reduced stock of menhaden and a reduced number of vessels landing at fewer plants.

Table 4.1 shows that average hold capacity of menhaden vessels in the summer fishery went from 831,000 standard fish (252 MT) in 1972 to 1,142,000 (347 MT) in 1979, an increase of 37%. Only 29% of the vessels had refrigerated holds in 1972, while 67% were refrigerated in 1979. These figures further reflect the need of the industry to be able to take advantage of peak catches when available. While the total hold capacity of the fleet increased by about 53% between 1972 and 1979, it is still well below that in the late 1950's. During 1955-1959, an average of 112 vessels fished from Long Island southward, with a mean vessel capacity of about 678,000 standard fish, for a total fleet capacity of approximately 76,000,000 standard fish (data calculated from Nicholson 1971). This large fleet of unrefrigerated vessels landed daily catches at about 20 menhaden reduction plants located from New York to Florida. Today's fleet of about 35-40 vessels fishing in the same area lands at only 8 plants.

C. Processing facilities

From a few cast iron pots on the Rhode Island shore (Frye 1978), the processing of menhaden has become a highly mechanized operation. As companies have consolidated operations, the remaining plants have been upgraded so that each can handle peak catches that formerly might have been distributed among several plants. As with the vessels, the plants must have the capacity to process peak catches when they occur to compensate for the generally reduced volume of day-to-day landings. Because of this peak-processing capacity, today's plants have the capability to process far more menhaden than the fleet can supply (Table 4.2).

All of the plants currently processing menhaden have made significant investments in recent years to meet Federal, State, and

Table 4.1. Numbers of Atlantic menhaden processing plants, aircraft, vessels, vessel hold capacity (standard fish) and other information for plants and vessels wholly dependent on the Atlantic menhaden fishery, 1972-1979 (one standard fish = 0.667 lb)

Year	Number of Plants	SUMMER FISHERY Number of Aircraft	Number of Vessels	Percent Refri-gerated	Hold Capacity ('000) Total	Mean	FALL FISHERY Number of Vessels	Percent Refri-gerated	Number of Aircraft	Hold Capacity ('000) Total	Mean
1972	7	23	35	29	29,085	831	15	40	15	14,285	952
1973	8	24	39	44	34,960	896	16	44	15	13,360	835
1974	8	26	41	49	38,160	931	18	39	16	13,710	762
1975	8	27	43	51	42,710	993	23	48	18	19,860	863
1976	8	26	41	56	40,560	989	20	60	17	18,260	913
1977	8	28	43	65	48,125	1119	18	67	17	18,275	1015
1978	8	28	38	66	44,350	1167	17	65	11	19,550	1150
1979	8	29	39	67	44,550	1142	18	67	11	21,500	1194

Table 4.2. Calculated processing capacity (MT) of 11 reduction plants active in the 1976 purse seine fishery.

Hourly rate	Weekly rate[1/]	Season[2/]
556	33,360	834,000

1/ Weekly rate = 12 hours per day times 5 days

2/ Season = 25 weeks

local pollution control requirements, and all are in compliance with those standards.

Table 4.3 shows the distribution of processing plants at various times during the last 100 years. The number of plants has been stable since 1972 (except for 1974). Figure 1.1 shows the location of menhaden processing plants along the Atlantic coast in 1979. The Maine and Massachusetts plants processed menhaden when available, relying principally on cuttings from large foodfish processing operations for their raw material. The Rhode Island plant no longer processes menhaden; it serves as an unloading site for fish which are trucked to another plant for processing. One small North Carolina plant processes a small amount of scrap fish in addition to menhaden. All of the other plants rely on Atlantic menhaden (and a small amount of Atlantic thread herring, Opisthonema oglinum, in North Carolina) for their raw material.

D. Fishing and Landing Areas

The Mid-Atlantic Bight (Long Island, NY to Cape Hatteras, NC) accounts for about 70% of today's landings (Table 4.4). Catches in the South Atlantic (Cape Hatteras, NC to southern South Carolina), including the North Carolina Fall fishery, generally make up about 25% of the harvest. Landings in New England and Florida fluctuate widely as might be expected of fisheries located near the edges of the geographic range of the species. The seven processing plants located in New Jersey, Virginia, and North Carolina (including most of the South Atlantic catch) normally process about 90% of the harvest (Figure 1.1). The data in Table 4.4 illustrate the recent year-to-year variations in landings by area. The data also indicate that the South Atlantic area (principally North Carolina) had higher catches in recent years.

E. Fishing Seasons

Purse seine fishing is seasonal, with the appearance of schools of menhaden dependent on warming of coastal waters in the spring and cooling in the fall. Two fairly distinct fisheries occur, the "summer fishery" and the "fall fishery". The former usually begins in April with the appearance of schools of menhaden off North Carolina and Florida. The fish migrate generally northward, appearing in New England in June, having become distributed by age along the coast (younger fish in the southern area, older fish to the north). Peak landings occur during June-September (Figure 4.1). In early fall a southward migration begins. During November, the Florida fishery ends as those schools fished in Florida break up. By late November and December fish of all ages from all along

Table 4.3. Distribution of menhaden reduction plants along the Atlantic coast in selected years, 1875-1980 (from Reintjes, 1969, and NMFS records).

STATE	Ca-1875	1912	1929	1955	1965	1967	1970	1971	1972	1973	1974	1975-1980
MAINE[1]	22	1	-	2	-	-	-	-	-	-	-	2
MASSACHUSETTS[1]	4	-	-	2	-	-	1	1	1	1	1	1
RHODE ISLAND[1]	13	-	-	1	-	-	1	1	1	1	-	-
CONNECTICUT	5	-	-	1	-	-	-	-	-	-	-	-
NEW YORK	26	5	2	1	1	-	-	-	-	-	-	-
NEW JERSEY	5	5	3	3	2	2	1	1	1	1	1	1
DELAWARE	-	2	3	2	1	-	-	-	-	-	-	-
VIRGINIA	4	19	12	6	7	7	4	3	3	2	2	2
NORTH CAROLINA	2	12	12	6	7	7	7	7	4	4	4	4
SOUTH CAROLINA	-	-	1	1	-	-	-	-	-	-	-	-
GEORGIA	-	-	1	-	-	-	-	-	-	-	-	-
FLORIDA	-	1	2	3	2	2	1	1	1	1	1	1
TOTAL	81	45	36	28	20	18	15	14	11	11	9	11

1/ Reduction plants located in ME, MA, and RI during 1970-1980 are not dependent solely on menhaden for raw material as are the plants located in NJ, VA, NC, and FL. Thus, there have been only 8 full-time menhaden processing facilities on the Atlantic coast since 1973. The plant located in RI has not processed menhaden since 1973; it currently functions solely as an unloading point for fish shipped to another plant for processing.

Table 4.4. Atlantic menhaden catch ('000 MT) and percent by the three principal landing areas, 1972-1980 seasons.

Area	1972	1973	1974	1975	1976	1977	1978	1979	1980	Mean
North of Long Island	14.5	29.9	35.8	23.1	28.4	15.0	31.4	29.4	29.6	26.3
	4%	9%	12%	9%	8%	4%	9%	8%	7%	8%
Long Island to Cape Hatteras	300.1	277.4	194.8	149.8	243.3	244.1	214.1	230.6	282.8	237.4
	82%	80%	67%	60%	72%	72%	62%	61%	71%	70%
South of Cape Hatteras (Including Fall Fishery)	51.3	39.6	61.6	77.3	68.8	82.0	98.5	115.7	89.1	72.6
	14%	11%	21%	31%	20%	24%	29%	31%	22%	22%
Total	365.9	346.9	292.2	250.2	340.5	341.2	344.0	375.7	401.5	339.8

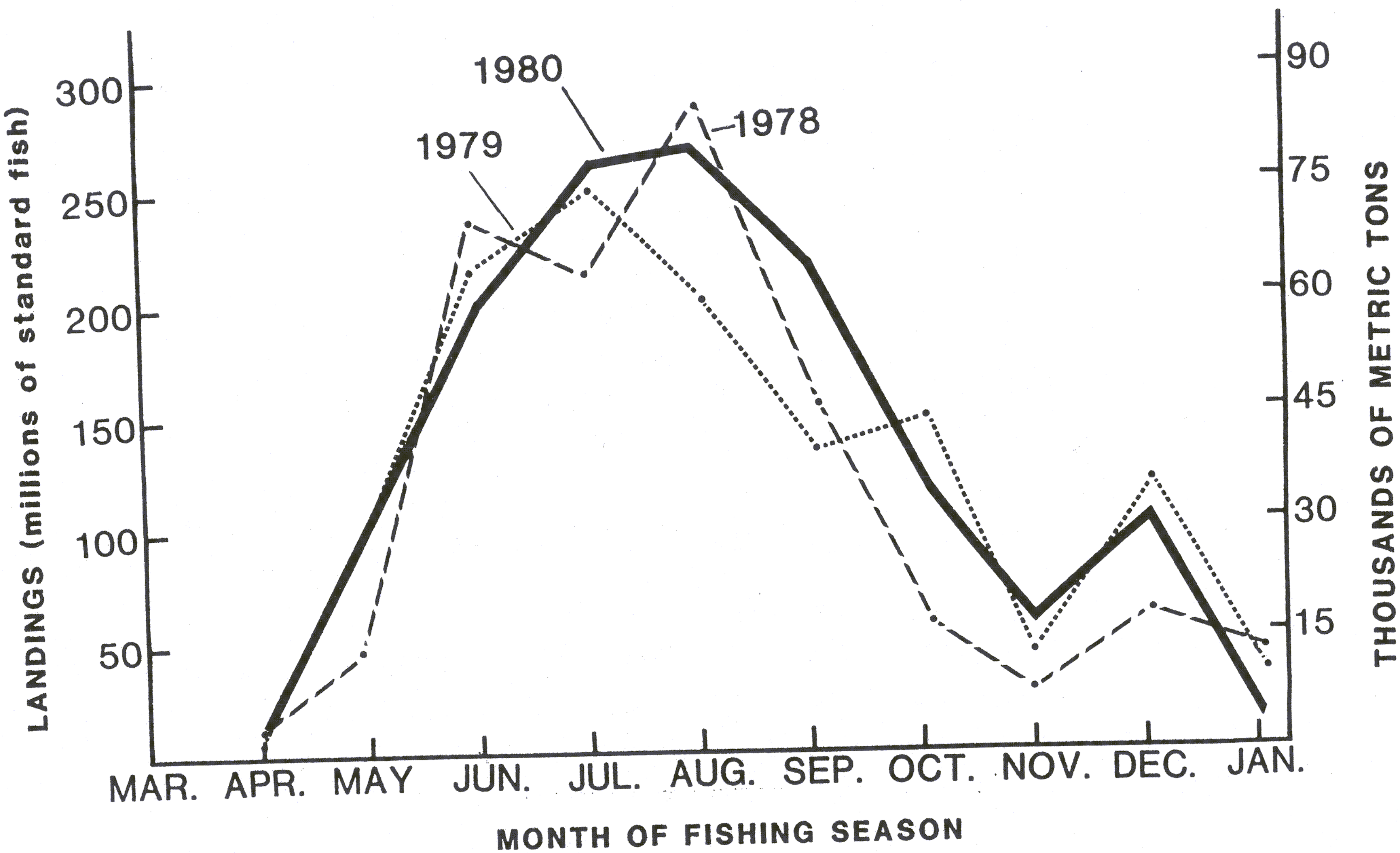


Figure 4.1. Monthly landings of Atlantic menhaden during the 1977-79 fishing seasons.

the Atlantic coast north of South Carolina are found between Cape Hatteras and Cape Fear, NC. Menhaden vessels based in Beaufort, NC pursue these fish in the fall fishery. Fishing continues into January. Menhaden appear to leave the coastal fishing grounds and migrate to deeper ocean waters offshore North Carolina to Florida. Effort and landings in the fall fishery fluctuate widely, depending largely on weather conditions.

F. Conflicts

The menhaden fishery has repeatedly been accused of taking large quantities of edible fish in addition to menhaden. A number of scientific studies have investigated this issue, and all reports have indicated no significant catch of any species other than Atlantic menhaden (Christmas, Gunter, and Whatley 1960). Sampling in Pamlico Sound, North Carolina during December 1978, showed similar results.

Other conflicts have been principally spatial and aesthetic, involving competition for space with recreational boaters and fishermen. Most menhaden purse seine vessels operate under a code of ethics designed to avoid conflicts. Generally, the vessels try to stay away from recreational boaters, beaches, piers, etc.; avoid areas known to be used for shellfishing, pound netting, and other commercial fishing activities; clean up spills of fish; and cooperate to the fullest extent possible with State fishery management agencies. Very few problems have been reported in recent years; in fact, the menhaden industry by its efforts to work harmoniously with recreational fishermen and boaters, the general public and governmental agencies, has set an example for the commercial fishing industry.

G. Landings

1. Purse Seine Landings, 1940-1979

While the production from the resource since 1940 has been impressive by all standards, the fishery witnessed considerable changes in abundance prior to its record-setting years in the 1950s (Table 1.1 and Figure 4.2). After achieving record landings of 712,000 MT (1.6 billion pounds) in 1956, landings began to decline. By 1962, the harvest was still impressive at 538,000 MT, but catches in 1963 crashed to 347,000 MT. The downward slide continued for the next six years, reaching the lowest harvest of 161,000 MT in 1969. Landings improved for a few years, reaching 365,000 MT in 1972. This was a shortlived recovery as landings fell to 250,000 MT in 1975. Landings stabilized at about 340,000 MT during 1976-78,

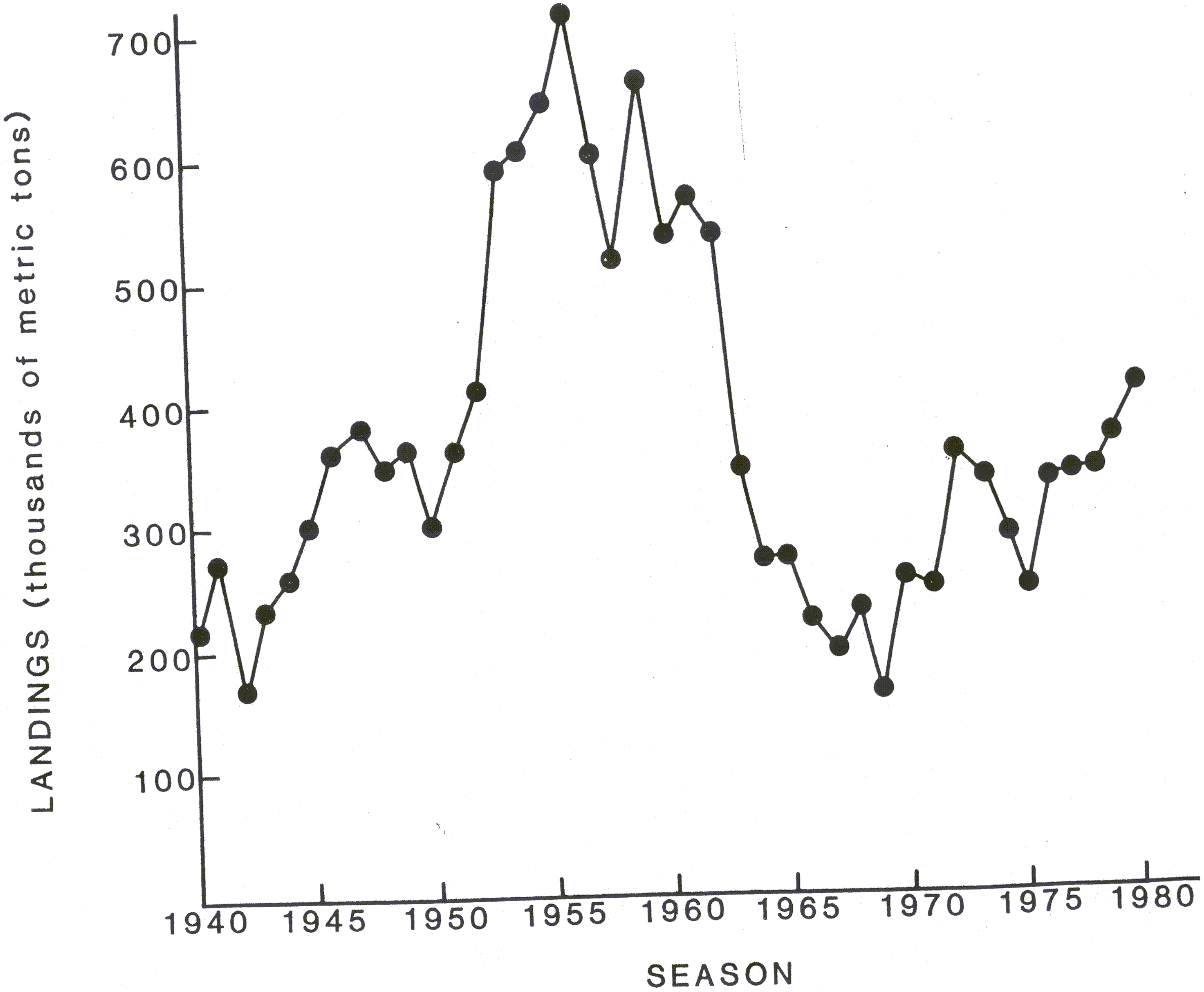


Figure 4.2. Atlantic menhaden purse seine landings, 1940-1980.

and increased by about 18% in 1980 (401,500 MT). The figures in Table 1.1 show the great range of fluctuations in landings for each major area over the years. The relative importance of the different areas is also apparent; recent catches from the north and mid-Atlantic areas and the North Carolina Fall fishery contribute a much smaller portion of the total than they did prior to the mid-1960s. The Cheapeake Bay fishery (actual landings combined with mid-Atlantic landings to protect individual company data) dominates the industry today. Landings in the south Atlantic area have been most consistent over the years, although there have been significant fluctuations (Figure 4.3).

2. Landings of Atlantic Menhaden by Other Gear - Reported landings data by gear (from NMFS) show that during 1969-74, purse seine landings accounted for an average of 95% of the total catch of Atlantic menhaden. Pound nets were second in importance (averaging 4%) principally in Chesapeake Bay and New Jersey. Other gears were gill nets and haul seines. Catches by purse seine obviously account for an overwhelming portion of the reported landings of Atlantic menhaden, but pound nets might make a fair impact on the resource in selected circumstances.

3. Other Sources of Mortality - In addition to being harvested by man as described above, Atlantic menhaden are one of most important prey species along the Atlantic coast of the United States. Menhaden are eaten by bluefish, striped bass, and many other fishes (see Section 1C).

Millions of menhaden sometime die in a single fish kill; in late December 1978, an estimated 57 million menhaden washed ashore along a 27-mile stretch of ocean beach in northern North Carolina; kills in the hundreds of millions have been reported in Chesapeake Bay and New Jersey. Frequently, no causes can be found for these mortalities, although a virus has recently been implicated in Chesapeake Bay mortalities (Stephens et al. 1980). Records from a single nuclear power plant estimated that more than 10,655,000 individual Atlantic menhaden were trapped on its intake screens during an 8-month period in 1978. Data on numbers of eggs and larvae which were killed going through the plant are not yet available. Virtually all intake pipes located in Atlantic estuaries between southern New England and central Florida probably contribute to the mortality of Atlantic menhaden.

Menhaden often form an important segment of the bycatch in trawl fisheries for finfish and shrimp. For example, menhaden contributed 10.3% of the bycatch in South Carolina (Keiser 1976) and 7% in Georgia (Knowlton 1972).

