

THURSDAY—NOVEMBER 29

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**The Status of Scientific Knowledge about the Red Snapper  
(*Lutjanus aya* Bloch) and the Economic Importance  
of this Fishery**

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ABSTRACT

Although the red snapper was found to be the third largest fin fishery in the Gulf of Mexico, there was a paucity of scientific information on this animal. Various programs were suggested to fill the gaps of ignorance in order to further develop the industry.

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**Biological Investigation of Atlantic Coast Menhaden**

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INTRODUCTION

THE MENHADENS of North America constitute a resource supporting the largest fishery in the Western Hemisphere. In 1955 landings amounted to over 1.8 billion pounds, or roughly 40 per cent of the total fish production in the United States.

The bulk of the catch is taken by purse seine vessels operating from reduction plants located on the Atlantic and Gulf coasts. A small, but significant, quantity also is taken by pound nets in the middle Atlantic region and in Chesapeake Bay. The catch is processed into fish meal, oil, and condensed solubles.

Four species of menhadens occur throughout the range of the fishery; however, the Atlantic form, *Brevoortia tyrannus*, is by far the most important. It comprises an estimated 75 per cent of the combined annual menhaden production. A second species, *B. smithi*, occurs on the Atlantic coast, but it is of no importance to the fishery at present.

The large-scale commercial fishery for menhaden had its beginning in the late 1850s when the mechanical screw press was adopted for recovering the oil. The fishery subsequently grew rather slowly until about 1870 when the use of steam and the hydraulic press for processing the fish enabled the factory stage to become fully developed. The fishery during this period of expansion was centered in the Gulf of Maine and extended southward along the middle Atlantic coast to southern New Jersey. By 1876 the factories processed approximately 310,000,000 pounds of fish to produce nearly 3,000,000 gallons of oil and over 50,000 tons of fertilizer. In the 1880s the center of menhaden produc-

tion shifted to the middle Atlantic region following the disappearance of the fish in the waters north of Cape Cod. Subsequently, the fishery expanded southward along the Atlantic coast and into the Gulf of Mexico.

The recent growth of the Atlantic coast fishery is illustrated in Figure 1, showing the landings from 1929 through 1953. It may be seen that the fishery has undergone a marked increase over the 25 year period, with fluctuations clearly evident. The rise in the 1940s was due, in part, to the increased demand for fish meal as an animal feed ingredient. The discovery of vitamin B<sub>12</sub> as an important constituent of the animal protein factor found in fish meal emphasized the importance of menhaden as a source of this product. Undoubtedly the marked decline of the California sardine and Pacific herring fisheries contributed greatly to the increased demand for menhaden meal.

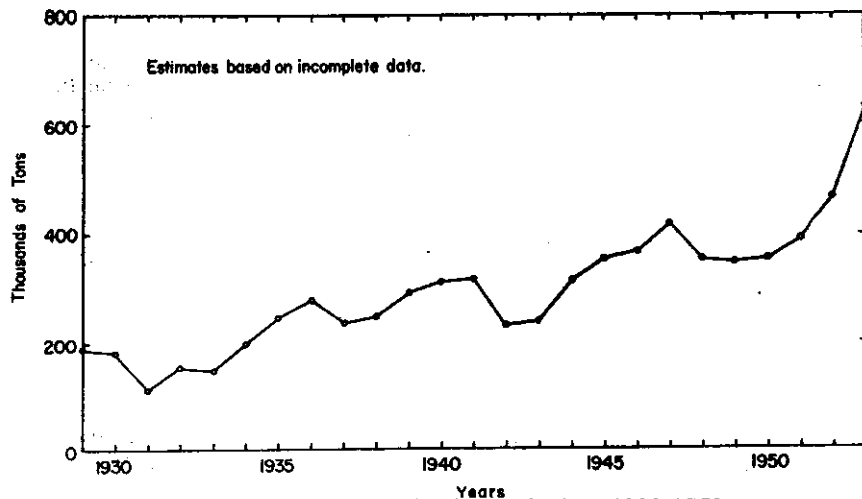


FIGURE 1. Catch of Atlantic menhaden, 1929-1953.

