Woods Hole Laboratory
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Redfish Production Has Climbed Steadily

George F. Kelly* Reveals That Catch Reached Peak in 1951; Three-Quarters of Stocks Now on Grounds are Mature Fish

THE commercial redfish industry, which first started in 1935, developed hand in hand with the new freezing and processing technology of the past 20 years. It has been a constantly expanding fishery, the highest catch having been taken in 1951. There has been a shifting of fishing effort eastward through the years so that the bulk of the catch, originally made in the Gulf of Maine, now comes from the Nova Scotian Banks. Fishing has been started on the Grand Banks during the past two years and is rapidly increasing in that area. A movement of the industry to the northward also has started and Canada is in a very favorable position for the expansion of her redfish industry.

The redfish, *Sebastes marinus*, is the fish that has been most recently exploited commercially in the North Atlantic region. Although it is one of the most abundant fishes throughout most of the northern Atlantic Ocean, it has not been fished heavily except in the Gulf of Maine and along the coast of Nova Scotia. The commercial redfish industry is an otter trawl fishery and almost 70% of the catch is made by medium otter trawls (50-150 gross tons).

A new fishery of this sort must start by harvesting the untouched stocks of fish and will inevitably reach a point of reduced returns. It may then either continue at a reduced level of equilibrium or may fall dangerously to serious depletion, depending on the destructiveness of heavy fishing effort and the ability of the fish to withstand exploitation. Our index of abundance shows that the catch-per-unit-of-effort has stabilized in the Gulf of Maine at about 10 thousand pounds per twelve-hour-day, whereas the Nova Scotian grounds are approaching stability at a level between 15 and 20 thousand pounds per day.

The purpose of biological research of the redfish is to measure the extent of fish stocks and evaluate the breeding potential of the fish so as to have a sound basis for recommendations to maintain the fishery at a profitable level.

Distribution of Redfish

Although the extent of redfish stocks in the North Atlantic is not completely known, the fish does occur in almost all deep waters from Cape Cod northward along Newfoundland, Labrador and Greenland eastward to Iceland and northward along the coast of Norway to the Barents Sea. All of the present commercial catch is taken on the bottom; however, the fish has been caught by Europeans at depths of 100-150 fathoms out in the open ocean over depths of 1000 fathoms or greater. This indicates that the fish is not a true bottom fish but may occur off the bottom in depths where food and proper temperature conditions prevail.

In the Gulf of Maine and Nova Scotian waters there is no evidence of migration of redfish. The average size of fish from different fishing areas remains fairly constant and a consistent difference from one year to the next is maintained between the average sizes from these areas. Tagging of the fish has not yet been possible because of the difficulty of bringing the fish up from the depths in lively condition.

In the Gulf of Maine a copepod ectoparasite attacks the redfish, appearing as an external pendulous body. An analysis of the incidence of the parasite on the redfish discloses that areas of heavy concentration of the parasite exist and that distinctly different incidence values are maintained in closely allied fishing grounds. This indicates that there is comparatively little mixing of fish from one fishing ground to the next. The copepod does not occur along the Nova Scotian banks but does again appear to the eastward on the Grand Banks and more abundantly to the north along the coast of Labrador. This evidence also indicates that there is no general movement of the fish from one bank to the next, which move-

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Large catch of redfish comes to surface in small experimental trawl used by Woods Hole (Mass.) Oceanographic Institution during recent exploratory fishing in deep water off New England coast. The redfish found were considerably larger than those ordinarily caught.

97' redfish dragger "Paul Howard", owned by United Fisheries Vessels Co., Gloucester, Mass., and skippered by Capt. John Norte. During the vessel's recent overhaul, her 400 hp. Atlas main engine was moved aft 5 feet to increase fish hold capacity to 175,000 lbs. A 120 hp. Murphy Diesel operates her New England winch, and she has Bowers MLL-21 batteries.

* Fish & Wildlife Service biologist stationed at Woods Hole, Mass. This address was presented at the recent annual meeting of the Atlantic States Marine Fisheries Commission in Boston, Mass.

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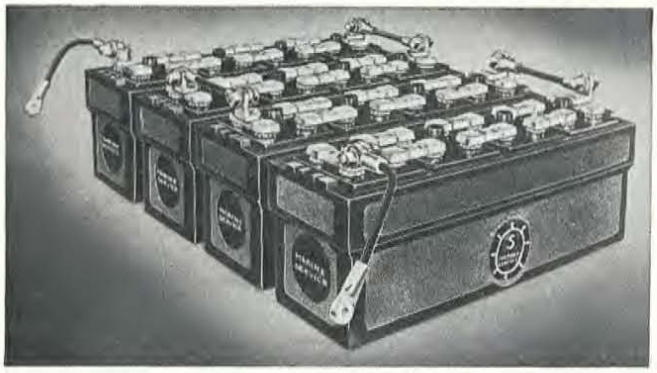

Redfish Production

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ment would result in a homogeneous distribution of the parasite wherever the redfish occurs.

Biological Characteristics

Most of our knowledge of the redfish has been based on material gathered from the commercial catch. This has afforded a great deal of knowledge of the quantities and sizes of fish taken, but has left much unknown of the biology of the fish. Since the fish comes from deep water it is rarely observed and almost never taken alive. Consequently, spawning habits, feeding habits and the rate of growth of the fish have not been clearly understood. A resume of the known and unknown facts of the life-history will show something of the results of our research.