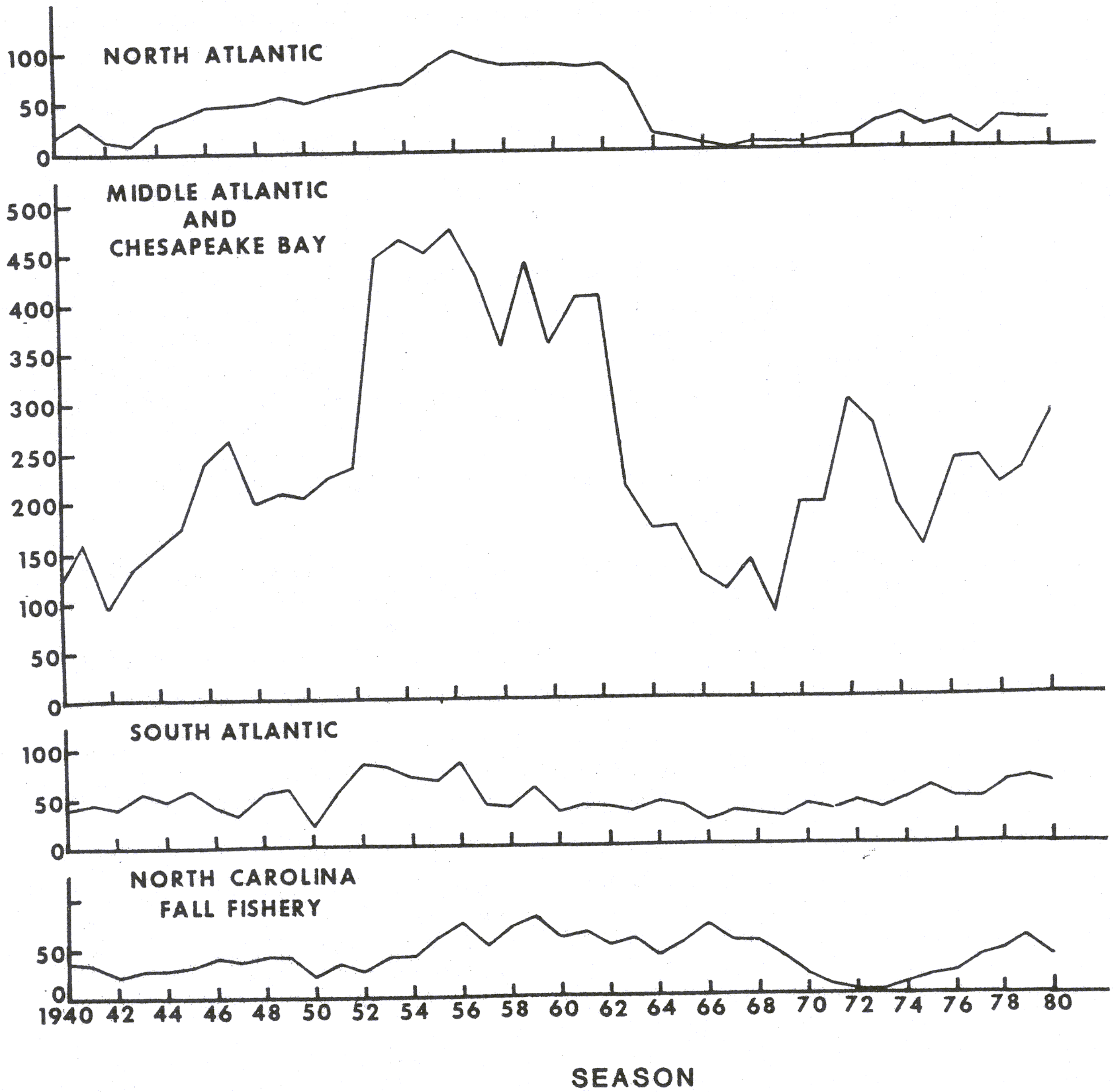


Figure 4.3. Atlantic menhaden purse seine landings by area, 1940-1980 seasons.

From the above discussion it is obvious that little information is available on mortality factors affecting Atlantic menhaden other than the purse seine fishery. Investigations in this area should help elucidate the role of the purse seine fishery as a cause of Atlantic menhaden mortality.

SECTION 5. DESCRIPTION OF THE ECONOMIC CHARACTERISTICS OF THE FISHERY

A. Domestic Harvesting Sector

In 1980 only three small processing plants in the New England area, two in Maine and one in Massachusetts, reported menhaden landings by 5 vessels (Table 1.2). These plants operate primarily on offal from the food fish industry and other industrial fish. Menhaden received and processed are usually from the incidental catch of other fisheries. Seasonally, however, if menhaden are plentiful or food fish are scarce, fishermen will fish specifically for menhaden. The New England boats are fewer and smaller than the conventional menhaden purse seine vessels. Less than ten percent of the Atlantic menhaden catch is landed in New England.

There are six companies from New Jersey through Florida that have menhaden purse seine vessels and processing plants devoted to the catching of menhaden for reduction to fish meal, fish oil and fish solubles.

These companies, in 1980, collectively operated 46 menhaden vessels for a full season and landed fish at 8 reduction plants located in the States of New Jersey, Virginia, North Carolina and Florida. They accounted for 90% of all the Atlantic Menhaden landed for reduction purposes. In contrast to those in the New England fishery, these companies own and operate their own fishing vessels. The National Fish Meal and Oil Association, in 1979, estimated the replacement cost of the processing plants to be $35 million, not including the value of the sites. The replacement value of the fishing vessels and fishing gear was estimated at $62.5 million.

The harvesting and processing of fish is an integrated operation as practiced by the major menhaden companies today. Therefore, meaningful ex-vessel values can only be obtained from company records which are not available for public examination.

Review of a practice employed prior to vertical corporate integration of the menhaden industry may suggest a possible method of approximating ex-vessel values. Prior to 1955, there were several individuals and companies that owned and operated menhaden vessels. The vessel owners sold their fish catch to companies that owned menhaden processing plants, thereby augmenting the catch of the processing companies' vessels. Over the years, the "independent" operators' vessels were purchased by the processing companies. Thus, today most of the menhaden fishing vessels are owned and operated by the processing companies.

The only precedents for establishing an ex-vessel price were the arrangements negotiated by the independent boat owners with the processing companies. The processing plant would, by contract, agree to receive the fish from the owner's boat for the ensuing season. The standard agreement was to pay the boat owner 60% of the gross value of the fish products produced from the fish that were landed by the independent boat. (The yields of oil, meal and solubles produced were the averages from all of the fish landed at the plant). The gross value of products was the actual selling price of the total season catch, less freight, brokerage, bags and other costs of sales. Independent boat owners normally got periodic cash advances for fish landed to cover current labor and operating costs. A final settlement for the independent boat owner's share of the catch would be made when all of the season's products had been shipped and sold. Some of the menhaden companies today use the 60% of gross value as boat income for internal accounting.

In the New England area, the processing companies anticipate the market values of the fish products for the season. Then, using a formula similar to the one described above, they negotiate an ex-vessel price with the boat owners that will apply to fish landed during that season.

Some menhaden are sold for crab bait and as bait for sport fishermen. The quantity and value of menhaden used for these purposes is not known at present because there is no uniform system of reporting such landings. (The National Marine Fisheries Service collects data on daily landings from each vessel in the menhaden purse seine industry but it does not collect similar data from other sources.) Most of the menhaden sold for bait are from the incidental catch of other fisheries. However, it is reported that a directed fishery for menhaden to be sold for bait exists in some areas.

Most of the menhaden vessels operating prior to 1955 were wooden vessels built before World War II and had been designed specifically for menhaden fishing. Decommissioned Navy mine sweepers (twin screw, wooden vessels, built to Navy specifications) became available after World War II. Because of the large supply, the hulls were inexpensive and could be economically modified and converted to menhaden fishing vessels. In the 1950s the approximate cost of converting a mine sweeper hull to a menhaden fishing vessel was $300,000. A few years later these vessels were repowered with modern marine diesel engines for about $100,000 per vessel.

The recent trend has been to replace the aging converted wooden mine sweepers with steel vessels that can accommodate refrigerated fish holds. Some of these steel boats were specifically designed and built as refrigerated menhaden vessels. Decommissioned military vessels have also been converted to menhaden vessels with refrigerated holds. The typical modern vessel can carry more than 500 short tons of fish in refrigerated holds. The cost of converting an ex-military vessel or building a new refrigerated menhaden vessel is approximately $2 million. The cost of operating and maintaining the modern vessel is about three times greater than that of a converted mine sweeper, because of the larger engines, refrigeration and auxiliary equipment.

Each company projects their estimates of fish catch, product yields and values for a season to arrive at an estimated gross income. Knowing the fixed costs, they prepare detailed estimates of processing and fishing costs to obtain an estimated total of fixed and variable costs. With these data, company personnel make economic judgments relating to the estimated production efficiency of the various vessels. Such projections include a company appraisal of each vessel's operating and maintenance costs and expertise of captain and crew available. Each company maintains detailed records of costs of vessel operations and records relating to the catching skills of captains and their crew. Thereby, they can make knowledgeable decisions about the impact of each vessel on the profit estimation.

B. Domestic Processing Sector

1. **Description of Processing** - (See Figure 5.1) The menhaden industry produces three major products - fish meal, fish oil and condensed fish solubles. In addition, a few specialized products are produced by some processors. Whole fish are processed promptly after unloading from the holds of the boats. The fish are first cooked in a continuous steam heated cooker. The cooked fish are pressed in a screw type press to remove most of the fish oil, body liquors and process water.

The press cake, or solids, composed of the cooked flesh and bone of the fish, is dried to approximately 10% moisture and treated with an anti-oxidant. This "fish scrap" is held in storage for a short period of time and then ground and sold as menhaden fish meal. Menhaden meal (as described by the American Feed Manufacturers Association's Buyer's Guide) contains a minimum of 60% protein, 10% fat, approximately 20% minerals and 10% moisture.

The liquid from the pressing operation (press liquor) is passed through screens or decanters (centrifugal separators) to remove suspended solids. The solids are combined with the press cake. The clarified press liquor is pumped to centrifuges for removal of the fish oil from the water product of the process.

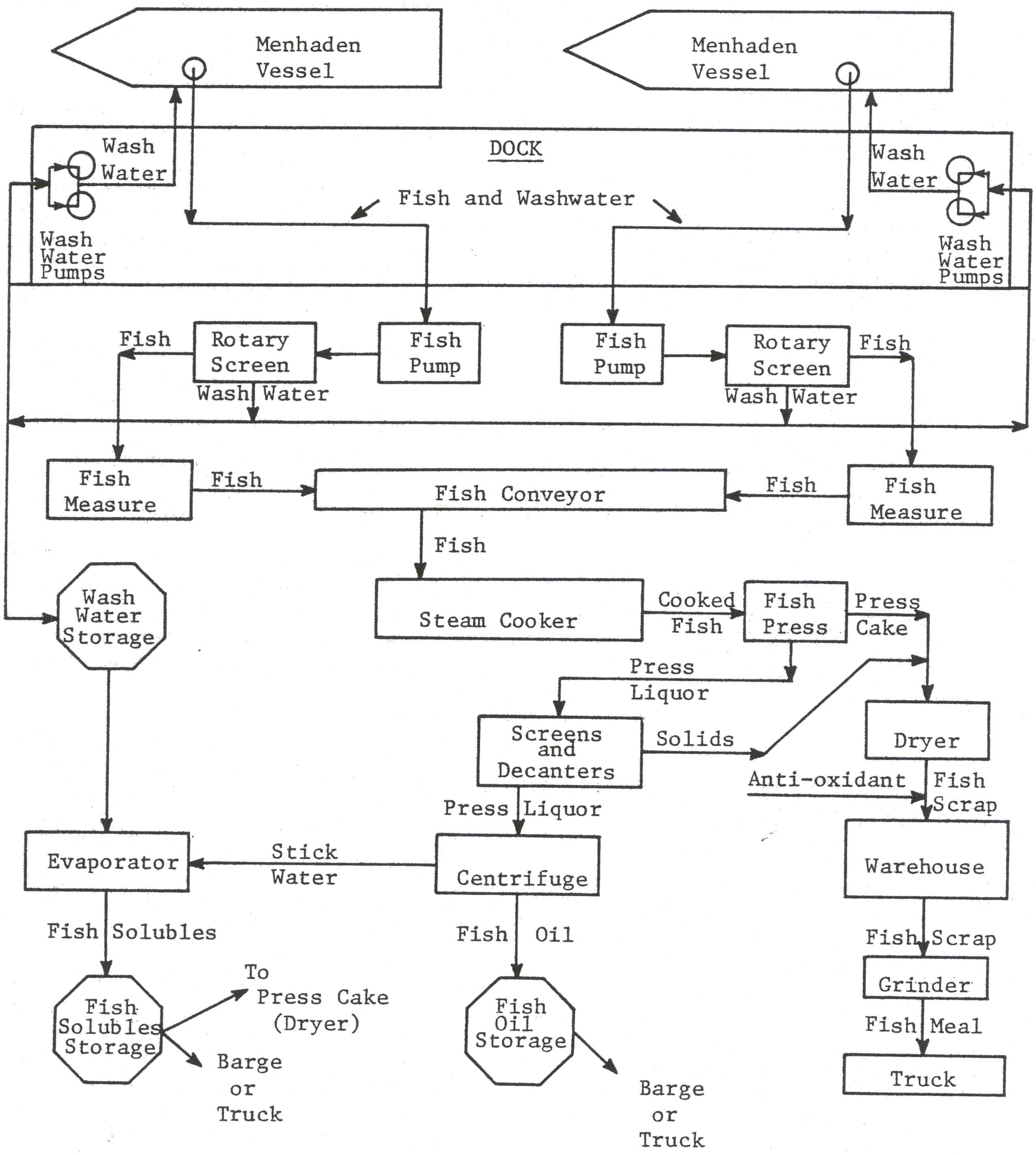


Figure 5.1. Schematic Diagram of a Menhaden Fish Processing Plant - 1980.

The clarified press liquor, after removal of oil, is referred to as stickwater. This liquid contains about 92% water and 8% dissolved or finely divided solids composed of residual fat, hydrolized protein, and minerals leached from the bones of the fish during processing. Fish unloading water (wash water) and plant wash up water is added to the stickwater. Stickwater is evaporated to increase the solids content from an initial 8% to 50% in a multi-effect evaporator. The product, condensed fish solubles, has a molasses-like consistency and contains 50% water and approximately 30% protein, 10% fat and 10% minerals. The solubles can be sold as a liquid feed ingredient to the feed trade or they can be added back to the press cake and dried to produce "full fish meal" (fish meal with solubles added).

2. Description of Products - Menhaden meal is a valuable ingredient for poultry and livestock feeds. It contains high levels of lysine and methionine which are essential amino acids required for rapid growth and development of poultry and swine. The fat content contributes to the metabolizable energy (caloric content) of the feed ration. The calcium, phosphorous, selenium, sulfur and trace minerals contribute to the nutritional requirements of the designed feed formula.

The chicken (particularly, broiler) industry is the largest user of menhaden fish meal, followed by the turkey and swine industries. Aquaculture, an expanding industry, has recently demonstrated an increased demand for fish meal. Some formulators design feed rations containing 40% fish meal for catfish, trout and shrimp (as this industry grows, so will the demand for fish meal).

Today, most of the feed formulations are determined by computer programs designed to derive a "least cost feed formula." The nutritionist prepares a matrix for the computer of the nutritional requirements for the animal to be fed. For example, in the broiler industry a "starter feed" is designed as the food required for a chick until it is about three weeks old. A "grower feed" is designed to supply the nutritional requirements for the bird from two to six weeks of age; and a "finisher feed" is fed thereafter until the bird reaches marketing weight or age. This matrix describes the optimum nutritional composition requirements of the feed in terms of total protein, various amino acids, minerals, vitamins and energy. Knowing the total daily feed intake per bird, all of the nutrients and minerals required for maximum growth and development can be supplied. The formulator prepares computer cards for each feed ingredient available. Each card contains detailed composition of the nutritive qualities of each ingredient. A second set of computer cards is prepared for each ingredient showing the current delivered cost. Using the data from these three sources (nutritional requirements, available feed ingredients, and price), the computer prints out a formula showing the percentage of each feed ingredient required to produce a ration that meets the nutritionist's requirements at the least expensive cost per ton of feed.

Some nutritionists believe that fish meal contains an "unidentified growth factor" (sometimes called "fish factor"). This "factor" is related to observations that fish meal can contribute to the weight gain or growth of a chicken at a rate far greater than that indiated by the chemical composition of fish meal. These nutritionists may "lock in" a minimum requirement of 1 1/2% to 2% fish meal in their computer for their formula so that almost regardless of market prices, the "minimum" fish meal will be used. Others will subtract several dollars a ton from the quoted fish meal price used in the computations to allow for the estimated "fish factor" value.

Nutritionists do not uniformly agree on the preferred matrix for a specific ration or on the nutritional qualities of the various ingredients. Also, some feed ingredients are more available or less expensive in one area of the country compared to another. For these reasons, the ingredient composition of a specific feed can vary from company to company or area to area.

Ingredients commonly used in compounding feeds for poultry and swine include corn, soybean meal, fish meal, meat and bone meal, poultry by-product meal, bakery by-product meal, corn gluten meal, fat, phosphate, lime, salt and synthetic amino acids. Only two of these ingredients, corn and soybean meal, are traded as "futures options" on the Chicago Board of Trade. The market values of the others are determined daily, depending on supply and demand for the particular ingredient.

The relative market values of the ingredients adjusted by the computer for nutritional factors determine the percentage of fish meal desired in the "least cost formula." If the computer demand for fish meal is high and the fish meal supply is scarce or moderate, the fish meal market price will tend to increase. If the computer demand for fish meal is low and the fish meal is high, the fish meal market price will tend to decrease. Thus, no other single feed ingredient can uniformly be used as an index for estimating a fish meal price.

In 1978, Feedstuffs magazine estimated the annual production of formulated feeds for poultry to be 27.9 million tons and 9.8 million tons for swine, or a total of 37.7 million tons. Had only 1% fish meal been used in these feeds, 377,000 tons of fish meal would have been required. The average United States production of menhaden fish meal, Gulf and Atlantic, is approximately 200,000 tons annually, thus the potential demand for fish meal in the United States is far greater than the domestic supply. Menhaden fish meal represents about 75% of the total U.S. fish meal production.

The average production of menhaden oil in the United States for the years 1975-1977 was 86,000 tons (NMFS 1978, 1979). A little over 16% of this amount (14,250 tons) was produced from Atlantic menhaden. The oil from Atlantic menhaden contains higher proportions of highly unsaturated fatty acids than does the oil from menhaden in the Gulf of Mexico. (Unsaturation is a measurement of the oil's ability to chemically combine with oxygen from the air to form a film or protective coating such as paint or varnish.) This characteristic makes the oil desirable for use in the drying oil or paint industry. Oil from Gulf menhaden is more saturated and is not suitable for a drying oil. Crude menhaden oil, however, must be refined and further processed before it can be used by the paint manufacturer. There are only two companies along the Atlantic Coast that refine fish oil and both are located in the mid-Atlantic area.

The process of refining fish oil is quite costly. There are very few industrial products that can be produced from the oil in the crude stage because of the presence of color bodies, free fatty acids and the solid stearine fraction. To bring crude fish oil into a state where it can be utilized, there are three processing steps: WINTERIZATION, NEUTRALIZATION AND BLEACHING.

WINTERIZATION removes the more saturated fraction and increases the iodine value of the oil. Crude fish oil is cooled in tanks in a refrigerated room. The oil is agitated intermittently with air jets and cooled to 40°F. It is then pumped to a filter press where the two oil fractions are separated (liquid and solid at 40°F). The solid fraction, known as stearine, has lower value. Stearine may be melted and sold a crude stearine or further refined. The liquid fraction of the cooled oil can be sold "as is" but it is normally processed further.

NEUTRALIZATION involves alkali refining to remove free fatty acids and some color bodies. Oil is pumped through an in-line mixer where sodium hydroxide is added. The sodium hydroxide reacts with free fatty acids to form a soap that is insoluble in the neutralized oil. This mixture is pumped to a centrifuge which separates soap from the oil. The soap can be sold as an energy ingredient for animal feeds. The oil is pumped to polishing centrifuges where water is mixed with the oil to wash out the final traces of soap.

BLEACHING involves the adsorption of color bodies in the oil by the addition of activated or bleaching clays. The clay is mixed for twenty minutes in oil which was heated to 180°F. The mixture is pumped through filter presses where the clay with the adsorbed color bodies is removed from the oil. The clay is disposed of as waste. The bleached oil can be used as an intermediate to produce other products.

Hence, using any combination of these three basic processes, multiple intermediate products can be produced from crude fish oil. The selling price of refined fish oil is largely determined by the price of linseed oil and soybean oil which are preferred by paint manufacturers.

Menhaden fish oil has, for many years, been used as an edible oil in Europe. The oil is refined, deodorized and hydrogenated to blend with other fats for cooking oils and margarine. Menhaden oil and other marine oils compete in the European market with palm oil, soybean oil and other vegetable oils. Fish oil is not used as an edible oil in the United States since the Food and Drug Administration has not approved its use. When legislation was passed in the 1940s to permit the manufacture of margarine for domestic consumption, it is alleged that only those vegetable oils from products under the Department of Agriculture's subsidy program were listed as oils suitable for margarine. Obviously, fish oil was not included in that list. The menhaden industry is currently contributing funds to help finance the exhaustive studies that the Food and Drug Administration requires to consider approval of menhaden fish oil for use in edible hydrogenated fat products in the U.S.

The selling price of menhaden fish oil to the European hydrogenator, even after deducting costs of ocean freight, is often higher than the U.S. refiner can afford to pay for the oil, absorb the costs of refining and profitably sell for domestic industrial uses.

There are some domestic users of menhaden oil, other than the paints and varnish industry, but they do not consume a significant quantity of oil. These users would be companies producing fractionated fatty acids for use as plasticizers in the plastic or rubber industries or in the production of marine lubricants.