The menhaden fishery, from its inception, has been subject to great variations in yield. The catch in one region of the coast sometimes differs markedly from those in other regions, or even in adjacent localities in the same season, and periods of high production in a given locality often are followed by several years of poor fishing. Perhaps the most striking example of these vicissitudes was the complete collapse of the fishery in New England in the 1880s. In 1876 seventeen factories located in Maine utilized nearly 142,000,000 pounds of menhaden. Several years later the fish had almost completely disappeared, and except for one or two seasons, they did not return to those waters for nearly 50 years. Since 1950, production in the Gulf of Maine has gradually increased, and a modern record, based on preliminary data, of over 66,000,000 pounds were produced in 1956.

#### BIOLOGICAL INVESTIGATIONS

An investigation of the menhadens of the Atlantic coast was undertaken early in 1955 by the U. S. Fish and Wildlife Service. The program is an expansion of preliminary biological studies initiated in 1952. The program of investi-

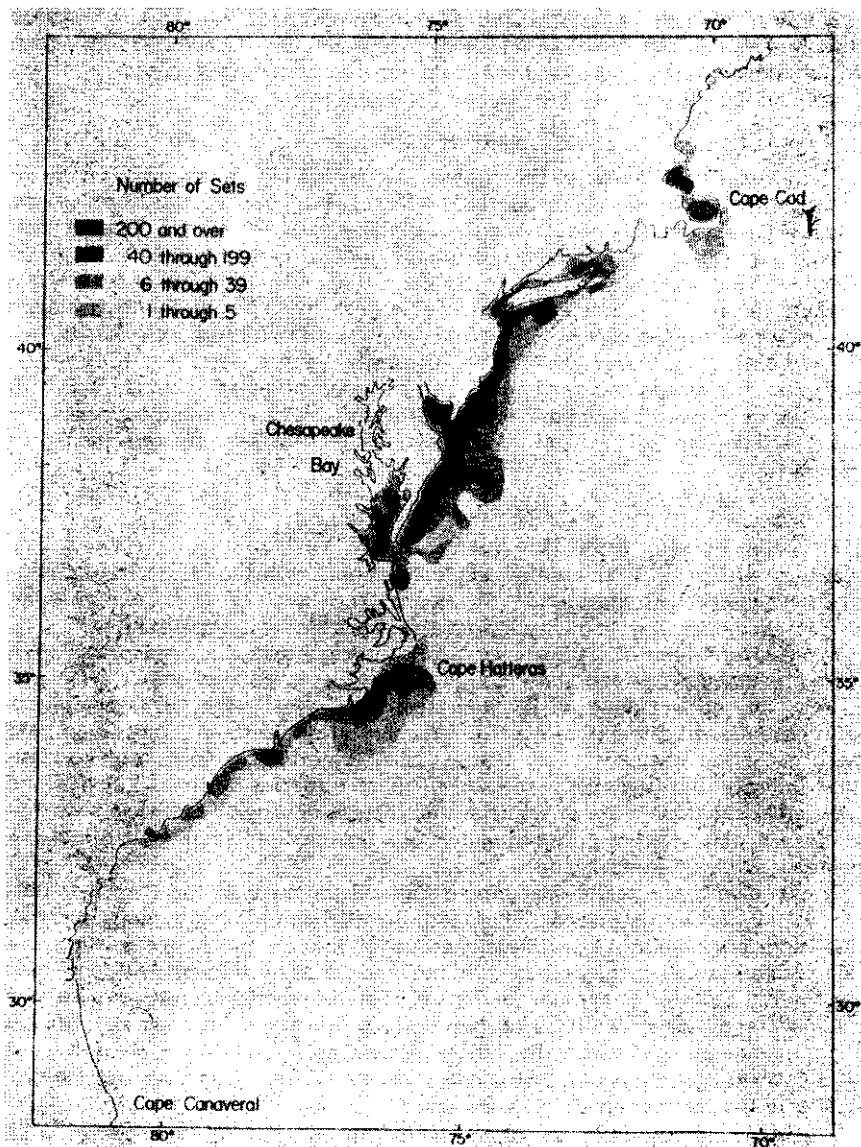


FIGURE 2. Geographical distribution of purse seine fishing, 1955.

gation is designed to determine the causes of fluctuations in the fishery and the extent to which these are predictable. Since *Brevoortia tyrannus* at present is the only important species in the commercial fishery in the Atlantic, research activities, for the most part, have been limited to this species. The immediate objectives of the work are to (1) determine the structure and relationships of populations, (2) gather knowledge respecting its life history and biology, and

(3) follow changes in the age and size composition of the stock in relation to fluctuations in the catch. In addition, measurements of catch, fishing effort, and abundance are being compiled from records of landings at the reduction plants and fishing logbooks kept by the fishermen.