The average annual production of menhaden fish solubles for the years 1975-1977 was 89,000 tons (NMFS 1978, 1979). Menhaden solubles are used as a liquid feed ingredient for poultry and swine feeds. Almost all of the ingredients used in the feed industry are dry materials like corn, soybean meal and fish meal which can be handled by conveyors and stored in bins. Many feed mills do not have storage tanks, pumping facilities and meters to handle liquids, other than feed fat. There are not many potential buyers for solubles because the high moisture content reduces the nutritional concentration. Some nutritionists will use up to 4% solubles if they feel the sacrifice due to additional moisture in the feed is more than offset by the presence of the "fish factor" in the solubles.

The turkey industry has a high preference for fish solubles as a feed ingredient due to existing evidence that this product increases fertility and hatchability.

A large market for solubles exists in the Midwest where solubles are dried on carriers, such as soybean meal to be used as an ingredient for swine feed. Solubles produced in the Gulf of Mexico can be shipped to the Midwest by barge. Over the past ten years, the increases in rail freight rates have far exceeded the increases in river barge rates. Thus, today solubles from the Atlantic coast cannot compete, freight wise, with Gulf solubles in the Midwest market.

Some menhaden producers consume a large portion of their solubles by adding it back to their fish meal in the drying process to produce "full meal." Others dry it on a carrier, such as soybean meal, which is sold to the feed industry as a fish meal replacement. One producer devised a process to spray-dry defatted solubles to produce a dry powdery product known as "dried solubles." This is used in the fermentation industry (drugs) and in shrimp feeds. Fish solubles are also exported to Europe for use in poultry and swine feeds.

3. Recovery of Fish Products - The yields of fish meal, oil and solubles can vary by company, area of fishing, time of year, age or size of fish, and from one season to another.

In 1972 a study was conducted to determine the proximate analysis of 413 individual menhaden caught in Chesapeake Bay (Dubrow et al. 1976). Fish of varying lengths and weights were analyzed for moisture, lipid, protein and ash. The data indicated that regardless of size or time of year caught, the fish were composed of 80% moisture plus lipid and 20% protein plus ash. Thus the yield of "full fish meal" containing 10% moisture and 10% fat should be 25% of the weight of the raw fish. The yield of fish oil, according to the data could range from 0 to 15% of the raw fish weight.

The design of the processing plants and level of process control are not identical for all companies. Therefore, some companies can produce more tons of products (less shrink or loss) from the same quantity and class of fish than other companies, because of process efficiency. Also, because the relative markets of the products vary from sale to sale, it is difficult to equate the value of one product to the other in the total value of the fish. But as a guideline only, the fish meal could be 65%, fish oil 20% and the solubles 15% of the gross value of the fish.

C. International Trade in Fish Oil and Fish Meal

Due to the prohibition of using menhaden fish oil in domestic edible products by the Food and Drug Administration, 80 to 90% of the menhaden oil production is exported.

In 1978 exports amounted to approximately 106,600 tons, of which 9,125 tons were exported to Western Hemisphere countries and 97,500 tons to Europe for use in margarine and shortening. The largest purchaser was the Netherlands (~ 20,000 tons).

During 1979 a total of 96,450 tons menhaden fish oil were exported, of which 10,700 tons were shipped to the Western Hemisphere and 85,000 tons to Europe. The largest purchaser was the Netherlands (~ 37,000 tons) followed by the United Kingdom (22,500 tons) and Belgium (8,800 tons). Recently Colombia has been a regular buyer of U.S. menhaden oil.

Menhaden oil in world markets has to compete with Japanese fish oil which is produced from sardines, mackerel, and other species. Japan has annual exports approximating 220,000 tons. In Japan fish oil is sold as a by-product. Menhaden oil on the other hand represents one of the two major products derived from menhaden and contributes a large percentage to the revenue of menhaden processors.

Fish oil in Europe is the cheapest raw material for edible fats. Soybean oil is the nearest competitor, and on occasion, so is palm oil. One major hardener of fats purchases 70 to 75% of the total fish oil trade thus pricing fish oil at his convenience and valuation.

Other competing nations are Norway, Denmark and to a lesser degree Chile, Peru and South Africa. The latter two nations have consumed their own production during the last few years and on occasion have been importers of fish oil.

The world markets are dominated by fish meal exports from Chile, Peru, Norway, Denmark and Iceland. U.S. menhaden fish meal is infrequently exported in any appreciable quantities. Exports take place only when the U.S. market is unduly depressed. During 1978 total exports amounted to 50,700 tons of menhaden meal; approximately 30,000 tons were exported to West Germany and Egypt took about 14,000 tons.

Exports of menhaden fish meal during 1979 were very limited but some production was exported in conjunction with other fish meal types. There is an export movement taking place currently. It is estimated that approximately 40,000 tons menhaden fish meal were exported during 1980. Menhaden producers sell a large portion of their production for export during the time of production and stocks are cleared out prior to beginning of a new season, April 15th. There is little dependency on the export market due to the availability of fish meal from other nations and competing protein meals such as soybean meal, corn gluten feed.

D. Atlantic Menhaden Cost Questionnaire

A confidential questionnaire was submitted to and completed by three firms* which harvest and process Atlantic menhaden. The purpose of the questionnaire was to provide a better understanding of the types of costs incurred by the industry and their relative magnitudes during the 12 month period ending December 31, 1978. Tables and figures present the sum of the responses by the participating firms.

Table 5.1 provides background information which indicates the relative importance of the participating firms in the Atlantic menhaden fishery. These three firms deployed 31 vessels which fished a total of 1004 vessel-weeks in 1978. Their combined production of 960 million "standard fish" or 292,000 metric tons was approximately 86% of the total catch of Atlantic menhaden reported in 1978. The participating firms operate a total of 5 plants in Virginia, North Carolina and New Jersey.

Figures 5.2 and 5.3 and Table 5.2 summarize the total number of employees and their earnings according to job description. The three participaring firms employed 1010 persons during the 1978 fishing season. Approximately 82% of those persons worked on menhaden vessels or in processing plants. This included captains, crewman, production managers and production employees. Other employees worked as spotter pilots, net menders, shore engineers, administrative personnel, etc. Persons employed during the season earned over $11 million. Some employees are salaried, some are paid an hourly wage and others, primarily vessel employees, are paid according to the quantity of the fish landed.

A comparison of season and off-season employment indicates that firms shifted their work force from harvesting and processing during the fishing season to repair and maintenance during the off-season. This provided continuous employment for some employees in an otherwise seasonal fishery. Nevertheless, total employment was reduced to 461 persons during the off-season. Table 5.3 lists the

---

* Seacoast Products, Inc., Standard Products Company, Inc., and Zapata Haynie Corp.

Table 5.1. Vessels deployed, vessel-weeks fished, and catch in 1978 by 3 Atlantic menhaden firms

Total number of vessels fishing:	31
Total vessel weeks fished:	1,004
Calendar weeks fished this season:	30
Calendar weeks this off-season:	22
Combined catch	960 million standard fish

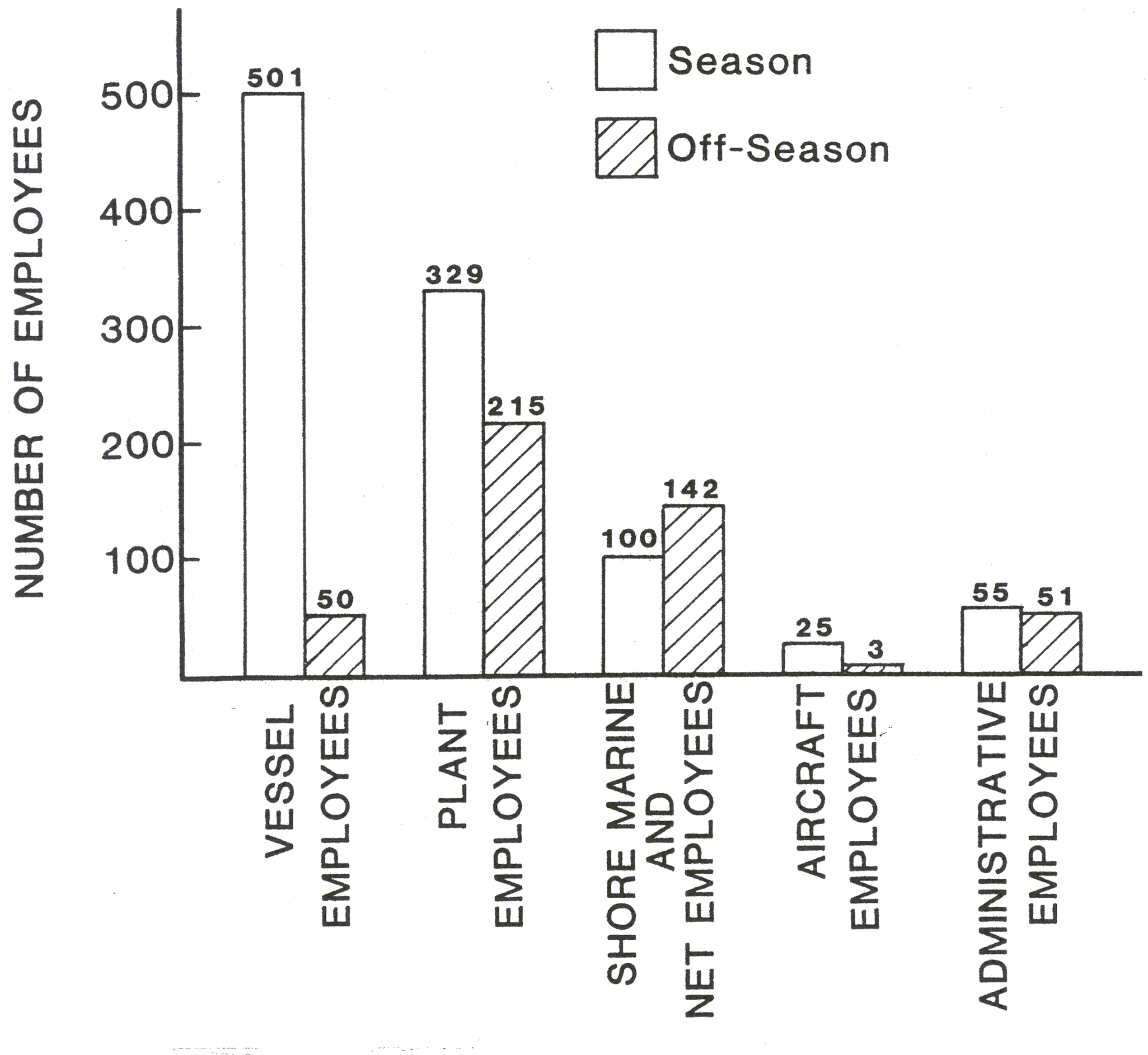


Figure 5.2. Number of Employees by Work Category. (Source: Table 5.2)

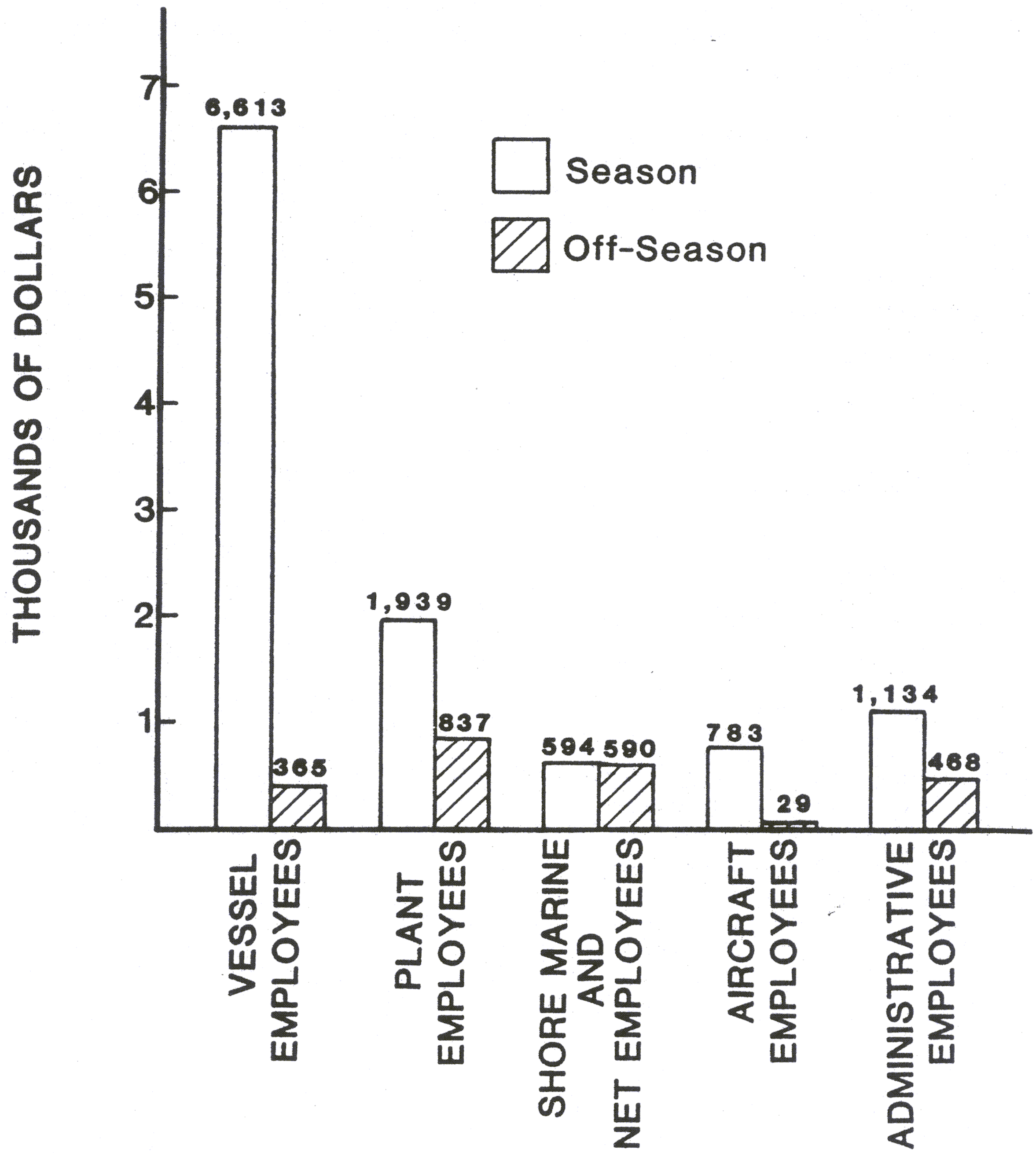


Figure 5.3. Gross Wages Earned by Employees of 3 Atlantic Menhaden Firms During 1978. (Source: Table 5.2)

Table 5.2. Employees and wages by work category (Staff requirements (number of employees) used in each of the following areas of operation during the fishing season and during the off-season, and the amount of their earnings).

	SEASON			OFF-SEASON		
	Number salaried	Number fish catch of hourly	Gross wages	Number salaried	Number hourly	Gross wages
1. Vessel employees	0	501	$6,613,000	0	50	$365,000
2. Aircraft employees	20	5	783,000	2	1	29,000
3. Shore marine & net	10	90	594,000	10	132	590,000
4. Plant employees	20	309	1,939,000	18	197	837,000
5. Administrative	39	16	1,134,000	37	14	468,000
6. Other	0	0	0	0	0	0
TOTAL EMPLOYEES, ETC:	89	921	$11,063,000	67	394	$2,289,000

During season:

Total salried:	89
Total fish catch or hourly:	921
TOTAL:	1,010

During off-season:

Total salaried:	67
Total hourly:	394
TOTAL;	461

Table 5.3. Numbers of employees laid off at the end of the 1978 fishing season by 3 Atlantic menhaden firms (The number of employees in each category that are routinely laid off at the end of the fish processing season each year).

1. Vessel employees	453
2. Aircraft employees	20
3. Shore marine & net	0
4. Plant employees	114
5. Administrative	4
6. Other	0
TOTAL:	591

Table 5.4. State of residence for employees of 3 Atlantic menhaden firms based on the staffing levels during the 1978 fishing season.

State	Number of Employees
Virginia	747
North Carolina	171
South Carolina	2
Maryland	3
New Jersey	85
Louisiana	2
TOTAL:	1,010

Table 5.5. Number of employees per vessels. Number of employees that would be laid off if 3 Atlantic menhaden firms each reduced their fleet by one vessel.

1. Vessel employees	49
2. Aircraft employees	2
3. Shore marine & net	1
4. Plant employees	1
5. Administrative	0
6. Other	0
TOTAL:	53

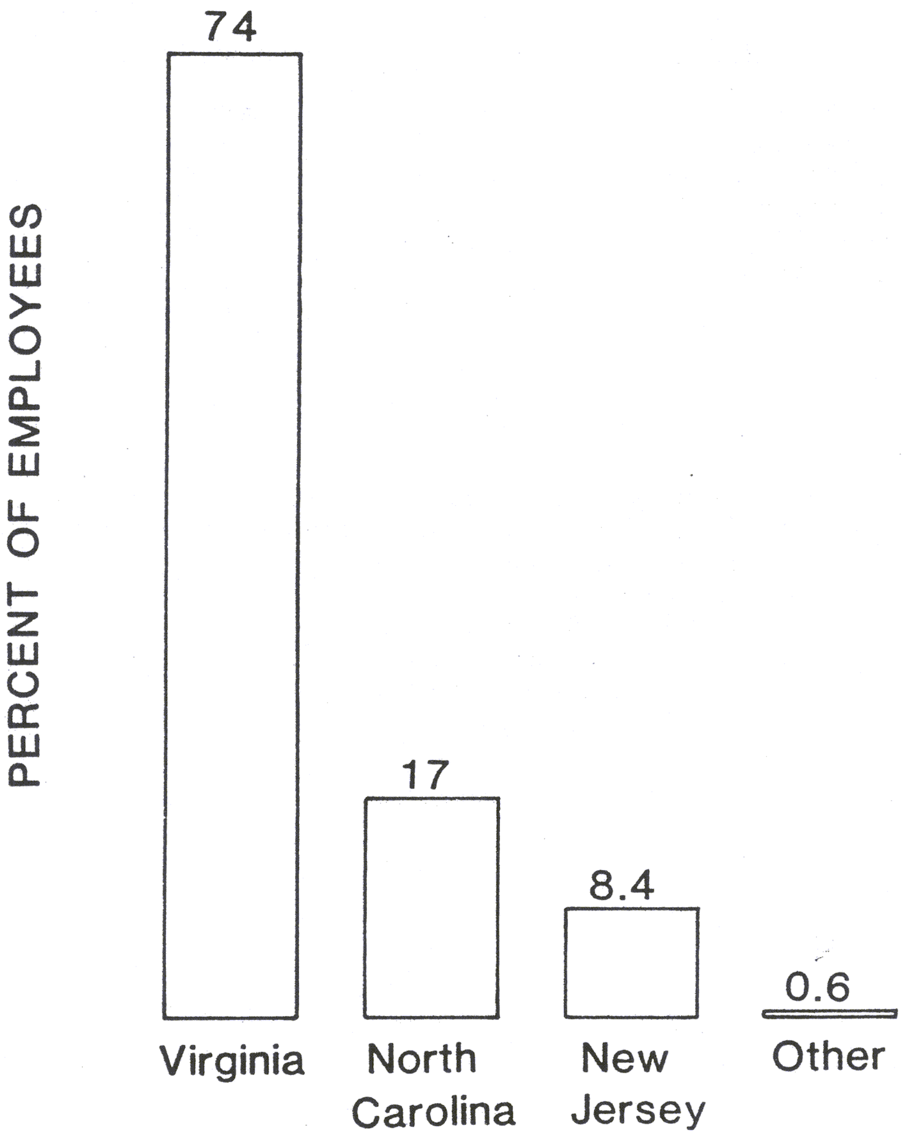


Figure 5.4. State of Residence for 1010 Employees of 3 Atlantic Menhaden Firms During the 1978 Fishing Season. (Source: Table 5.4)

Table 5.6. Aggregate Budget for 3 Atlantic menhaden firms (12-month period ending December 31, 1978) in thousands of dollars ($000)

	SEASON COST			OFF SEASON	YEAR
	Fixed	Variable	Total	Total	TOTAL
Catching Cost					
Labor	$3,245	$4,745	$7,990	$ 984	$8,974
Benefits	791	904	1,695	148	1,843
Energy	828	553	1,381	50	1,431
Repair & Maintenance Materials	675	1,395	2,070	1,307	3,377
Net Materials	181	210	391	126	517
Depreciation	1,414	0	1,414	464	1,878
Other	229	114	343	155	498
TOTAL	$7,363	$7,921	$15,284	$3,234	$18,518
Plant Cost					
Labor	$1,343	$ 596	$ 1,939	$1,837	$ 2,776
Benefits	438	122	560	275	835
Energy	395	2,885	3,280	152	3,432
Repair & Maintenance Materials	978	518	1,496	1,189	2,685
Depreciation	690	0	690	240	930
Other	341	164	505	304	809
TOTAL	$4,185	$4,285	$ 8,470	$2,997	$11,467
Administration					
Labor	$1,029	$ 105	$ 1,134	$ 468	$ 1,602
Benefits	285	29	314	123	437
Other	375	20	395	230	625
TOTAL	$1,689	$ 154	$ 1,843	$ 821	$ 2,664
GRAND TOTAL	$13,237	$12,360	$25,597	$7,052	$32,649

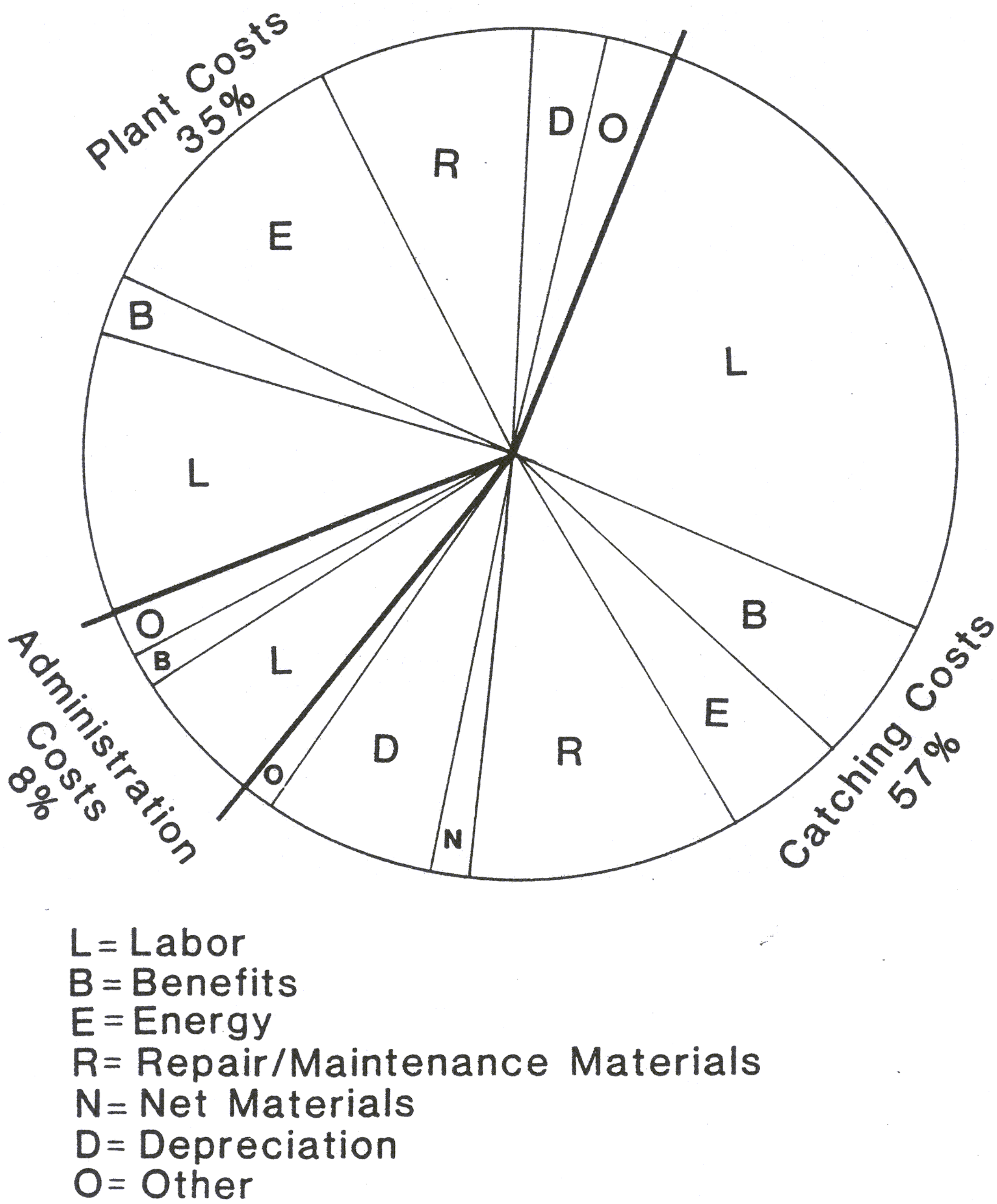


Figure 5.5. Distribution of Total Costs for 3 Atlantic Menhaden Firms During 1978. (Source: Table 5.6)

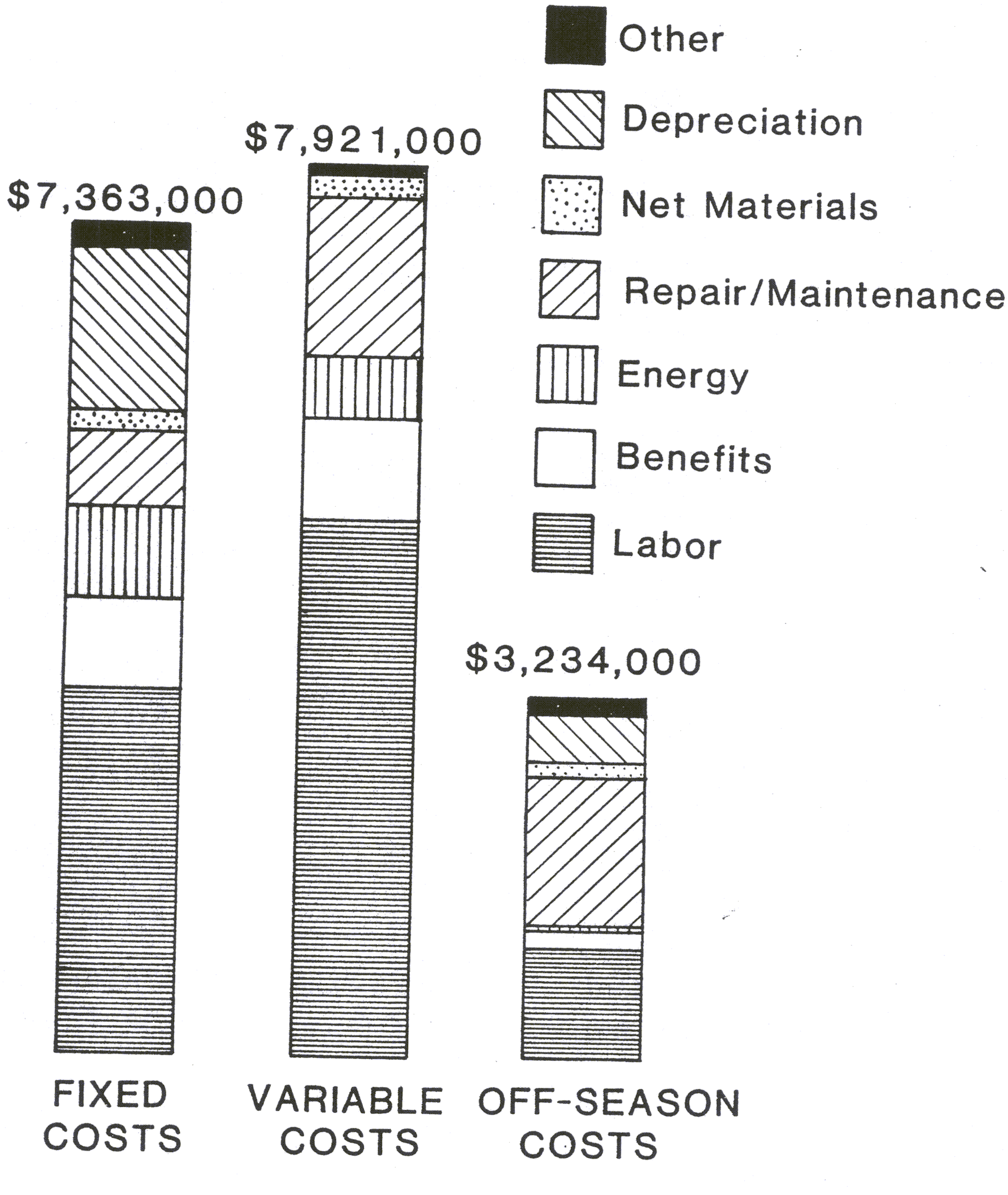


Figure 5.6. Total Catching Costs by 3 Atlantic Menhaden Firms During 1978. (Source: Table 5.6)

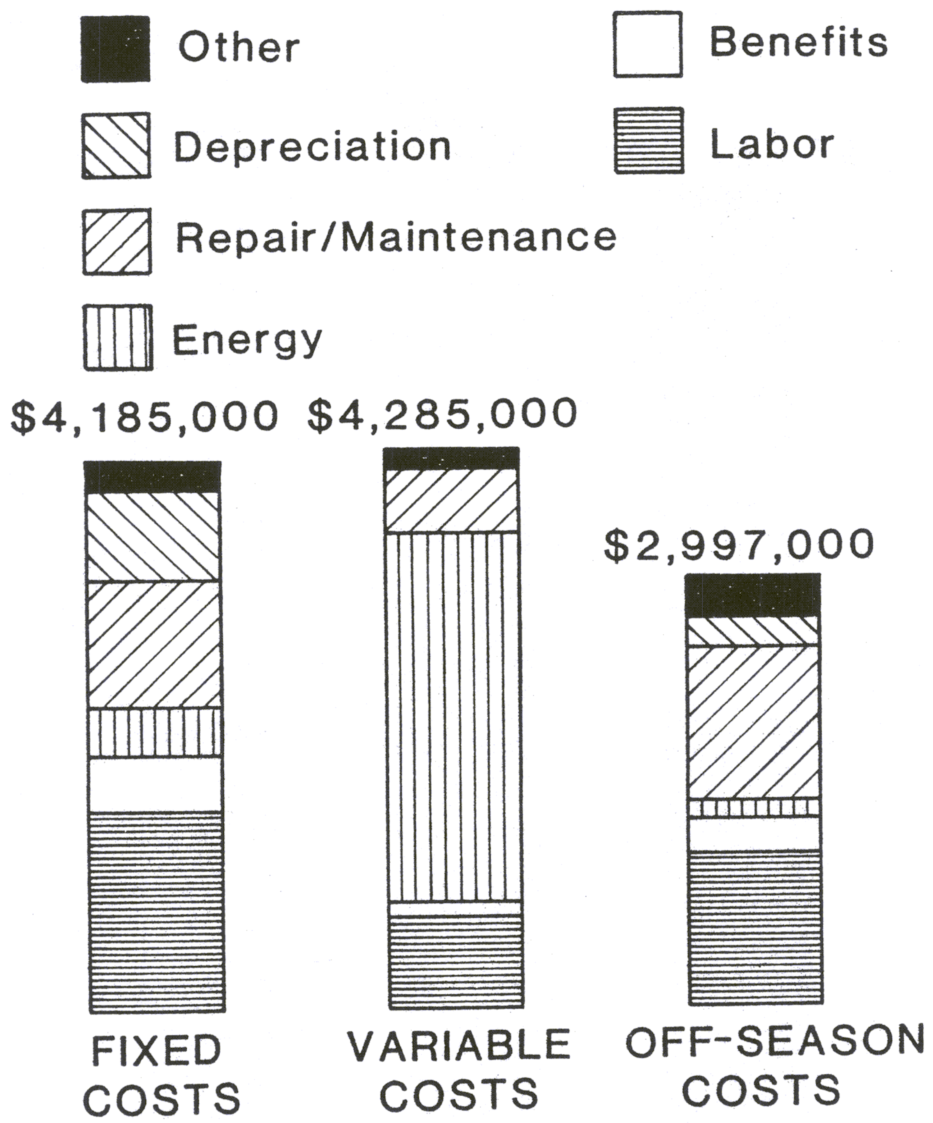


Figure 5.7. Total Plant Costs by 3 Atlantic Menhaden Firms During 1978. (Source: Table 5.6)

number of persons in each category who were laid-off at the end of the 1978 fishing season. Only the shore marine and net work force was increased (by 42 persons). Total employment declined by 549 or 54% during the off-season. Persons employed during the off-season earned approximately $2.3 million.

Table 5.4 and Figure 5.4 indicate the state of residence for persons employed during the 1978 fishing season. Nearly three-fourths of the employees resided in Virginia although only two of the five plants are located there.

Table 5.5 presents the total number of employees that would be laid-off if each of the three firms reduced its fleet by one vessel. Most of those laid-off would be vessel employees. The normal number of crew is 16 or 17 members per vessel. This includes the captain, mate, pilot, engineer and a dozen crewmen. Some vessels employ a cook.

Table 5.6 and Figures 5.5-5.7 summarized the harvesting, processing and administrative costs incurred by the three participating firms. Total costs incurred by all three firms were $32.6 million. Costs incurred during the fishing season amounted to $25.6 million. Fixed costs accounted for nearly 52% of this $25.6 million. Off-season costs amount to $7.1 million.

Seven general cost categories and their relative share of total costs are identified as follows: labor (40.9% of total costs), benefits (9.5%), energy (14.9%), materials for maintenance and repair (18.6%), net materials (1.6%), depreciation (8.6%) and miscellaneous expenses (5.9%). Labor costs and the associated benefits accounted for over 50% of total costs. The cost of materials for maintenance and repair of vessel and plant equipment was the largest off-season cost incurred by the participating firms.

Costs associated with harvesting menhaden accounted for 57% of total costs. Labor costs and benefits represented 71% of variable harvesting costs during the fishing season. Materials for vessel and equipment repair represented nearly 18% of variable harvesting costs. Energy costs accounted for 7% of variable harvesting costs in 1978. Since then fuel costs have increased by 2 1/2 times as of mid 1980. Fixed costs amounted to 48% of harvesting costs during the 1978 fishing season.

Plant costs accounted for 35% of the total costs. Among variable plant costs, energy was the largest cost element.

Energy accounted for approximately 67% of variable plant costs. Labor and benefits represented 17% of variable plant costs. Fixed costs comprised 49% of plant costs during the 1978 fishing season.

Total energy costs were $4.8 million in 1978. Of this amount, $3.4 million were plant costs. This accounted for over 28% of all plant costs. The participating firms incurred $1.4 million for energy in the harvesting sector. This represented approximately 8% of all harvesting costs. This suggests that when challenged by rapidly rising energy prices in 1979 and subsequent years, the potential to economize on energy expenditures is greater in the processing than harvesting sector.

Reductions in the volume of fish caught and processed induces management to seek ways to reduce costs. During the fishing season variable costs can be reduced. Management can also economize on off season costs by deferring maintenance and repair expenses to a future year. Expected reductions in off-season costs due to various percentage reductions in the number of fish processed are shown in Figures 5.8 and Table 5.7. Figure 5.8 slopes downward because greater percentage reductions in the fish catch result in larger expected reductions in off season costs due primarily to off-season deferrments.

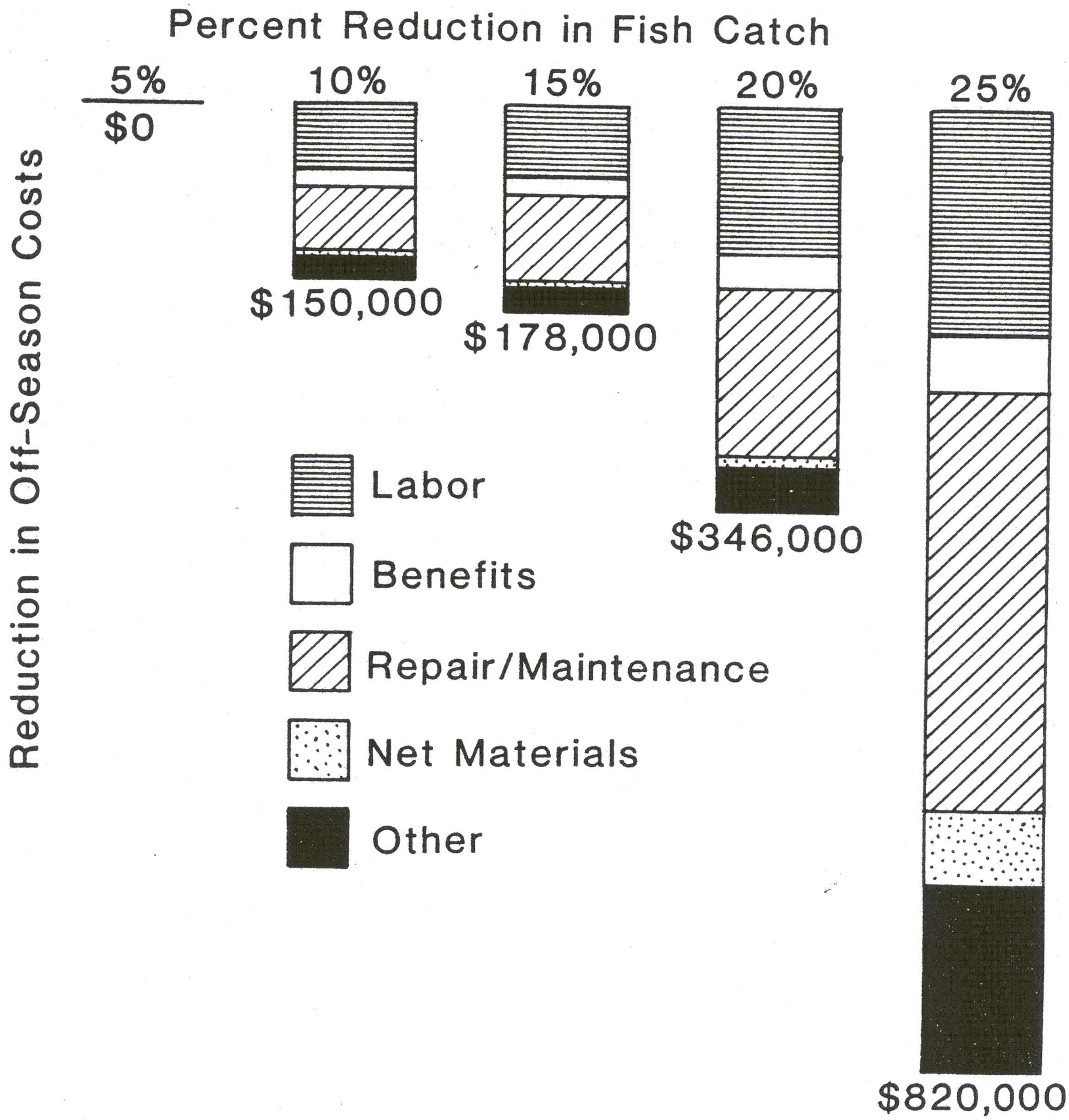


Figure 5.8. Total Anticipated Reduction in Plant and Vessel Off-Season Costs for 3 Atlantic Menhaden Firms. (Source: Table 5.7).

Table 5.7 Total anticipated reduction in plant and vessel off-season costs for 3 Atlantic menhaden firms (It is assumed that substantial reductions in the number of fish processed during a fiscal year will reduce the amount of money that would be spent during the off-season of that fiscal year. The effect on plant and vessel off-season dollar costs of various percentage reductions in fish catch are listed below. It is assumed that there is no change in the number of weeks in the off-season and that there is no reduction in the number of vessels which fished).

	Percent reduction in fish catch				
	5%	10%	15%	20%	25%
Labor	$ 0	$ 57,000	$ 63,000	$125,000	$193,000
Benefits	0	14,000	15,000	31,000	47,000
Energy	0	0	0	0	0
Repair/ Maintenance Materials	0	55,000	76,000	142,000	358,000
Net Materials	0	5,000	5,000	10,000	65,000
Other	0	19,000	19,000	38,000	157,000
TOTAL:	$ 0	$150,000	$178,000	$346,000	$820,000

SECTION 6. DESCRIPTION OF THE BUSINESSES, MARKETS, AND ORGANIZATIONS ASSOCIATED WITH THE FISHERY

A. Marketing

Until the end of World War II, all of the fish products were sold through brokers. At that time, there were very few customers for fish meal but they were large companies and used large quantities of fish meal each year. The feed industry, particularly the poultry feed industry, expanded rapidly in the decade following World War II. This expansion created many new but smaller feed companies throughout the Midwest as well as along the Atlantic and Gulf Coasts. Menhaden companies observed that they were using the same brokers to distribute their products to a rapidly increasing number of customers and reasoned that to fully exploit the expanding market they should have their own sales organizations. The largest menhaden producer started this trend shortly after World War II. A second producing company formed a sales group in 1956 and a third company in 1957. Today, each menhaden company has its own sales organization, and each sells their fish meal directly to consumers or to broker-jobbers who in turn sell to the feed industry.