#### DISTRIBUTION

The present distribution of the Atlantic menhaden (*B. tyrannus*) is known to include the area roughly from Boothbay Harbor, Maine, southward to Daytona Beach, Florida, and offshore to a distance of less than 75 miles. It is not found in equal abundance throughout this range, but is concentrated in localities where feeding conditions appear to be most favorable. It is found in greatest numbers during the warmer months of the year when the fish congregate at the surface in schools of many thousands and even millions of individuals.

The commercial fishery covers the presently known range of this species. In Figure 2 is shown the geographical distribution of purse seine fishing, with the areas of heaviest concentration shaded more heavily. The data on which the figure is based are taken from fishing logbook records kept by vessel captains and pilots.

#### POPULATIONS

Since the Atlantic menhaden occupies some 3,000 miles of coastline, it is necessary first of all to determine whether it exists as a single, freely intermingling and interbreeding group of fish, or whether there are several independent or semi-independent groups, each with its own biological peculiarities.

From several lines of evidence we have concluded tentatively that there exists at least two distinct populations. Comparisons of average numbers of vertebrae, fin rays, and ventral scutes of juvenile menhaden reveal rather large differences between those fish inhabiting estuarine nursery areas north of Long Island and those occurring south of Long Island. Furthermore, size frequency distributions indicate that juveniles occurring in those estuaries north of Long Island reasonably could not have arisen from the same spawning as those from farther southward. Those from northern waters are considerably smaller than those in estuaries south of Long Island.

It is known that a major spawning occurs off the coast of the Carolinas during the fall and winter months. There also is evidence to indicate that a separate spawning, presumably by a different group of fish, occurs in waters north of Long Island in the spring and early summer under very different environmental conditions. Thus, it is hypothesized that adult fish segregate into at least two distinct groups for spawning, and the observed differences in body structure of juveniles are induced either by inherited tendencies which are preserved, or differences in environmental conditions at the time of spawning, or they may result from the interaction of both influences.

Persistent differences in size of menhaden of the same age also occur. Two and three year old fish, for example, are larger in the northern limit of the geographical range of a year class; smaller fish occur farther south, while those intermediate in size are found in the central region. These differences are believed to represent differences in growth rates arising from different populations.

We also are studying body structure of spawning fish from both the northern and southern areas to determine whether they differ and the extent to which they resemble juveniles from adjacent nursery areas. However, progress on this work has been too limited to permit any conclusions at this time.

## LIFE HISTORY AND BIOLOGY

Knowledge of the basic features in the life history and biology of menhaden and their relation to the physical and biological environment is essential to understanding changes within populations and their effects on the fishery. If the events in the life history of each year class could be followed closely from the time of its origin as eggs on the spawning grounds, it is likely that the reasons underlying its success or failure could be adduced. Certain stages in the early life history, for example, may be found to be especially critical, explaining why variations in year class survival occur. Thus, determination of the causes of variation in mortality rates of eggs and young would aid in predicting the abundance of year classes.

To provide a frame of reference for the execution of an investigation of this type, we have begun with the earliest stage in the life history, i.e. spawning. Detailed studies are being made of the gonads of fish sampled from the pound net and purse seine fisheries throughout the year to determine the times and places of spawning and the size and age at which sexual maturity is attained. In addition, limited plankton work, both at sea and in estuaries, is being conducted to determine the distribution of eggs and larvae in time and space.