In 1957, menhaden companies experimented with anti-oxidants to retard heating of the fish meal in storage. Fish meal contains about 10% fish oil which will combine with oxygen from the air, causing the meal to heat. However, a properly administered anti-oxidant will retard the rate of oxidation of the oil in the meal and minimize the danger of serious heating when the meal is stored in bulk.

Stabilizing the storage temperature of fish meal with anti-oxidants was an innovation which revolutionized the storage and distribution of fish meal. Formerly, fish meal producers' warehouses had only small areas for the bulk storage of newly produced fish meal where it could be turned to release the dryer heat. The warehouse was designed to store palletized bags of fish meal where any heat generated by auto oxidation could be dissipated. Customers' warehouses were similarly designed to store fish meal in bags. With anti-oxidants, fish meal could safely be stored and shipped in bulk. Producers converted the "flat storage" areas of their warehouses to bulk storage and shipments of fish meal were made in bulk, thus saving the cost of bags, bagging and handling. As bulk shipments of fish meal became available, the feed industry was able to receive and handle fish meal with the mechanical system used for all of their bulk ingredients. Today, few feed mills carry more than several days supply of fish meal (or other bulk ingredients). They depend on the supplier and the railroads or trucking companies to deliver the material to their plant as needed. Thus, today, most of the inventory of fish meal is held in the warehouses of the producing companies with their sales departments directing the sale and shipment of the product. The shipments are in units of truckloads or rail carloads (20 tons to 60 tons). Sales contracts may be executed for a single truckload for immediate delivery or they may be for hundreds or several thousands of tons for delivery over an extended period of time. The price may be fixed at the time of sale, or the contract may provide for the buyer and seller to agree on the price on the date of shipment, or periodically throughout the life of the contract.

Fish oil and fish solubles are sold in multiple units of truckload, rail carload or bargeload quantities. It is not unusual for a producer to sell the entire season's production of fish oil for a plant in two or three individual sales.

B. Trade Organizations.

The principal trade organization for the Atlantic menhaden producing companies is the National Fish Meal and Oil Association (NFMOA) which is a division of the National Fisheries Institute (NFI). All of the major menhaden fish meal producers belong to this organization. Almost all of the fish meal brokers and jobbers that trade with menhaden producing companies also are members of the NFMOA and the American Feed Manufacturers Associations, as well as many regional feed producers groups.

SECTION 7. SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES[1]

A. Ethnic Character, Family Structure, and Community Organization

In the early to mid-1800s, the lure of the profitable New England based menhaden fishery drew people from other occupations and fisheries. The labor force at that time consisted largely of Portuguese crews and Yankee managers. However, as the base of menhaden fishing and processing operations moved south in the 1870's the labor force makeup shifted to crews of southern blacks and southern native born whites in management. To the present day, the ethnic makeup of the industry labor force varies regionally. In New England, where the menhaden vessels are independently owned and separate from the processing sector (other than the processor supplying seines and catch boats), the labor force from the crew level through management is white. In contrast, the vertically integrated firms which operate in the Mid-Atlantic states are supported by a labor force makeup of whites and blacks occupying positions as captains, mates, pilots, engineers, cooks, and deckhands.

Traditionally, southern blacks have been the dominant ethnic group constituting the menhaden crew labor force in the Mid-Atlantic. Southern blacks have found wages and benefits possible from menhaden purse seine fishing higher than alternative occupations (see Table 7.1). Also, whites in the Mid-Atlantic areas traditionally have not participated to any great extent in purse seine crews. Therefore, because of the vessel captains' necessity to enroll crews that possess ability in menhaden fishing, the southern black has been the natural group supplying this labor market.

The geographic and ethnic factors inherent to menhaden purse seining results in a sociologically-diverse occupational work force that stretches from Maine to the Gulf of Mexico made up of over 1,700 people employed in Atlantic menhaden harvesting and processing. In 1978, an estimated 150 of these were employed in the New England fishery in which three processing firms were supplied by eight vessels. Processing personnel are recruited locally and are active in menhaden processing as the seasonal availability of menhaden permits. During the balance of the year the processing sector may concentrate on activities such as herring reduction, reduction of non-fishery products, or may enter foodfish processing. Vessels also are generally manned by local crews and supply the processing plants as the availability of menhaden and other desired species permits.

1/ This summary is based on the work of Liguori (1967), interviews conducted Orbach (1978) and personal communication with NMFS fishery reporting specialists.

Table 7.1 Unemployment Rates, Comparative Weekly Wage Rates, and Total Remuneration Potentials, by Area.

State/County	Total Population	Average Monthly Unemployment Rate 1977	Average Weekly Wages[1] Const.	Man.	T,C, & U	Trade	Menhaden Remuneration Potential by Area (33 Week season/off season)
Virginia							
Northumberland	9,700	13.6[2]	$149	$149	$122	$114	$ 286/110
Lancaster	9,800	15.3	157	142	200	127	
Richmond	6,700	9.9	142	132	232	136	11,540[3]
Westmoreland	13,600	10.3	128	105	219	140	
North Carolina							
Carteret	35,758	6.6	128	156	199	109	161/112
Craven	68,240	4.5	$163	$185	$199	$109	$ 7,428[3]
New Jersey							
Monmouth	492,800	8.0	Not Available				200/100[4] 7,400[3]

1 2nd quarter, 1977

2 1977 data from Virginia Employment Commission

3 yearly remuneration: salary plus unemployment

4 based on 5,200 in a 26-week regular season/weekly unemployment rate (maximum)

The balance of the 1978 labor force included approximately 960 fishermen and 630 processing personnel employed in the Mid-Atlantic area, which is strictly a seasonal operation in New Jersey, Virginia and North Carolina.[1] The majority of these people live in two general areas: Carteret and Craven Counties in North Carolina, and Northumberland, Westmoreland, Lancaster, Richmond, and Matthews Counties (the "Northern Neck," or "Tidewater" area) in Virginia. This residential concentration of the Mid-Atlantic menhaden labor force, the southern black crew dominance previously discussed, and the wide-ranging migratory habits of the Atlantic menhaden result in an intricate and rather specific labor force migratory pattern (Figure 7.1).

With the beginning of the menhaden purse seine fishery in spring, some 50 people migrate from North Carolina to the Northern Neck of Virginia to join the work force of approximately 500 fishermen employed on 22 vessels (361 at any one time) and 400 employed in two processing plants. During the course of the menhaden season, fishing activity expands northward following the menhaden migration pattern. To accommodate this activity up to 110 crew personnel (85 at any one time; 5 boats) migrate from the Northern Neck to work in New Jersey. These crew personnel reside in New Jersey on weekdays but return home on weekends. Also, 65 to 85 processing personnel relocate from the Beaufort/Morehead City area of North Carolina to New Jersey and reside there for the entire season.

As the summer fishery comes to a close and the fall fishery gears up in response to the availability of menhaden, some 50-60 people migrate from the Northern Neck to North Carolina to participate in the fishery out of Beaufort. The total work force represented in the fall fishery consists of approximately 300 crewmen (18 boats) and 150 processing personnel.

In addition to vessel and processing personnel, the Mid-Atlantic fishery employs approximately 29 spotter pilots on either a full or part-time basis. Aircraft are either company-owned or contracted. During the off season in the Mid-Atlantic, considerably fewer personnel are employed by the menhaden companies for maintenance (see Section 5). Limited employment is also possible in boat yards to help on vessel repairs.

B. Age and Educational Profile of Fishermen

Complete and accurate details on the age and educational characteristics for the entire Atlantic menhaden industry are not available at the present time. Results of a survey of employees conducted by Zapata Haynie Corp. for its Virginia plant is considered typical of the industry as a whole (Table 7.2).

1/ The number of employees cited here includes some "turnover" in the labor force.

FIGURE 7.1. Seasonal migratory patterns of the Mid-Atlantic labor force; vessel and processing personnel.

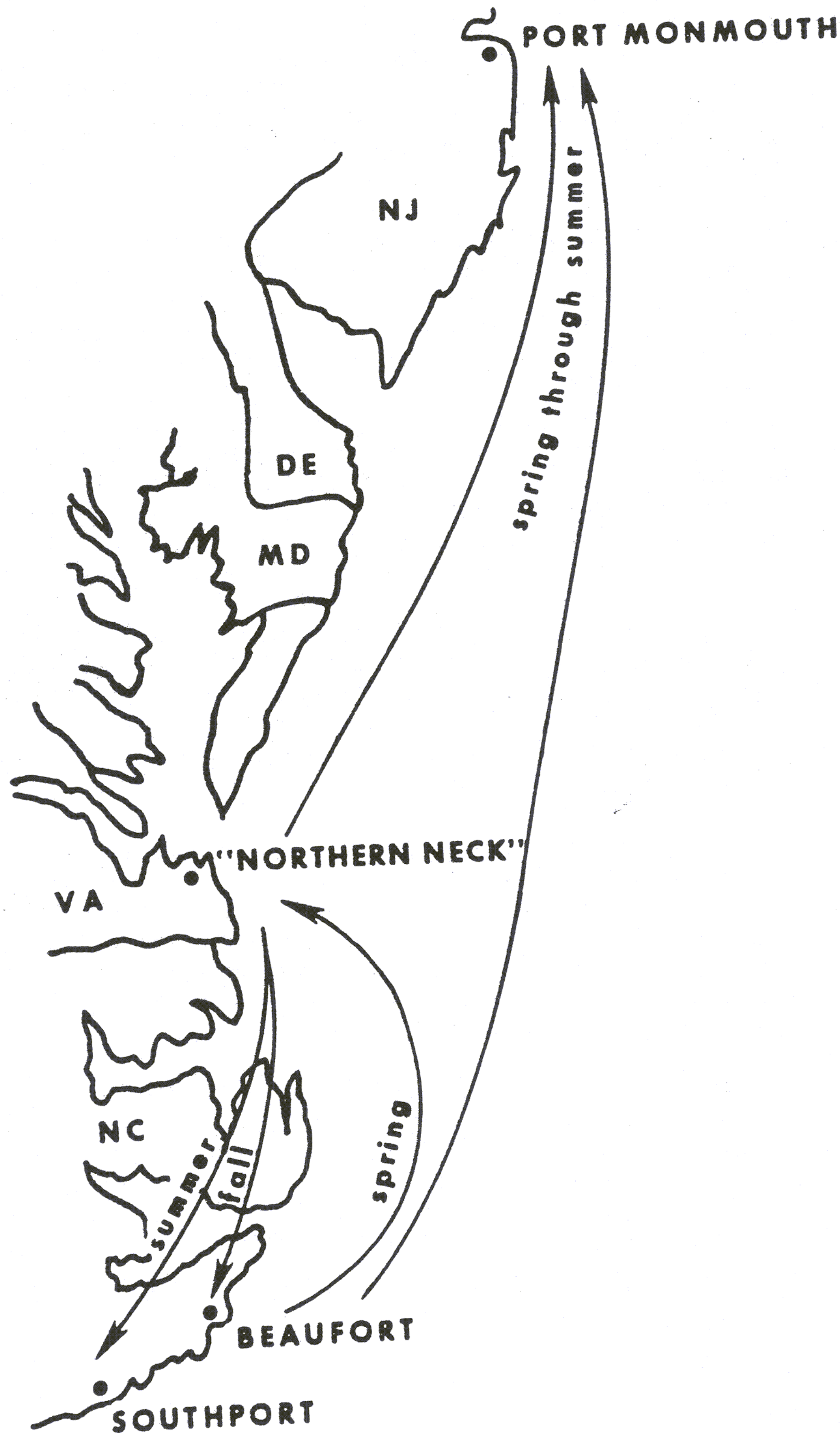


Table 7.2. Age and educational profile of Atlantic menhaden vessel personnel from one company.

	Number	Mean Age	Mean Years Education
Vessel Officers	68	43.3	10.1
Crew members	108	40.2	8.9
Total	176	42.8	9.7

C. Employment, and Economic Dependence on Commercial Fishing and Related Activities

Money appears to be the main impetus, rather that esthetic appeal, that attracts the labor force to menhaden fishing. Although occasionally family tradition has been a factor. At the crew level, participation is based on the fact that one can make relatively large sums of money in a shorter time in menhaden fishing than in alternative shore side occupations.

During the off season the New England processors and vessels may engage in other fishery activities, previously mentioned. However, in the Mid-Atlantic with only seasonal full-scale operation of menhaden firms, most of the labor force goes on unemployment where benefits average around $110 per week. Those who do not enter the unemployment ranks enter shore side endeavors such as timber or pulp-cutting, farming, oyster shucking, or go into other fisheries. These off season activities may contribute to long term commitment to menhaden fishing by some. Monetary incentives such as bonuses for completion of a fishing season are held in higher regard by older fishermen. Regardless, when fishermen find a more profitable alternative to menhaden fishing they are apt to leave the industry.

D. Distribution of Income within the Fishing Communities

In New England, vessels are usually paid on the basis of a preseason contracted price in terms of dockside pounds delivered. At the crew level this is allocated by a typical share system. In the Mid-Atlantic the system is different in that all fishermen are paid either on a volumetric (thousands standard fish) or weight basis.

Mates, pilots, and chief engineers receive a proportionate increase for their more skilled duties. The captains receive even higher amounts and their remuneration rate itself is often on a sliding scale which varies with the amount of fish caught.

Several companies offer bonuses to crewmen who remain with a boat until the end of the season. In addition, a captain may pay a particular crewman more than the established rate, but the additional monies may have to come out of his own pocket.

Some of the companies offer guaranteed minimum payment for 1.4 million fish every two weeks. Several companies offer retirement plans and one offers savings and profit sharing programs to the fishermen.

Information on income potential and occupational alternatives for the fishery is shown in Table 7.1 (information for the New England and Florida fisheries is not available at this time). The yearly income figures assume that the individual works the entire year, taking advantage of all segments of available fishing time. The figures are approximations obtained from interviews with informed individuals. They should not be viewed as actual earned income but as a representation of the potentials for participation and remuneration available to individuals in the various geographical locations.

SECTION 8. DETERMINATION OF OPTIMUM YIELD

A. Specific Management Objectives

The State-Federal Menhaden Sub-board, on November 17, 1976, adopted the following objectives for management and presented them to the Scientific and Statistical Committee (S&S) as a charge:

> To achieve a reliable, predictive capability for the Atlantic menhaden so that harvest may be maintained with confidence at or below the level of maximum sustainable yield (MSY);
>
> To take cognizance of the role of menhaden in the food chain of predatory game fish when determining MSY;
>
> To maximize yield per recruit consonant with the geographic distribution of the resource and historic needs of the fishery;
>
> To encourage maintenance of a stable business climate.

On February 15, 1977, the S&S Committee submitted "A Management Plan for the Atlantic Menhaden (Interim Report)" to the Sub-board. On the basis of that document and subsequent discussions the charge to the S&S Committee was changed to read:

> Develop an MSY, with confidence statement;
>
> Develop an annual quota and fix geographic areas with sub-quotas, for an appropriate 12 month period (menhaden year) to begin in 1978;
>
> Match up harvestable surplus with effort required to take it, for 1977.

After eight S&S Committee meetings at which voluntary management options were developed, the effort was interrupted by a memo from NMFS General Counsel, which suggested that voluntary action by the industry might be in violation of anti-trust laws. Thus frustrated in its search for a management program the S&S Committee requested a meeting with the Sub-board. A meeting was held on July 19 and 20, 1977, and after much discussion a new charge was given to the S&S Committee as follows:

> "To prepare a program for utilization of Atlantic menhaden that is biologically, economically, and sociologically sound and which protects the resource and its users."

This charge constitutes the overall objective of the Atlantic menhaden management program. The S & S Committee believes that it is consistent with the national standards of FCMA and allows the development of long-term and short-term objectives in the program. To further this objective the S&S Committee prepared a list of options as stated in subsection B (below). The Sub-board at its meeting in Philadelphia, Pa. in August 1980 agreed that the stock is in need of management and directed the S&S Committee to further investigate and develop options 2, 5, and 6.

B. Description of Alternatives and Analysis of Beneficial and Adverse Impacts of Potential Management Options

Since it has been generally agreed that the resource is being fully utilized by the U.S. fishery, there is no need to consider foreign catch since foreign allocations would be automatically eliminated under the provisions of the Fisheries Conservation and Management Act of 1976. Therefore, management options each with several variations need only involve the U.S. fishery. It is felt that they are best presented in outline form.

1. No Action (Fishery would be managed under the existing rules and regulations enforced throughout the Atlantic coastal fishery.)

a. Assume stock of menhaden is healthy (at or above MSY)

PROS: (1) Allows industry to operate so that the individual companies can maximize their benefits (full flexibility for industry);

(2) Minimal costs to Nation (administrative).

CONS: (1) Does not generate national attention or moral and financial support for monitoring and stock assessment (false sense of security);

(2) Results in possible reduction of fishing areas due to action by pressure groups without sound biological or economic basis;

(3) May lead to overcapitalization of industry and over-exploitation of resource;

(4) The existing attitude for change within the industry may be dissipated if no action is taken.

DISCUSSION: Since this option assumes the stock is healthy, i.e., composed of a wide range of year classes, and it is generally agreed that this condition does not exist, this cannot be considered a viable option at this time.

b. Assume stock unhealthy (below MSY)

PROS: (1) Allows industry to operate so that the individual can maximize their benefits (full flexibility for industry);

(2) Minimal costs to Nation (administrative).

CONS: (1) May drive the fishery beyond MSY;

(2) May drive the fishery beyond biological break-even point (BBEP);

(3) May result in significant economic problems in industry and other users, secondary social costs, job, income taxes, etc., at the local, state and national level;

(4) Social and political conflicts at all levels of government would be likely;

(5) Ecological replacement likely (niche competitors). Effects upon predator population possible;

(6) Industries' existing attitude for change may be dissipated.

DISCUSSION: Given the assumption that the stock is unhealthy, i.e., not composed of a wide range of year classes, given the "Cons" or the possible consequences of taking the no action option, and given the charge of the Menhaden Sub-board, this is not considered to be a viable option at this time.

2. Number of Vessels and Capacity

PROS: (1) This is a simple approach for obtaining a rough effort limit;

(2) This would be a good starting point even if it affected only the three major companies;

(3) This would be easy to monitor;

(4) This would have the greatest effect in the area of greatest harvest of the resource;

(5) Minimal additional costs to all parties concerned (administrative costs);

(6) This would reduce the chance of possible over-capitalization by industry;

(7) This represents a short-term holding action;

(8) May be adequate to allow harvest at MSY.

CONS: (1) Not all companies are at the same level of harvesting capability relative to the historic record;

(2) A freeze of the fleet size could allow excess harvest, depending upon future determination of MSY.

DISCUSSION: This option might have some beneficial effect on the stock over a long period of time, particularly if we were so fortunate as to realize several dominant year classes. It might not by itself be effective and could waste valuable time if it were implemented by itself. It might be ineffective or misleading if smaller than average year classes are produced.

The following options are based upon a quota of some sort, such as effort or landings. Quotas in general tend to lead to technological innovation and maximization of operating unit efficiencies. While quotas are most frequently established relative to MSY, the determination of MSY is not mandatory. Effort or catch can be defined on the basis of history and averages may be used as the basis of allocation.

3. Effort Quota (effective effort has yet to be defined for the menhaden fishery -- nominal unit of effort presently used is the vessel-week)

a. Total fishery effort quota

PROS: (1) Easy to implement and administer (minimal costs);

(2) Assumes Atlantic Coast fishery is upon a single stock;

(3) Permits companies to formulate their own fishing strategies.

CONS: (1) May encourage overcapitalization;

(2) If the Atlantic coast fishery consists of two or more stocks, this option may be inappropriate;

(3) May encourage concentration by time and location;

(4) May jeopardize late season fishery, particularly the North Carolina Fall fishery;

(5) May cause socio-economic dislocation (local and widespread effects);

(6) Might favor the larger companies;

(7) Some costs would be incurred to administer this option.

DISCUSSION: This might well be an effective option but it has serious drawbacks in that it might jeopardize the late season fishery, and may cause socio-economic dislocation and reduce the period of employment for seasonal help. It could also encourage an "arms race".

b. Coastal effort quota with subdivision by area of landings (3 areas)

PROS: (1) Tend to continue the traditional or "normal" pattern of fishing activity within each area;

(2) Reduces the potential for overconcentration by time and location;

(3) Reduces the potential of socio-economic dislocation;

(4) Encourages continuity of smaller companies.

CONS: (1) Would require additional costs to administer;

(2) Does not prevent boats from one area going to another area to fish;

(3) Does not protect any particular part of the stock;

(4) Could cause overcapitalization.

DISCUSSION: This option would be helpful in rebuilding the stock, but by itself, would not do the best possible job since it does not protect any particular segment of the stock. It could exert undue pressure the latter part of the season in each area.

c. Coastal effort quota subdivided by areas of origin of catch (3 areas)

PROS: (1) Promotes an equitable distribution of fishing effort, may be to the advantage of smaller less mobile companies;

(2) Establishes accurate records of the areas where effort was expended in the fishery (Captain's Daily Fishing Report initiated in 1978);

(3) More truely represents catch and effort in the areas of fishery;

(4) Socio-economic dislocation minimal.

CONS: (1) Relatively high cost to administer this program;

(2) Difficult to accurately monitor where fish are being caught;

(3) Would tend to encourage overcapitalization and encourage overconcentration by time and location on an area basis.

DISCUSSION: While this would be a somewhat sharper tool than the above, it would have some of the same drawbacks, and it would be difficult, by itself, to achieve the desired result.

d. Coastal effort quota with subdivision for major companies

PROS: (1) Quota could be allocated on the basis of existing data set, using Captain's Daily Fishing Report;

(2) Quota could account for over 70% of fishery activity;

(3) This would leave small companies free of restraint;

(4) This would be relatively easy and inexpensive to monitor;

(5) This would allow corporate flexibility and technological innovation.

CONS: (1) Probably discriminatory to allocate common property resource on an official basis to individuals or companies;

(2) Might cause social and economic dislocation;

(3) Unfair burden upon cooperating parties receiving quotas;

(4) Could disrupt normal flow of product from fishing, warehousing and sale standpoint;

(5) Would not protect any particular part of the stock.

DISCUSSION: Until the legality of allocating to an individual or firm is clarified this cannot be considered as a viable option. If it was determined to be legal it would be a fairly good tool, not much better than the above as far as the resource is concerned, but it would have the advantage of assuring firms of a share of the resource.

4. Catch Quota (landings)

a. Total fishery catch quota without subdivisions

PROS: (1) Easy to implement and administer (minimal costs);

(2) Assumes Atlantic Coast fishery is upon a single stock;

(3) Permits companies to formulate their own fishing strategies.

CONS: (1) May encourage overcapitalization;

(2) If the Atlantic Coast fishery consists of two or more stocks, this option may be inappropriate;

(3) May encourage overconcentration by time and location;

(4) May jeopardize late season fishery, particularly the North Carolina Fall fishery;

(5) May cause socio-economic dislocation (local and widespread effects);

(6) This option might favor the larger companies;

(7) Some costs would be incurred to administer this option.

DISCUSSION: This might well be an effective option but it has serious drawbacks in that it might jeopardize the late season fishery, and may cause socio-economic dislocation and reduce the period of employment for seasonal help. It could also encourage an "arms race".

b. Coastal catch quota with sub-division by area of landings (3 areas)

PROS: (1) Tend to continue the traditional or "normal" pattern of fishing activity within each area;

(2) Reduces the potential for overconcentration by time and location;

(3) Reduces the potential of socio-economic dislocation;

(4) Encourages continuity of smaller companies.

CONS: (1) Would require additional costs to administer;

(2) Does not prevent boats from one area going to another area to fish;

(3) Does not protect any particular part of the stock;

(4) Could cause overcapitalization.

DISCUSSION: This option would be helpful in rebuilding the stock, but by itself, would not do the best possible job since it does not protect any particular segment of the stock. It could exert undue pressure on the latter part of the season in each area.

c. Coastal catch quota sub-divided by areas of origin of catch

PROS: (1) Promotes an equitable distribution of fishing effort, may be to the advantage of smaller less mobile companies;

(2) Establishes accurate records of the areas where effort was expended in the fishery (Captain's Daily Fishing Report initiated in 1978);

(3) More truly represents catch and effort in the areas of fishery;

(4) Socio-economic dislocation minimal.

CONS: (1) Relatively high cost to administer this program;

(2) Difficult to accuratel y monitor where fish are being caught;

(3) Would tend to encourage overcaptialization and encourage overconcentration by time and location on an area basis.

DICUSSION: While this would be a somewhat sharper tool than the above, it would have some of the same drawbacks, and it would be difficult, by itself, to achieve the desired result.

d. Coastal catch quota with sub-division of major companies

PROS: (1) Quota could be allocated on the basis of existing data set, using Captain's Daily Fishing Report;

(2) Quota could account for over 70% of fishery activity;

(3) This would leave small companies free of restraint;

(4) This would be relatively easy and inexpensive to monitor;

(5) This would allow corporate flexibility and technological innovation.

CONS: (1) Probably discriminatory to allocate common property resource on an official basis to individuals or companies;

(2) Might cause social and economic dislocation;

(3) Unfair burden upon cooperating parties receiving quotas;

(4) Could disrupt normal flow of product from fishing, warehousing and sale standpoint;

(5) Would not protect any particular part of the stock.

DISCUSSION: Until the legality of allocating to an individual or firm is clarified this cannot be considered as a viable option. If it was determined to be legal it would be a fairly good tool, not much better than the above as far as the resource is concerned, but it would have the advantage of assuring firms of a share of the resource.

e. Coastal catch quota with sub-divisions by origin of catch and some restriction on small fish

PROS: (1) Promotes an equitable distribution of fishing effort, may be to the advantage of smaller less mobile companies;

(2) Establishes accurate records of the areas where effort was expended in the fishery (Captain's Daily Fishing Report initiated in 1978);

(3) More truly represents catch and effort in the areas of fishery;

(4) Socio-economic dislocation minimal;

(5) The stock should have an opportunity to build up to a higher level of abundance;

(6) The New Jersey and Massachusetts fisheries should acquire a larger resource base to work on;

(7) The resource base in the southern portion of the range should increase in one to two years.

CONS: (1) Relatively high cost to administer this program;

(2) Difficult to accurately monitor where fish are being caught;

(3) Would tend to encourage overcapitailization and encourage overconcentration by time and location on an area basis;

(4) There would be some reduction in catch for a year or two;

(5) Might put an unfair burden on southern fishery.

DISCUSSION: Probably the best option so far, but with restriction only on juveniles it might put an unfair portion of the rebuilding burden on the Virginia and North Carolina fisheries.

5. Mesh Regulation to Permit Selective Fishing

PROS: (1) Easy to enforce;

(2) Minimal cost if new nets are phased in as old ones wear out;

(3) Should allow virtually all fish below a certain size to escape throughout the season.

CONS: (1) Might select for slower growing genotype, or late spawners;

(2) Reduced catch.

DISCUSSION: This is felt to be a very good option, particularly if consideration is given to adjusting the mesh size to the fish that are expected in a given area.

6. Season or Area Closure to Protect a Portion of the Resource Each Year

PROS: (1) Easy to enforce;

(2) Low cost to enforce;

(3) Seasons and areas could be adjusted annually to allow escapement of the proportion of the resource deemed necessary to meet objectives.

CONS: (1) Could be a serious short term socio-economic disadvantage;

(2) Requires rapid regulatory response.

DISCUSSION: This would be a very good option but would give a different type of control than could be realized with Item 5 above.

7. Size Limit (establish percentage of a boatload that can be below a certain size -- could be seasonal)

PROS: (1) Would be effective.

CONS: (1) Expensive to enforce;

(2) Cumbersome.

DISCUSSION: The enforcement costs of this option would be prohibitive.

C. Trade-off between Beneficial and Adverse Impacts

In order to rebuild the menhaden stock, fishing mortality must be reduced. Ideally this reduction should apply to all age groups. The basic options for doing this consist of limiting fishing effort, limiting the fishing season, limiting fishing areas or limiting the catch.

Limiting effort would have the adverse effects of limiting or reducing the number of crews hired or reducing the length of the season of employment. They could be inspired to work harder while they are fishing and the firms would be encouraged to make their units of effort more effective, thus offsetting the effect of a reduction in effort.

Limiting the length of the season would have essentially the same effect as limiting effort. Efficiency may be increased and the season of employment would be reduced.

Limiting area would have an effect similar to limiting season, but might increase travel time to fishing grounds.

Limiting the catch by imposing a simple quota would not serve to protect the younger age classes and would reduce income both to the worker and to the firm.

Limiting the catch by a mesh size restriction would make the fishing unit less effective and would temporarily reduce income to the workers and firms somewhat. However, they would have the option of searching for larger fish and perhaps offsetting this reduction in income to some degree. It would have the beneficial effect of reducing mortality on the smaller fish in any given area, and could be designed to spread the burden of mortality reduction on the younger age classes over the geographic range of the fishery.

D. Specification of Optimum Yield

Production model analysis did not provide a useful estimate of maximum sustainable yield (MSY) for the Atlantic menhaden fishery. A broader age structure of mature fish is considered desirable to reduce the risk associated with successive recruitment failure and to increase the yield from the resource. The estimated benefits from improvement in yield per recruit and degree of these benefits are related to the amount of reduction and/or reallocation of effort.

As an initial target for the entire Atlantic Coast (not by any one state or geographic area), it is recommended that the fishery be conducted in a manner so that the landings, as an indicator of the age composition of the resource, include at least 10% by number of age 3 or older fish by the end of the 1983 season.

E. Options Recommended by Sub-board in August 1980

The Atlantic Menhaden Sub-board in August 1980 instructed the S&S Committee to develop the area and seasonal closure options consistent with the optimum yield statement for the short-term management program. Area and seasonal closure recommendations are to be based upon a review of existing data on age composition of the purse seine landings by week and area of landing. Further, they directed the S&S Committee to consider mesh size regulation as a potential long-term option for future use in Atlantic menhaden management. Mesh selectivity of menhaden purse seines is not adequately defined at this time. An RFP has been developed to define the mesh selectivity relationships for Atlantic menhaden throughout the range and season of the fishery. This research is scheduled for funding in FY 81-82. Upon completion of the study the utility of the mesh size management option will be evaluated in the program.

SECTION 9. MEASURES, REQUIREMENTS, CONDITIONS OR RESTRICTIONS SPECIFIED TO ATTAIN MANAGEMENT OBJECTIVES AND RECOMMENDED OPTIONS

In order "to prepare a program for utilization of Atlantic menhaden that is biologically, economically and sociologically sound and which protects the resource and its users" as stated in the Sub-board Charge of July 1977, the stock must first be enhanced in a manner which would have the minimum adverse effect on the economic and sociological aspects of the fishery. Once this has been accomplished and provision made for its maintenance, the management program will have met its goal of protecting the resource and its users. The strategy recommended combines the concept of seasonal closures by area to reduce the catch of selected ages of fish in the short term and possible application of mesh size regulations in the long term.

A. Outline of Atlantic Menhaden Management Measures

1. Short-Term (the 1980's) Objective -

   Achieve by the close of the 1983 season for the entire Atlantic coast (not by any one state or geographic area) an age composition in the resource so that landings, used as an indicator of the overall stock age composition, include at least 10% age 3 or older fish by number.

   This is to be effected by adjustments of the catch of fish in the South Atlantic, North Carolina Fall fishery, Chesapeake Bay, Middle Atlantic, and North Atlantic. The adjustments will include a combination of two approaches:

-- reducing the catch of age 0, 1 and 2 fish to enhance the survival of menhaden to sexual maturity and increase yield per recruit

-- reducing the catch of age 3+ menhaden to enhance the number of individuals in the spawning stock.

2. Long-Term Objective -

   Achieve the greatest continuing yield for each area by determining the age at which menhaden should be harvested and eliminating other restrictions which do not contribute to the management goal.

3. Recommended Implementation Methodology -

   a. Short-term

      1) determine age composition by area during each week of the season

      2) adjust time and area closures if necessary (based on the best data available) to achieve the short-term objective.

b. Long-term

1) define mesh size selectivity of Atlantic menhaden purse seines

2) define proximate composition of Atlantic menhaden by size, age, area, and season

3) maintain knowledge of the economic structure and sociological characteristics of the menhaden reduction industry

4) evaluate the results of short-term management actions in view of accrued new knowledge as well as all pertinent biological, sociological, and economic factors and decide if existing management measures should be changed.

B. Recommended Institutional Structure and Functions

The Atlantic menhaden management program will include several advisor and action groups. The Atlantic Menhaden Management Program will be a constituent part of the Atlantic States Marine Fisheries Commission's Cooperative Interstate Fisheries Management Program.

1. Atlantic Menhaden Management Board (AMMB).

The AMMB shall be composed of the six chief fishery management administrators of states actively participating in the management program, six menhaden industry executives who request membership, and an ex-officio representative from NMFS. Members are appointed by the Atlantic States Marine Fisheries Commission (ASMFC) Executive Committee members from states having declared an interest. The AMMB essentially functions in the roles of the former Northeast Fisheries Board and Atlantic Menhaden Sub-board. This group will meet a minimum of two times per year to consider recommendations of their Atlantic Menhaden Implementation Subcommittee (AMIS) and take action on the AMIS recommendations and implementation strategy. Actions taken by the AMMB constitute the final approval required for management measures developed under the Atlantic Menhaden State/Federal Management Program. The approved fishery management plan for Atlantic menhaden and other approved management actions may be forwarded by the AMMB to other agencies which may be affected. Individual State members of AMMB would thereafter initiate appropriate steps to secure adoption of the approved management actions in their respective jurisdictions and other pertinent states. The intent is to obtain approval of a uniform management program in all waters. The AMMB establishes management policy, goals, and objectives and gives guidance to the AMIS. Appointments to AMIS and the Atlantic Menhaden Advisory Committee (AMAC) are made by the AMMB.

2. Atlantic Menhaden Implementation Subcommittee (AMIS).

The AMIS shall be composed of 3 industry and 3 state administrator members of the AMMB and will be appointed by the AMMB to conduct the day to day activities of the overall management program. The AMIS will provide guidance to the AMAC on specific issues, receive management action recommendations from the AMAC, and formulate a strategy for implementation of each recommendation that they approve. The AMIS will present their management action recommendation(s) along with background or supporting justification and an implementation strategy to the AMMB. The AMIS will submit a recommended AMAC membership roster to the AMMB.

3. Atlantic Menhaden Advisory Committee (AMAC).

The AMAC will be appointed by the AMMB and be composed of fishery biologists designated as representatives by the States actively participating in the management program, industry representatives designated by the companies in the purse seine fishery, and a NMFS biologist from the menhaden program who is actively engaged in the research and data base management. This committee will meet two or more times per year to review data bearing on the status of the resource and fishing activity relative to the efficacy of current management measures in meeting the management objectives. Recommendations from this group, based upon review of the technical data base and new research results, will be forwarded to the AMIS for action. Specifically, AMAC shall formulate recommendations for short term management actions over the next one or two fishing seasons, propose new research topics as RFP's, IFB's or recommended future NMFS activity, and request special analyses of Atlantic menhaden data by NMFS-SEFC scientific staff for future review by the committee.

4. National Marine Fisheries Service - Southeast Fisheries Center (NMFS-SEFC)

Virtually all of the data base and technical expertise relative to the Atlantic menhaden has been developed by a research program administered through the NMFS-SEFC and its Laboratory at Beaufort, North Carolina. Continuation of the menhaden research and stock assessment program, development of new data types, and analyses of available data sets shall be provided by NMFS-SEFC from its laboratory at Beaufort, N.C. in support of the activities described in this management plan.

C. Permits and Fees

Licenses are required by all Atlantic coast states which allow purse seining. Fees are summarized in Section 3 of this document.

D. Time and Area Restrictions

Maine, New Hampshire and Virginia specify menhaden purse seine fishing seasons. All other Atlantic Coast States' regulations specify "no closed season" or are silent in this regard, except for Maryland which prohibits menhaden purse seine fishing.

In the short-term, closure recommendations, if necessary, will be based on an analysis of the age composition of landings by area and season. Closures would be recommended for periods when fish of the ages to be protected predominate the catch, and the length of the closed season would be proportional to the reduction in catch deemed desirable. This approach will allow enhancement of the stock in the near future without the delay involved in collecting information needed to initiate the long-term program.

In the long-term, the above management measures may be replaced by mesh size regulations.

E. Catch Limitations

1. Total Allowable Level of Foreign Fishing - Since the U.S. fishery is capable of fully utilizing the resource, there is no surplus available for foreign allocation. The U.S. fishery is capable of utilizing any conceivable increase in stock size.

2. Type of Catch Limitation - The forms that catch limitations might take remain to be determined as described under the short-term objective.

F. Type of Vessels and Gear

Initially, this plan shall be directed at the purse seine fishery. Gear restrictions (purse seine mesh size) are a possible future management tool, but details cannot be presented at this time. Recommendations for adoption of mesh size as a management tool depend upon assessments specified under implementation methodology. As more data become available it may be desirable to include other gears.

G. State, Local, and Other Laws and Policies

A legal matrix, incorporating all of the state laws pertaining to the Atlantic menhaden fishery, is presented in section 3 of this document. The matrix includes information on licensing, closed seasons and areas and penalties for violations.

H. Institutional Arrangements

Both the short and long term management approach (=strategy) depend upon the States adopting necessary regulations or statutes. Recommendations relative to these management approaches will be made by the AMAC.

With the completion and adoption of the Atlantic Menhaden Management Plan, the need for AMAC and AMIS meetings could be somewhat reduced. It is recommended that provision be made for at least two AMAC meetings annually to provide for timely updating of the stock status, landings and recruitment data, other pertinent information and a discussion of management needs. Meeting(s) of the AMIS and AMMB should be scheduled before August so that management recommendations can be considered before the industry has made commitments for the next fishing season.

I. Limited Access Systems

While no limited access system is contemplated for the Atlantic menhaden purse seine reduction fishery, it is unlikely that a new reduction facility could be established today because of restrictions against filling wetlands, restrictions on effluents and air emmissions, and availability of adequate shore sites for plant construction. Thus, a limited access system exists, in practice, created principally by factors outside the fisheries field.

J. Habitat Preservation, Protection and Restoration

Unbridled alterations in the estuaries and coastal areas of the Atlantic Coast, rampant a few years ago, have been brought under control in most areas by State and Federal legislation. At the present time, filling and dredging is probably less of a threat to menhaden habitat than water pollution. Estuaries and nearshore ocean waters are subjected to various types of pollution such as raw or primary treated domestic sewage, overflows from combined sanitary and storm water systems and the ocean dumping of sewage sludge, dredge spoils and chemical wastes. While some progress has been made in the abatement of pollution, there is no doubt that remaining discharges have a substantial negative effect on the menhaden resource. In addition, apparent natural fish kills destroy millions of menhaden annually and deserve investigation. All together, the numbers of menhaden destroyed annually by fish kills may be significant. Particular problem areas are the greater New York Harbor, New Jersey, Delaware Bay, Chesapeake Bay and the North Carolina coast.

K. Management Costs

The cost of managing this resource will rise in the future. The ongoing program at the NMFS Beaufort Laboratory must be augmented to define an effective unit of effort, test and utilize a simulation model of the Atlantic stock and fishery (now being developed), continue the monitoring and evaluation of the stock, update the fecundity and spawning data, and develop a juvenile abundance index which provides an adequate predictive capability. In addition, the recently inaugurated Captain's Daily Fishing Report system should be continued and the data made available on a timely basis.

SECTION 10. ATLANTIC MENHADEN DATA NEEDED FOR RESOURCE MANAGEMENT.

Management of the Atlantic menhaden resource will require long-term continuation of several on-going research programs at the Beaufort Laboratory and special projects of a shorter duration from time-to-time designed to answer specific problems posed by the AMIS or others.

The on-going research program of the NMFS-SEFC, Beaufort Laboratory dates back to 1955. Specific areas of research data generation and data storage for multiyear period include: daily landings records of the purse-seine vessels, fleet composition data, Captain's Daily Fishing Reports, sampling of landings for age and size of menhaden, collection of recovered tags in the reduction plants. Data reports and summaries of fishery characteristics (effort, landings, etc.) and indepth analysis of various biological attributes of the Atlantic menhaden resource throughout its range are to be provided to the AMAC in a timely fashion. Data presently available through NMFS-SEFC at its Beaufort Laboratory are considered adequate for initial recommendations to meet the short-term objective of this plan. The long-term objective involves the development of additional new data through NMFS, the States, industry, and other sources.

NMFS-SEFC Beaufort Laboratory is to serve as the primary data collection, processing, storage, and analysis institution. The research program budget and staffing of that facility must be augmented to facilitate the attainment of this management plan's goal and to fully meet the agency obligations assigned to it.

A. Harvest in the Fishery

The catch of Atlantic menhaden by the various gears must be reported in a more timely fashion than it is presently. The purse seine fishery voluntarily continues to provide daily catch records, plant production data and a Captain's Daily Fishing Report which provides the data needed for accurate and timely assessment of the fishery, monitoring of fleet activity, and periodic summary of landings in the fishery by date and area. Landings by other gear are obtained by the various States and NMFS personnel through interview and voluntary release of data. They do not provide parallel detail for all gears as that obtained from the purse seine fishery.

Minimum catch reporting requirements recommended are:

Purse seine fishery - continue Captain's Daily Fishing Report. A mechanism for printing the forms, collecting the completed forms, coding the data and loading the data on computer for use by the management body. A copy of the form used in the 1980-81 seasons is appended.