Results thus far obtained indicate that spawning occurs over a wide geographical range and during the entire year. Spawning appears to be largely concentrated in the fall and winter months off the coast of the Carolinas. This spawning appears to have its beginning in the vicinity of Long Island, and possibly farther northward, in the fall when a southward movement of the fish is in progress. Based on extensive sampling of the catches over the past three years, all fish present in those waters at the close of the fishing season in October have been found to be sexually mature; however, roughly only 60 per cent are in spawning condition. The remainder, comprising fish of the same size and age, are in non-spawning condition. Several weeks later identical size and age groups of fish occur in the fishery off the North Carolina coast, but only fish in spawning condition have been found in our samples to date. These findings suggest that although fish in varying stages of sexual development occur together in northern waters in late summer and early fall, spawning fish somehow become segregated from non-spawning individuals between the time of the disappearance of the former group from Long Island waters after the close of the purse seine fishing season and the appearance of spawning fish in North Carolina waters a short time later. Indeed, fish in non-spawning condition, representing the same size and age groups, have been taken in large numbers by the pound net and mackerel gill net fisheries along the New Jersey coast at the same time that spawning fish make their appearance in North Carolina waters.

It also appears that a later spawning takes place in waters north of Long Island in spring and early summer. Fish with gonads in developing stages of ripeness enter the pound net fisheries in the vicinity of Raritan Bay and central Long Island normally in March and April. Within a period of several weeks, these fish disappear from the fisheries, and a short time later, identical size groups, with many individuals in partially spawned-out condition and others in advancing stages of ripeness, make their appearance in the pound net catches in the vicinity of Block Island. Nowhere else along the coast are fish in spawning condition encountered at that time of year.

We presently are developing a method, based on ova diameters and ovary weight, of determining rapidly and objectively the stages of maturity of the

gonads to provide more efficient and extensive information concerning these phenomena.

Present knowledge indicates that spawning and early larval development take place entirely in the ocean and possibly are limited to the waters over the continental shelf. Some time after absorption of the yolk sac, the larvae enter estuaries and bays and spend the following several months of their life in these nursery areas. In the fall the juveniles emigrate from the estuaries and apparently migrate southward, for they occur in tremendous numbers along the coast of North Carolina in late fall, and frequently large schools may be seen along the shore in northern waters traveling in a southward direction. Furthermore, during the following summer these fish appear as one year-olds only in the southern and central parts of the range. Such a distribution would be possible only if juveniles migrated into those waters sometime after they left the estuaries.

Investigation of the biology of larval menhaden also is being conducted under controlled conditions in the laboratory. Preliminary studies of their feeding habits, using radioactive tracer elements, suggest that, following absorption of the yolk sac, they feed mostly on copepods, a small crustacean. A change in feeding habits is believed to occur when the gill rakers (a straining apparatus) become developed. At this later stage their food consists predominantly of microscopic plants and animals, including diatoms and flagellates. Other experimental studies are concerned with rearing larvae under different conditions of temperature and salinity to determine the effects of these factors on growth and morphology.

An intensive study of the estuarine life of juvenile menhaden also is being carried on at our field laboratory located at Indian River, Delaware to determine (1) mortality rate, (2) growth, (3) amount of intermingling of juveniles within the estuary, (4) feeding habits and food preferences, and (5) responses of populations to changes in physical and biological features of the environment.

Results of this work indicate that juveniles do not occur randomly in the nursery areas, but tend to be congregated where phytoplankton production is highest. Growth under these conditions is rapid, for by the time that they are ready to emigrate from the estuaries in the fall, young fish have attained a maximum length of about six inches. Varying conditions of salinity, temperature, and oxygen also influence the distribution and behavior of juveniles in the estuaries. The most difficult problem concerned with the estuarine phase of the program is to devise suitable measures of mortality rate and abundance. The findings to date respecting these two features are inconclusive, but some have been noted which will form a basis for future work.

Following their early life in the estuaries, menhaden appear to be restricted to the littoral, or coastal, waters to roughly the 20-fathom curve. One of the most outstanding characteristics of the fish is its tendency to aggregate into dense schools near the surface. A further feature, significant to the study of its biology, is the tendency of individuals of the same size to school together. So far as we know, juveniles, following their emigration from estuarine nursery grounds, always school separately. One year old fish usually do, but the largest may join schools of smaller two year old fish. Furthermore, differences in the size distribution of samples from schools in a given area indicate a tendency for schools of a given size range to occur together distinct from those of an adjacent, but overlapping area.