Other Commercial Fishing Gear - Haul seine, pound net, gill net, etc. take menhaden in their normal operations. Daily, weekly, or monthly catch reports should be implemented by the

States to provide parallel data to that of the purse seine fishery. Samples of these catches would be processed for biological data, such as age, weight and length of fish. This would provide a characterization of the catch which parallels that for the purse seine fishery. Forms for catch reports could be distributed to the fishermen at the time of license purchase with a clearly defined schedule for report filing.

Data Management - A centralized data management system for Atlantic menhaden landings and biological data should be implemented in both the Southeast and Northeast regions of NMFS. Data access and confidentiality can be directly controlled through user codes.

The NMFS-SEFC Beaufort Laboratory will provide primary data summaries and analyses for the Atlantic Menhaden Advisory (technical) Committee.

B. Harvest Other Than Fishing

High volume water users impinge young menhaden and other fishes on their intake screens. At present these data are dispersed among the various industries and states and are not immediately available in most cases. Each permittee should provide the appropriate permitting agency with monthly reports of fishes killed during the water intake phase of their operations. Data could include daily estimates (counts) by species. The water use permitting agency would forward quarterly data reports to the Atlantic menhaden program at the Beaufort Laboratory.

Each state should develop a program for the assessment of fish kills (natural, thermal, or toxic substance related). The designated state agency should report a summary of findings and estimated numbers killed to the Atlantic menhaden program at the Beaufort Laboratory at quarterly intervals. The procedure developed by the Pollution Committee of the Southern Division of the American fisheries Society could be used as the model for investigation and reporting of fish kills in Atlantic coastal waters.

C. Resource Assessment and Monitoring

Biological health and response of the resource under management are to be ascertained by data from the population at large. Landings alone will not suffice as a measure of the resource's recovery under the implemented management actions. Data needs listed below are essential to the management program.

1. Composition of the Harvest - A port sampling program similar to or expanded from that presently undertaken by NMFS is critical to assessment of the biological health of the resource. The data taken would be cross referenced to the catch reports for each gear sampled. Data obtained from individual fish in a sample of the catch (be it purse seine, pound net, power plant intake screen, fish

kill, etc.) would include: scales for age, weight, length. Periodic intensive sampling should be undertaken for sex ratio, stage of maturity, fecundity, etc. These data would be integrated with that from other sources for reporting, analysis and assessment of the resource.

2. Juvenile Survey and Forecasts - Juvenile abundance assessment in the estuarine nursery areas must be continued and expanded to develop indices which are quantitative and predictive. The data set should allow quantitative forecasting of the purse seine harvest. Sampling programs should be devised which would allow a more active involvement of the individual States in the monitoring of the resource. Data input would be through the comprehensive coastal wide data management system, and annual assessments would be provided to the Atlantic Menhaden Advisory Committee.

D. Special Projects

This document contains several references to special research projects needed to support the management program or to provide a background data for evaluation of the proposed long-term management approach. "Nagging" questions and long-term data needs for management of the Gulf menhaden fishery were summarized by Christmas and Etzold (1977). Pertinent pages from that document are appended for reference. In general, parallel questions exist for the Atlantic menhaden fishery. Several problems are exacerbated in the Atlantic by the extensive migration pattern, age class mixing, present depressed mean age and age structure in the resource, multiple resource users, large number of States within the range of the fishery, and economic factors arising from the distribution of landing ports within the range of the fishery. The AMAC, AMIS and AMMB will use these and other sources for guidance in the formulation of the research program, assignment of research priority, and response to management questions.

CAPTAIN'S DAILY FISHING REPORT

NAME OF VESSEL 1	PLANT 2	DATE OF SETS 3	4

LEFT DOCK 5 ANCHORAGE

DATE

TIME : ☐AM ☐PM

IF DID NOT LEAVE DOCK (CHECK ONE) 6

☐ WEATHER UNFIT FOR FISHING ☐ UNLOADING
☐ LACKING SUFFICIENT CREW ☐ RADIO
☐ MECHANICAL ☐ OTHER______
☐ NET

IF NO SETS WERE MADE (CHECK ONE) 7

☐ ROUGH SEAS ☐ OTHER______
☐ FOGGY
☐ NO FISH SHOWING
☐ NO PLANES
☐ CHANGING LOCATION

SET NO. 8	TIME 9 START	TIME 9 END	FISH (000) 10	PLANE NO. 11	LOCATION 12		MILES AND DIRECTION TO SHORE 13		WEATHER CONDITIONS AND REMARKS 14	15
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

16

REMARKS & COMMENTS 17

____
CAPTAIN'S SIGNATURE 18

This form is required by State Law

INSTRUCTION

CAPTAIN'S DAILY FISHING REPORT

The following is a list of instructions for filling out each section of the report form. The numbers correspond to the blanks on the form. One report must be turned in for each fishing day even if no sets were made. The box under name of vessel is for recording the number of the purse net used, if required by your company.

1. Name of Vessel.
2. Plant - the name of the plant location where these fish will be unloaded.
3. Date - the day these sets were made.
4. Leave blank.
5. Date and Time Left Dock or Anchorage - write in the date and the time you left the dock or your anchorage. Check whether it was AM or PM.
6. If Did Not Leave Dock - check one reason.
7. If No Sets Were Made - check one reason.
8. Set No. - if you make more than twelve sets in one day please use a second form and date the second form the same as the one with twelve sets. Include sets where no fish were caught.
9. Time Start and End - list the time that you start and end each set. Set time is considered to be the time you leave the steamer until you are ready to go again.
10. Fish - this is the estimated fish caught in each set. The thousands are already on the form, therefore just write in the beginning numbers. (like 25, 72, 150).
11. Plane - list the spotter number that set you on each set. If you set yourself use the code "0" for that set.
12. Location - give the location that each set is made using known reference points. Be as specific as possible. Record the code number for that location in the space to the right.
13. Miles and Direction to Shore - give, to the nearest 1/2 mile, the distance to the nearest mainland on the left column and give the direction in the right column. (For example 2 1/2 mi North)
14. Weather Conditions and Remarks - give a brief description of the weather conditions at the time of the set and any remarks about the set.
15. Leave blank.
16. Leave blank.
17. Remarks and Comments - use this space to make any remarks and comments concerning fishing outlook and problems.
18. Captain's Signature - be sure to sign each report.

3.2 IDENTIFICATION OF PROBLEMS

To properly develop a management plan for a fishery resource, an awareness of problems and potential problems within the fishery is necessary.

The Gulf Menhaden Management Task Force addressed this question and enumerated the following problems. The numerical arrangement does not imply an attempt to prioritize these items in terms of any subsequent research timetables.

3.3 PROBLEMS ANNOTATIONS

3.3.1 Biological

1. Inadequacy of data to establish a satisfactory estimate of maximum sustainable yield of all menhaden stocks.

a. Estimate MSY for Gulf menhaden. Several problems identified by the Gulf Menhaden Task Force logically fall into one major problem area—that of identifying the effects of fishing on the stocks and the subsequent calculation of MSY. To determine the impact of fishing, and to determine dynamics of Gulf menhaden, the following problems have been grouped:

Inadequate estimate of MSY for menhaden
Estimates of unit of effort, as currently used, require better input data.
Natural mortality of menhaden is unknown
Biological Break Even Point (BBEP) for menhaden stock(s) has not been clearly defined.

b. Management of the Gulf menhaden is dependent on the establishment of a maximum sustainable yield value which can be used with economic and social information for the development of an optimum yield. The MSY value is obtainable through analysis of catch/effort data and through knowledge of reproductive potential, natural mortality and yield per recruit. This information has not yet been established.

The solution to establishment of MSY in the Gulf of Mexico hinges on a resolution of problems identified in the determination of a unit of effort which effectively describes fishing pressure, which can be back calculated to provide a historic catch/effective effort data base. Once an effective unit-of-effort has been established, fishing mortalities can be determined and natural mortality rates can be calculated from the present data base on total mortalities. The BBEP cannot be determined until an MSY curve is calculated. Determination of the BBEP is necessary to insure the continuance of the resource.

c. Change in the efficiency of the menhaden fishery has created a situation where the effective effort of a vessel has increased in relation to the total stock of Gulf menhaden. Efforts have been underway by NMFS since the late 1960's to standardize effort and to account for technological improvements. These efforts have been unsuccessful to date.

2. Annual fluctuations of menhaden population are not satisfactorily predictable.

a. Since year-class strength is strongly influenced by environmental factors, problem "Inadequate Knowledge of Environmental Factors that Influence the Abundance of Menhaden" is included under the general problem of predicting year-class fluctuations.

b. Environmental conditions that favor or inhibit growth and abundance, spawning and spawning success, migration of young, etc., have not been defined. Prediction of the number of fish available for harvest is not practical at the current level of knowledge.

c. Reasons Why the Problem Exists

1) Lack of data on natural mortality; 2) Lack of data on environmental factors that influence menhaden abundance; 3) Lack of data on catch of menhaden by other fisheries; 4) Lack of funding for items 1, 2 and 3.

3. Knowledge of menhaden year-class composition, and distribution beyond the currently exploited fishing grounds have not been determined.

a. Work has not been undertaken to determine if any appreciable numbers remain offshore throughout the year and do not enter the fishery. Information of the biology of menhaden in offshore waters is scanty.

b. 1) Lack of funding for offshore research; 2) Difficulty in pursuing offshore research on a pelagic, schooling species.

4. Detailed location data concerning the menhaden catch is not available.

a. Data on actual catching sites and all set sites are required.

b. This information has not been made mandatory for release.

5. Current annual estimates of juvenile populations cannot be satisfactorily used for predictive purposes.

a. Current estimates are not made on extensive enough data and background knowledge, such as natural mortality, is lacking. This deficiency has not allowed for following the juveniles to catchable size.

b. A historical data base involving these aspects has not been broad enough to date to construct a predictive model. The level of predictive precision and accuracy desired has not been defined. This level will be required to select both a method of sampling and the degree of effort expended.

6. Stock composition of Gulf menhaden has not been adequately determined.

Existing investigations indicate that the Gulf menhaden in the northern Gulf is a panmictic species; however, tagging experiments indicate that there is little migration between fish stocks east and west of the delta. If separate stocks do exist, it may be necessary to devise different management procedures for each stock.

7. Inadequacy of data to establish a satisfactory estimate of optimum sustainable yield of all menhaden stocks.

Accurate estimates of OSY is necessary to insure maximum benefits for both the industry and the consumer. Data is not available to ascertain MSY, ESY or social inputs to produce the needed OSY figures. Research is needed in all these fields.

8. The interaction between menhaden and other fisheries is relatively unknown.

Existing data on the bycatch and catch of other fisheries (notably the inshore shrimp and industrial bottomfish) are not sufficient to indicate their impact on menhaden populations although research into the shrimp bycatch is now underway and preliminary results indicate the impact may be considerable. Updating the studies done on the species composition of the menhaden catch and its impact on other fisheries (notably the recreational fishery) is also needed.

3.3.2 Economic

1. Lack of knowledge of areal and seasonal age and size variations in fat, moisture, ash and protein components in menhaden.

The lack of information in these areas hinders the industry in assessing the economic potential of fish from a certain area or at a certain time during the season. Advance information on these factors could allow for more efficient operation of plants and allocation of fishing time. If the fish from a certain area or time of the season were found to be "richer" in these biochemical components than those from another area or time during this season, the economic return would be greater from fishing the "richer populations.

2. Inadequacy of available data to establish satisfactory estimate of economic sustainable yield of all menhaden stocks.

This data, although on hand within individual companies, is not available on an industrywide basis. Managers lacking this type of data are not able to make decisions that provide for the most benefits for both the industry and the public.

3.3.3 Social

1. Lack of adequate sociological data for input into management considerations.

The management of any fishery, with respect to the concept of optimum yield and other management objectives, must be based on adequate knowledge of the preference patterns, traditions, values and lifestyles of all of the people involved in the fishery. Research should be performed by trained social scientists in order to enhance a properly balanced management program.

2. Lack of knowledge and documentation of the political/legal systems involved in coordinating management schemes on a regional basis with respect to the Gulf menhaden industry.

Once baseline data in the areas of biology, sociology, economics and ecology have been established, it is necessary to become familiar with the legal and political systems which are necessary to the implementation of fishery management schemes. A lack of scientific collection and presentation of information of this sort may lead to decision-making based on misinformation, uninformed opinion or historical perceptions which may create artificial blockages to cooperation and effective fisheries management.

3. Lack of understanding of the relationship between the menhaden industry, the general public and other resource users in the social environment.

An effective fishery management plan must take into account the relationships between the various users of the resource and members of the general public who are involved in the biological and social ecology of the fishery system. Lack of information and education concerning the goals, practices and policies of the fishing industry, or false impressions or distortions of these matters, may combine with ignorance of the role and importance of the fishing industry in local cultural and economic systems to produce unnecessary conflict and create impediments to rational management.

3.3.4 Other

1. Development of more energy-efficient methods of hauling the catch to the processing plants.

The contemporary menhaden carrier vessel is designed to meet critical criteria-speed and hold capacity. To satisfy these criteria it takes high horsepower engines with high fuel consumption rates. Large savings in fuel, as well as fuller utilization of boats and crews, could be achieved if the vessel could remain on the fishing grounds for as long as a week instead of periodically hauling the catch to the processing plants during that week.

2. More efficient fish-spotting techniques.

Spotter aircraft are presently used extensively for scouting and directing in the fishing operation. Since each company has its own fleet of aircraft, there is much duplication of effort for fleets working the same area.

3. More cost-effective vessel unloading system.

The average carrier vessel has refrigerated holds with total capacities of 1 to 1.5 million fish. Unloading at the processing plants is done with gear pumps requiring hold flooding to move the fish through 10-inch pipes and hoses. Pollution abatement requires judicious but costly disposition of pump water. A cost-effective system to minimize or eliminate the use of pump water is urgently needed.

4. Improvement in purse-boat safety.

Transfer of personnel to and from the carrier vessel as now practiced is somewhat hazardous at times. A large number of accidents in menhaden fishing operations occur in transferring to and from the purse boats.

5. New seining gear and methods.

The two-boat purse seine presently used by the industry is very efficient as a harvesting system but requires a large crew to handle. The large crew represents a significant overhead cost, but more importantly, results in many lost fishing days because of the problems associated with hiring and maintaining the number of people necessary to fish the two-boat purse seines.

6. Deficiencies, if any, of the menhaden purse seine are not defined.

An operational in-situ evaluation of the purse seine is needed to determine if deficiencies exist that can be corrected to increase production efficiency.

7. Evaluations of the menhaden purse seine and vessels are not available.

The operational characteristics of a carrier vessel, its purse seine and its handling and deployment, and the unloading of fish from the net need study to outline potential improvements in efficiency, safety or ease of operation.

Chapter 6. Recommendations

The following recommendations have been developed for consideration. Recommendations are classified as high, medium or low priority. The identification designations in parenthesis refer to Table 5, Chapter 7.

A. High Priority

1. That the TCC menhaden Sub-Committee continue its present function at least until the Management Board assumes responsibility for regional management.

This is necessary to maintain the program in that interval between completion and implementation of the plan.

2. That each state participate in and support a Gulf regional menhaden management plan.

This is essential because the ultimate management authority is vested in the several Gulf States.

3. That an advisory committee be appointed by the Board.

This committee is needed to supply input to the Board and/or to supply alternative solutions to current problems.

4. That the advisory committee should meet at least twice each year.

This is necessary to review current conditions and to make appropriate recommended changes for the Board to improve plan implementation.

5. That a study be conducted to establish a more satisfactory estimate of MSY (B-1).

Potential benefits are: to define stock size; to permit maximum long-range utilization of resource; and to provide basis for further management measures, if necessary.

6. That a study be conducted to satisfactorily predict annual fluctuations of menhaden populations (B-2).

Potential benefits are to allow industry to properly prepare for a season and to permit rational exploitation of the resource on a year-by-year basis.

7. That a study be conducted to determine detailed location of the menhaden catch (B-4).

Potential benefits are the determination of whether the fishery is inshore or offshore, and the determination of migration patterns of tagged juvenile menhaden after recruitment into the fishery.

8. That a study be conducted to improve current annual estimates of juvenile populations for predictive purposes (B-5).

Potential benefits are: More efficient application of commercial gear with respect to (1) where to fish (increase effort in unexploited areas), (2) how, when, where and amount to take, (3) increase lead time for allocation of fishing effort, shore facilities and marketing plans; and maximization of yield (landings).

9. That a study be conducted to develop data (biological, economic, social, environmental) to satisfactorily estimate menhaden stocks with respect to optimum sustainable yield (B-7).

Potential benefits are the assurance of optimum benefits from proper utilization of resource.

10. That a study be conducted to obtain adequate data to determine the economic sustainable yield of Gulf menhaden stocks (E-2).

Potential benefits are the development of economic data in consort with biological (and other) data so that an OSY may be determined.

11. That a study be conducted to obtain adequate sociological data for input into management considerations (S-1).

Potential benefits are the development of adequate sociological knowledge of the menhaden fishery in order to make better management decisions.

12. That a program be conducted to improve knowledge and documentation of the political/legal systems involved in coordinating management schemes on a regional basis with respect to the Gulf menhaden industry (S-2).

Potential benefits are that the research will clarify and present as a package the various State laws and policy and management practices which each state presently uses to deal with its own menhaden fishery industries. This knowledge will enable regional management bodies to fully take advantage of the benefits of the States' experience, and at the same time work to eliminate unnecessary conflicts or inconsistencies in those laws, policies and practices.

13. That a program be conducted to improve the understanding among the menhaden industry, the general public and other resource users in the social environment (S-3).

Potential benefits are that this project will create a better understanding of the role of the menhaden industry in the social, economic and ecological systems of the larger community. This will in turn reduce barriers to effective management and create a stable environment in which to rationally acknowledge and distribute the benefits of the fishery system.

14. That a study be conducted to improve vessel unloading system (O-3).

Potential benefits are in developing a cost-effective unloading system to minimize or eliminate the use of pump water.

15. That a study be conducted to improve purse boat safety (O-4).

Potential benefits are in decreasing personnel accidents and to lower company insurance rates.

16. That a study be conducted to develop more economic harvesting gear and fishing methods (O-5).

Potential benefits are in reducing the large purse-seine crews.

B. Medium Priority

1. That a study be conducted to determine menhaden year class composition and distribution beyond the currently exploited fishing grounds (B-3).

Potential benefits are in determining if a segment of the spawning populations does not enter the fishable stocks creating a spawning "bank"; greater delineation of spawning areas and times; better definition of stock composition and clarification of migratory patterns.

2. That a study be conducted to determine stock composition of Gulf menhaden (B-6).

Potential benefits are in helping maintain resources and possibly increasing the harvest potential.

3. That a study be conducted to obtain knowledge of areal and seasonal age and size variations in fat, moisture, ash and protein components in menhaden (E-1).

Potential benefits are that industry could more efficiently allocate fishing time in those areas that produce the "richest" fish for a greater economic return.

4. That a study be conducted to conserve energy and increase utilization of boats and crews (O-1).

Potential benefits are in increasing savings in fuel, as well as to obtain better utilization of boats and crews.

5. That a study be conducted to reduce fish spotting costs (O-2).

Potential benefits are in eliminating duplication of use of airplanes by the several companies when replaced by a useable operational satellite system.

C. Low Priority

1. That a study be conducted to determine the interaction between menhaden and other fisheries (B-8).

Potential benefits are in determining impact of other fisheries on the menhaden populations, and determining impact of menhaden industry on other fisheries.

2. That a study be conducted to evaluate the actual performance of menhaden purse-seine performance (O-6).

Potential benefits are in locating problem areas in the purse seine and to recommend improvements which will increase production efficiency.

3. That a study be conducted to perform an engineering study of vessels' purse seines operational characteristics (O-7).

Potential benefits are in outlining and describing changes, benefits and recommendations of improvements for future considerations.

SECTION 11. FEDERAL LAWS AS THEY AFFECT U.S. COMMERCIAL FISHING INDUSTRY

There are no known federal laws which would directly impact implementation of this fishery management plan. U.S. Fishery Laws generally could be improved with some reorganization, recodification and clarification. Congress should consider reorganizing and recodifying most of the fishery laws under one title of United States Code. Although many of the fisheries laws are now in title "16 CONSERVATION" others are scattered throughout titles "15 COMMERCE AND TRADE" and title "46 SHIPPING". There are some laws that pertain to fisheries that also pertain to other matters and would be best left in place. It would be helpful to separate fishery related laws from general shipping laws and wildlife laws. In some areas such as fisheries research and financial assistance to the fishing industry, consolidation of the laws would be beneficial. Any revision of the fisheries laws should include a revised designation of the powers, duties, and responsibilities of the Secretary of Commerce, as opposed to many existing references to the Secretary of Interior, to clarify the intent of the 1970 reorganization of functions.

There are many instances where specific laws could be improved by amendment. There are several instances in research and related activities where statutes are inconsistent or overlap with each other, and a clear designation of the Secretary of Commerce to administer these functions would be helpful. There is some inconsistency or overlapping among the conservation related laws and confusion as to whether certain activities and functions should be performed by the Secretary of Commerce or Interior. There are a few instances where the Fisheries Management and Conservation Act of 1976 could be better coordinated with other statutes. In the area of foreign relations, duty statutes may need revision and certain sanction statutes regarding foreign countries could be combined into one statute. There are several commerce related statutes which prohibit possession, sale, etc., of particular species but do not prohibit importing or exporting of those species; fish inspection is not now mandatory, and there is a division of responsibilities for fisheries matters between the Secretaries of Agriculture, Commerce, and Interior. It would be helpful to consolidate or summarize in one place the mandatory reporting required of the Secretary of Commerce. Federal statutes providing various forms of assistance to U.S. fisheries are scattered in Title 16 and 46 and should be consolidated. While the various laws are consistent in designating the Department of Commerce and the Coast Guard for enforcement, the fines provided should be increased.

A more detailed analysis of these general comments on fisheries laws as they affect the U.S. commercial fishing industry may be found in Appendix II of the REPORT TO THE CONGRESS by the Comptroller General of the United States titled THE U.S. FISHING INDUSTRY PRESENT CONDITION AND FUTURE OF MARINE FISHERIES, DATED DECEMBER 23, 1976. The U.S. fishery laws could be improved with reorganization, recodification and clarification of the existing statutes. The statutes as they now exist are cumbersome and unwieldy to work with.

SECTION 12. LITERATURE CITED

Breder, C. M. 1967. On the survival value of fish schools. Zoologica 52:25-40.

Brock, V. E., and R. H. Riffenburg. 1963. Fish schooling: A possible factor in reducing predation. J. Cons. Int. Explor. Mer. 25:307-317.

Chapoton, R. B. 1972. On the distribution of Atlantic menhaden, eggs, larvae, and adults: A briefing document. (Mimeo.).

Chesapeake Research Consortium. 1977. Proceedings of the Bi-State Conference on the Chesapeake Bay. Publication No. 61. Annapolis, MD.

Christmas, J. Y., G. Gunter and E. C. Whatley. 1960. Fishes taken in the menhaden fishery of Alabama, Mississippi, and eastern Louisiana. U.S. Fish and Wildl. Serv., Spec. Sci. Rep. Fish. 339, 10 p.

Commito, J. A. 1976. Predation, competition, life-history strategies, and the regulation of estuarine soft-bottom community structure Ph.D. thesis. Duke University, Durham, NC 201 p.

Corps of Engineers. 1977. Chesapeake Bay: Future conditions report. U.S. Army C.O.E. Norfolk, VA, multiple volumes.

Dietrich, C. S. 1979. Fecundity of the Atlantic menhaden, Brevoortia tyrannus. U.S. Natl. Mar. Fish. Serv. Fish. Serv. Fish. Bull. 77: 308-311.

Douglas, P. A. and R. H. Stroud. 1971. A symposium on the biological significance of estuaries. Sport Fishing Institute, Washington, D.C., 111 p.

Dryfoos, R. L., R. P. Cheek, and R. L. Kroger. 1973. Preliminary analyses of the Atlantic menhaden, Brevoortia tyrannus, migrations, population structure, survival and exploitation rates and availability as indicated from tag returns. Fish. Bull. 71:719-734.

Dubrow, D., M. Hale, and A. Bimbo. 1976. Seasonal variations in chemical composition and protein quality of Menhaden. Marine Fish. Rev. 38(9):12-16.

Frye, J. 1978. The men all singing. The story of menhaden fishing. Donning Co., Virginia Beach, VA. 242 p.

Goode, G. B. 1879. Man and the fisheries, p. 110-113. In G. B. Goode (ed.), The natural and economical history of the American menhaden. U.S. Comm. Fish., Rep. Comm., 1879, pt. 5.

Greer, R. L. 1914. The menhaden industry of the Atlantic coast. Rep. U.S. Comm. Fish. for 1914, Append. III, 27 p.

Guida, V. G. 1976. Sponge predation in the oyster reef community as demostrated with *Cliona celata* Grant. J. Exp. Mar. Biol. Ecol. 25:109-122.

Guthrie, J. F., and R. L. Kroger. 1974. Schooling habits of injured and parasitized menhaden. Ecology 55:208-210.

Gusev, E. E. 1964. Some peculiarities in menhaden morphology-*Brevoortia tyrannus* (Latrobe). [Translated by J. M. Moulton (Mimeo.) 4 p.] Contrib. Comm. Fish. Res. Arctic Basin (Murmansk) 2:13-16.

Harrison, R. W. 1931. The menhaden industry. U.S. Bur. Fish. Investigation Rep. No. 1. 113 p.

Higham, J. R., and W. R. Nicholson. 1964. Sexual maturation and spawning of Atlantic menhaden. Fish. Bull. 63:255-271.

Hilborn, R. 1975. The effect of spatial heterogeneity on persistence of predator-prey interactions. Theoret. Pop. Biol. 8:346-355.

Hildebrand, S. F. 1948. A review of the American menhaden, genus *Brevoortia*, with a description of a new species. Smithson. Misc. Coll. 107(18):1-39.

Hildebrand, S. F. 1964. Family Clupeidae, p. 257-454. In Fishes of the western north Atlantic. Sears. Found. Mar. Res., Mem. 1 pt 3.

Hoss, D. E., W. F. Hettler, and L. C. Coston. 1974. Effects of thermal shock on larval estuarine fish: Ecological implications with respect to entrainment in power plant cooling systems, p. 357-371. In J.H.S. Blaxter (ed.), The early life history of fish. Springer-Verlag, New York.

Huntsman, G. R., and R. B. Chapoton. 1973. Biostatistical data acquisition in the menhaden fisheries. Trans. Am. Fish. Soc. 102:452-456.

June, F. C. 1958. Variation in meristic characters of young Atlantic menhaden, Brevoortia tyrannus. Cons. Perma. I'nt. Explor. Mer., Rapp Proc. - Verb. Réunion 143(2):26-35.

June, F. C. 1961. Age and size composition of the menhaden catch along the Atlantic coast of the United States, 1957, with a brief review of the commercial fishery. U.S. Fish Wildl. Service, Spec. Sci. Rept. Fish. 373, 39 p.

June, F. C. 1965. Comparison of vertebral counts of Atlantic menhaden. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 513, iii + 12 p.

June, F. C. 1972. Variations in size and length composition of Atlantic menhaden groupings. Fish. Bull. 70:699-713.

June, F. C., and J. W. Reintjes. 1959. Age and size composition of the menhaden catch along the Atlantic coast of the United States, 1952-55; with a brief review of the commercial fishery. Natl. Mar. Fish. Serv., Spec. Sci. Rep. Fish. 317.

June, F. C., and J. W. Reintjes. 1976. The menhaden fishery, In M. E. Stansby (ed.), Industrial fishery technology. Rev. ed. R. E. Krieger, New York.

Keiser, R. K., Jr. 1976. Species composition, magnitude and utilization of the incidental catch of the South Carolina shrimp fishery. S.C. Mar. Res. Cnt., Tech. Rep. No. 16, 54 p. + Appendix.

Kendall, A. W., and J. W. Reintjes. 1975. Geographic and hydrographic distribution of Atlantic menhaden eggs and larvae along the middle Atlantic coast from R/V Dolphin cruises, 1956-66. Fish. Bull. 73:317-335.

Knowlton, C. J. 1972. Fishes taken during commercial shrimping in Georgia's close inshore ocean waters. Ga. Dept. Nat. Res., Div. Coastal Fish, Contrib. Ser. No. 20, 42 p.

Kroger, R. L., and J. F. Guthrie. 1973. Migrations of tagged juvenile menhaden. Trans. Am. Fish. Soc. 102:417-422.

Kroger, R. L., R. L. Dryfoos, and G. R. Huntsman. 1971. Movement of Atlantic menhaden tagged in New England waters. Chesapeake Sci. 12:114-115.

Kroger, R. L., G. B. Sekavec, and E. J. Levi. 1974. Loss of ferromagnetic tags when injected into the air bladder and abdominal cavity of Atlantic menhaden, Brevoortia tyrannus. J. Cons. Int. Explor. Mer. 35:244-248.

Lauff, G. H. 1967. Estuaries. (ed.). Publication no. 83. Amer. Assoc. Adv. Sci., Wash., DC. 757 p.

Liguori, V. A. 1967. Stability and change in the social structure of Atlantic coast commercial fisheries. Ph.D. dissertation, Princeton University, New Jersey.

Manooch, C. S., III. 1973. Food habits of yearling and adult striped bass Morone saxatilis (Walbaum), from Albemarle Sound, North Carolina. Chesapeake Sci. 14:73-86.

McHugh, J. L. 1967. Estuarine nekton. In G. H. Lauff (ed.), Estuaries, p. 581-620. Am. Assoc. Adv. Sci. Pbl. 83.

McHugh, J. L., R. T. Oglesby, and A. L. Pacheco. 1959. Length, weight, and age composition of the menhaden catch in Virginia waters. Limnol. Oceanogr. 4:145-162.

Menzel, R. W., E. W. Coke, M. L. Haines, R. E. Martin, and L. A. Olsen. 1976. Clam mariculture in northwest Florida: a field study on predation. Proc. Nat. Shellfish. Assoc. 65:59-62.

Merriner, J. V. 1975. Food habits of the weakfish. Cynoscion regalis, in North Carolina. Chesapeake Sci. 16:74-76.

National Marine Fisheries Service. 1973. Status of the international fisheries off the middle Atlantic coast. NE Fisheries Center, Lab. Reference no. 73-2. p. 102-105.

National Marine Fisheries Service. 1978. Fisheries of the United States, 1977. Current Fishery Statistics No. 7500, 112 p.

National Marine Fisheries Service. 1979. Fisheries of the United States, 1978. Current Fishery Statistics No. 7800. 120 p.

Nelson, W. R., M. C. Ingham, and W. E. Schaaf. 1977. Larval transport and year-class strength of Atlantic menhaden, Brevoortia tyrannus. Fish. Bull. 75:23-41.

Nicholson, W. R. 1971. Changes in catch and effort in the Atlantic menhaden purse seine fishery 1940-68. Fish. Bull. 69(4):766-781.

Nicholson, W. R. 1972. Fishing pressure and its influence on Monday catches of Atlantic menhaden in the Chesapeake Bay purse seine fishery. Chesapeake Sci. 13:215-218.

Nicholson, W. R. 1975. Age and size composition of the Atlantic menhaden, Brevoortia tyrannus, purse seine catch, 1973-71, with a brief discussion of the fishery. Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish. 684. 28 p.

Nicholson, W. R. 1978. Movements and population structure of Atlantic menhaden by tag returns. Estuaries 1:141-150.

Nicholson, W. R., and J. R. Higham. 1964. Age and size composition of the menhaden catch along the Atlantic coast of the United States, 1959; with a brief review of the commercial fishery. U.S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. 478. 34 p.

Orbach, M. K. 1978. Social economic and cultural factors in the Atlantic menhaden labor force. Unpublished report to the S&S Committee, document series reference No. 78-III-18. 10 p.

Oviatt, C. A. 1977. Menhaden, sportfish, and fishermen. Univ. R.I. Mar. Tech. Rep. 60. 24 p.

Pacheco, A. L., and G. C. Grant. 1965. Studies of the early life history of Atlantic menhaden in estuarine nurseries. Part I. Seasonal occurrence of juvenile menhaden and other small fishes in a tributary creek of Indian River, Delaware, 1957-58. U.S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. 504. 32 p.

Paloheimo, J. E., and L. M. Dickie. 1970. Production and food supply. In J. H. Steele (ed.), Marine food chains, p. 499-527. University of California Press, Berkeley.

Parker, R. O. 1973. Menhaden tagging and recovery. Part II. Recovery of internal ferromagnetic tags used to mark menhaden, genus Brevoortia. Mar. Fish. Rev. 35(5-6):36-39.

Pristas, P. J., and R. P. Cheek. 1973. Atlantic thread herring (Opisthonema oglinum) movements and population size inferred from tag returns. Fish. Bull. 71:297-301.

Pristas, P. J., and T. D. Willis. 1973. Menhaden tagging and recovery. Part I. Field methods for tagging menhaden, genus Brevoortia. Mar. Fish. Rev. 35(5-6):31-35.

Reintjes, J. W. 1960. Continuous distribution of menhaden along the south Atlantic and Gulf coasts of the United States. Proc. Gulf Carib. Fish. Inst. 12th Annu. Sess., pp. 31-35.

Reintjes, J. W. 1961. Menhaden eggs and larvae from _M/V Theodore N. Gill_ cruises, south Atlantic coast of the United States, 1953-54. U.S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. 393. 7 p.

Reintjes, J. W. 1964. The importance of the occurrence of menhaden in the coastal waters and estuaries of peninsular Florida. Proc. Gulf Carib. Fish. Inst. 16th Annu. Sess., pp. 108-113.

Reintjes, J. W. 1969. Synopsis of biological data on the Atlantic menhaden, _Brevoortia tyrannus_. U.S. Fish. Wildl. Serv. Circ. 320. 30 p.

Reintjes, J. W. and A. L. Pacheco. 1966. The relation of menhaden to estuaries. Amer. Fish. Soc. p. 50-58, Special Publication No. 3, 1966. A symposium on Estuarine Fisheries. Washington, DC.

Roithmayr, C. M. 1963. Distribution of fishing by purse seine vessels for Atlantic menhaden, 1955-1959. U.S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. 434. 22 p.

Schaaf, W. E. and G. R. Huntsman. 1972. Effects of fishing on the Atlantic menhaden stock: 1955-1969. Trans. Am. Fish. Soc. 101:290-297.

Schaaf, W. E., J. E. Sykes, and R. B. Chapoton. 1975. Forecasts of Atlantic and Gulf menhaden catches based on the historical relation of catch and fishing effort. Mar. Fish. Rev. 37(10):5-9.

Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Inter. -Am. Trop. Tuna Comm. Bull. 1(2):27-56.

Schaeffer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Inter. -Am. Trop. Tuna Comm. Bull. 2:247-268.

Shaw, E. 1978. Schooling fishes. Amer. Scientist 66(2): 166-175.

Slobodkin, L. B. 1968. How to be a predator. Am. Zool. 8:43-51.

Smith, R. F., A. F. Swartz, and W. H. Massmann. 1966. A symposium on estuarine fisheries. Amer. Fish. Soc., Spec. Publ. no. 3. 154 p.

Stephens, E. B., M. W. Newman, A. L. Zachary, and F. M. Hetrick. 1980 A viral aetiology for the annual spring epizootics of Atlantic menhaden Brevoortia tyrannus (Latrobe) in Chesapeake Bay. Jo. Fish. Diseases. 3:387-398.

Sutherland, D. F. 1963. Variation in vertebral numbers of juvenile Atlantic menhaden. U.S. Fish. Wildl. Serv., Spec. Sci. Rept. Fish. 435, 21 p.

Sykes, J. E. and C. S. Manooch, III. 1979. Estuarine predator-prey Relations. In Predator-prey systems in fisheries management. Henry Clepper, (ed.), Sport Fishing Institute, Washington, DC. 501 p.

Thompson, J. M. 1976. Prey strategies of fishes in evolution and ecology - or how to stay alive long enough to fertilize some eggs. Environ. Biol. Fish. 1:93-100.

Virnstein, R. 1976. The effect of predation by epibenthic crabs and fishes on benthic infauna in Chesapeake Bay. Ph.D. thesis, College of William and Mary, Williamsburg, VA. 87 p.

Washington Academy Sciences Journal. 1972. Science and the Environment (II): The fate of the Chesapeake Bay. Vol. 62(2).

Whitehurst, J. W. 1973. The menhaden fishing industry in North Carolina. Univ. N.C. Sea Grant Publ. No. UNC-SG-72-12, 51 p.

Wilkins, E. P. H., and R. M. Lewis. 1971. Abundance and distribution of young Atlantic menhaden, Brevoortia tyrannus, in the White Oak River estuary, North Carolina. Fish. Bull. 69:783-789.

Young, D. K., and M. W. Young. 1977. Community structure of the macrobenthos associated with seagrass of the Indian River Estuary, Florida. In B. C. Coull (ed.), Ecology of marine benthos, p. 359-381. University of South Carolina Press, Columbia.

Atlantic States Marine Fisheries Commission
1717 Massachusetts Avenue, N.W.
Washington, D. C. 20036

June 25, 1982

CHAIRMAN:
SPENCER APOLLONIO
DEPARTMENT OF MARINE
RESOURCES
STATE HOUSE ANNEX
AUGUSTA, MAINE 04330

EXECUTIVE DIRECTOR:
IRWIN M. ALPERIN
(202) 387-5330

VICE CHAIRMAN:
RALPH W. ABELE
PENNSYLVANIA FISH
COMMISSION
P. O. BOX 1673
HARRISBURG, PA 17120

MEMBER STATES:
CONNECTICUT
DELAWARE
FLORIDA
GEORGIA
MAINE
MARYLAND
MASSACHUSETTS
NEW HAMPSHIRE
NEW JERSEY
NEW YORK
NORTH CAROLINA
PENNSYLVANIA
RHODE ISLAND
SOUTH CAROLINA
VIRGINIA

At the October annual meeting of ASMFC a FISHERY MANAGEMENT PLAN FOR ATLANTIC MENHADEN was unanimously adopted by the Commission's member-States. This plan, dated August, 1981 was prepared for introduction to the Commission by the Atlantic Menhaden Management Board of the Interstate Fisheries Management Program (ISFMP). For the record, all States except Pennsylvania (which does not have a fishery for this resource), Maine and New Hampshire, had previously declared an "interest" in Atlantic menhaden, and in accordance with the Compact and Rules and Regulations were entitled to have a recorded vote in respect to any action taken on this species.

The FMP for Atlantic Menhaden contained a short-term management goal recommendation that 10%(by number) of the purse-seine landings of Atlantic menhaden be made up of age 3 and older fish. On May 19, 1982 at sequential meetings of the Atlantic Menhaden Implementation Sub-committee and the Atlantic Menhaden Management Board, and with the advice of the Atlantic Menhaden Advisory Committee, it was declared by the Board "that the short-term goal of 10% age 3 and older is not a practical, attainable goal ...".

Further, the Board discussed the announced intention of Seacoast Products' Co., Inc., of Port Monmouth, NJ, 2-year moratorium on Atlantic menhaden fishing, which would remove approximately 8-10% of the fishing effort on the Atlantic Coast. Positive and negative aspects of Seacoast Product's cessation of fishing during the 1982 and 1983 seasons was presented by the NMFS Beaufort Laboratory. One of the beneficial aspects would be a reduction in the catch of spawning-age fish (3 years and older).

The Atlantic Menhaden Implementation Subcommittee accepted a management option which would shorten the purse-seine fishing season in each area by approximately 4 weeks. The Atlantic Menhaden Management Board adopted this management measure for opening and closing of purse-seine fishing as follows:

Area*	Opening Period	Closing Period
North Atlantic	5/17-5/23	10/04-10/10
Middle Atlantic	5/17-5/23	10/11-10/17
Chesapeake Bay	5/17-5/23	11/08-11/14
South Atlantic and Fall Fishery	4/12-4/18	12/13-12/19

*1. Area 1 = North Atlantic: Waters along the southern coast of Long Island, east of a line due south of Moriches Inlet, Long Island Sound, and waters northward.

2. Area 2 = Middle Atlantic: Waters north of great Machipongo Inlet, Va. to a line running due south of Moriches Inlet (lat. 40° 46' N. and long. 72° 44' W.) on the southern coast of Long Island, N.Y

3. Area 3 = Chesapeake Bay: Chesapeake Bay proper and coastal waters outside the Bay lying between False Cape and Great Machipongo Inlet, Va. (lat. 37°32'N. and long. 75°43'W.).

4. Area 4 = South Atlantic: Waters between Cape Canaveral, Fla. and a line running due east from False Cape, Va. (lat. 36°35'N. and long. 75°53'W.).

5. Area 5 = "Fall Fishery": Temporal "Area" in North Carolina (Nov.-Jan.).

Upon adoption of the motion to effectuate this management option, ASMFC was instructed to recommend to all states in which purse-seine fishing for Atlantic menhaden is conducted the implementation of this regulation.

By this letter you are so advised to take such action(s) as may be required to implement this management measure.

Sincerely,

Irwin M. Alperin
Executive Director

(for the Atlantic Menhaden Management Board and the Interstate Fisheries Management Program Policy Board).

/s

cc: Allen E. Peterson