Sampling of the catches to obtain estimates of various parameters of the popu-

lation, therefore, involves drawing samples from a large number of different schools over the range of the fishery during given time periods. The main purpose underlying this phase of the investigation is to study variations in the strength of successive year broods, or year classes, of fish and their effect on the catch. These data also will furnish information on growth, migrations, mortality rates, and the population structure of the stock. In addition, information is being obtained on other pertinent biological features, including length and weight of fish at each age, sex ratio, and spawning.

Our present sampling program consists of obtaining representative samples of the catches at each location along the Atlantic coast where pound net and purse seine fisheries are active. The number of samples taken is roughly proportional to the catch in each locality.

The results of this work over the past two years reveal several outstanding features. Most important of these, perhaps, deals with the distribution of size and age groups in the fishery. During the summer months the older, sexually mature fish occur only in northern waters, while the younger, sexually immature fish occur only in the southern and central parts of the range. The data further indicate that one year old fish gradually move northward during the summer, and by late summer, most of the one year old fish have disappeared from southern waters. In each succeeding year this northward movement of a year class becomes more pronounced. Thus, a gradual mixing of size and age groups takes place. A southward migration occurs in the fall and early winter when those size and age groups occurring in the summer fishery north of Cape Hatteras appear in the fall and winter fishery off the coast of North Carolina. There appear to be slight variations in this generalized pattern of distribution from year to year. One year old fish, for example, may occur as far northward as New Jersey in some years, while in other years, they may reach no farther northward than Virginia. Furthermore, during mild winters, one and two year old, sexually immature fish apparently do not all move southward, for great numbers are taken in the pound net and gill net fisheries off the Maryland and New Jersey coasts.

Another significant finding is that marked variation in year class strength is evident. Although not completely documented, the 1951 year class, for example, predominated in the catch for several years and still is contributing an important share of the landings. The 1952 year class, on the other hand, appears to have been a rather poor one and has contributed relatively little to the fishery. A great deal remains to be learned, but sufficient data are being accumulated to assess this feature of the fishery.

#### MEASUREMENTS OF CATCH

Measurements of the abundance, amount of fishing effort, and total catch of menhaden are essential for evaluating and interpreting fluctuations in the fishery. These statistics require detailed data over a series of years regarding the time, place and amount of the catches, together with information on the amount of fishing effort that is required to take them. Such information is being obtained from the records of individual vessel landings kept by the processing plants and from fishing logbooks kept by the fishing fleet.

Measurements of total catch, apparent abundance, and total fishing effort have been completed for the middle Atlantic area from 1939 through 1954. A second measurement of apparent abundance is being calculated based on the

logbook data. The two series of measurements will be compared to determine if they indicate the same conclusions.

Compilation and analyses of these basic data have been partially completed for the south Atlantic and Chesapeake Bay areas. Progress on this phase of the program has been slow because of the great bulk of material; however, we hope to complete the analysis of the historical data during the coming fiscal year.

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## **Studies on the Life History of the Spotted Sea Trout, *Cynoscion nebulosus* (C. & V.)**

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### ABSTRACT

Apparent declines in inshore fish population have been reported for a number of years. These declines, particularly since 1945, in Florida have been attributed to such factors as the increasing number of tourists, new residents, land drainage, pollution, etc. The spotted sea trout is fairly well represented along the coastline from Virginia to Mexico. This study limits itself to the area between Stuart and Titusville on the Florida east coast. Studies of spawning, age, growth, food habits and abundance are being carried out.

Information is being obtained to establish the relative percentage of the total catch provided by each segment of the fishery—sport hook and line, commercial hook and line and commercial gill netters.

Studies as to seasonal trends in availability and seasonal migrations are also being conducted.

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## **Field and Laboratory Observations on the Growth of some Bermuda Reef Fisheries\***

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MOST TROPICAL AND SUB-TROPICAL FISHERIES have as yet not been under sufficient scrutiny to allow an estimate of the rates of fish production, or even, for that matter, of the numbers of fish present at any one time. Bermuda waters can, with some license, be called sub-tropical. Here the fishery pursued relies primarily on reef-bound species rather than on pelagic fish (Mowbray, 1947). The fishing area is relatively small and clearly defined and lends itself well to field observations. Fishery research in Bermuda might, therefore,

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