Under present classification, *Sebastes marinus* includes both the very large European redfish and the smaller Western Atlantic redfish. Superficially the fishes are identical, but the European fish grows to a much greater size. There is some evidence to indicate the existence of subspecific differences; however, it is also possible that the differences can be attributed to the fish's response to different ecological conditions.

A study has been started to compare redfish from several of our fishing areas with specimens from more northerly Canadian and European grounds. This is intended to better establish the taxonomic classification of the fish stocks and to endeavor to establish the pattern of growth variations and perhaps find the ecological factors affecting the growth rate.

The size composition of samples of fish taken from the central Gulf of Maine has not changed appreciably since 1936. The most noticeable trend has been the increase in the range of sizes landed, there being more large and more small fish in the catch since 1942. The majority of the fish for all years are mature. This would indicate that the stock, although diminished, has not been reduced dangerously to a point where only small, immature fish remain.

Age Determination Studies

The length-weight relationship of the redfish shows that an 8" fish, the size at which they first enter the fishery, is a little over half a pound in weight. This is a relatively small fish when compared with other market species, but is a size adaptable to frozen fillet packaging.

A proper understanding of the age and rate of growth of a species is necessary to evaluate the success of year-classes of fish and to analyze the effects of natural and fishing mortality. A method for determining the age of redfish has been difficult to establish. Perlmutter and Clarke in 1949 published a growth curve for immature redfish based on annulus readings from scale impressions which showed the growth rate to be about one inch per year. The scale readings were accurate only through age nine, and since this is about the age when the fish are entering the fishery, it is not applicable for determining the age composition of the commercial sizes.

During the past year we have carried the age determination further, using fish ear-bones or otoliths for reading annulus bands. It is possible to read ages of all commercial sizes of fish, readings into the twenties being common. The highest reading to date has been 41.

Most of our age determination work has been concentrated on fishes from the Gulf of Maine. The growth curve shows that the females grow considerably faster than the males. Although our work on other areas has been only preliminary, it appears that the growth rate may be higher or lower than that of the Gulf of Maine. The growth rate for Western Hole redfish is lower than that for the Gulf of Maine. Age readings of a small sample of large fish from the coast of Norway show that the growth rate is much higher than that of the Gulf of Maine.

Spawning Season

During 1951 and 1952 much has been learned about the spawning season of the redfish. From our sampling we

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have found that in our area spawning starts earliest out at the eastern end of Nova Scotia and progresses into the Gulf of Maine. We have established for some areas the time of fertilization of the eggs, the length of the incubation period and the length of the spawning season.

Using one-hundred fish samples and recording the percentage of fertilized females, unfertilized females and ripe males it is possible to plot the progress of breeding and spawning. In the Gulf of Maine, fertilization of the eggs starts in March and the first young are spawned about the first of May. The incubation period runs from 50 to 60 days; however, from the onset of fertilization till the last fry are spawned encompasses almost six months.

More Mature Than Immature Fish

In considering the breeding potential of a species it is necessary to know the condition and extent of the breeding stocks. This includes knowledge of the ratio of mature to immature fish, the success of the spawning, measured as percent of adult fish spawned, and the fecundity of the females.

In almost all of the areas sampled the mature fish outnumbered the immature fish. In the Gulf of Maine about 72 percent of the catch was of mature fish, whereas on the Nova Scotian banks about 64 percent of the males and 68 percent of the females were mature. Limited samples from the Grand Banks and the Gulf of St. Lawrence show between 85 and 98 percent of the catch to be mature.

The size at which the fish mature varies from one area to the next. In all of the areas sampled, 100 percent of the mature fish were found to be successful breeders. Even in the most heavily fished areas almost three-quarters of the fish available to the fishery are spawners, and an adequate brood stock is being maintained.

The fecundity of the female fish is related to the size of the fish. The larger fish develop larger ovaries and spawn higher numbers of fry; however, the fecundity values vary from one fishing area to another. The relationship of unfertilized egg-count to length of fish shows that in the Gulf of Maine a 12" fish produces about 48 thousand eggs. The resulting fry count of the same sized fish shows only about 25 thousand fry produced. This is about a 50% mortality during the incubation period, but compared to fish having externally fertilized eggs, it is a relatively low embryo mortality.

In summary, our research shows that the redfish stocks throughout the New England and Nova Scotian region are composed of about three-quarters mature fish, and that the fish are successfully spawning wherever they are found.

Oysters Successfully Grown in Salt Ponds in Massachusetts

John Mayhew and John Whiting of Martha's Vineyard, Mass., are using a salt water pond of one square mile for commercial growing of oysters. The pond is separated from the ocean by a sand beach. When new water is needed an inlet is dug through the sand to permit the entrance of ocean water. In this manner the salinity is controlled within ranges which are desirable to the oysters.

This is believed to be the first successful example of commercial pond culture of oysters, although oysters have been grown successfully in tanks on many occasions in the past. Dr. Robert Lunz, Bears Bluff Laboratory, South Carolina, in recent years has been able to grow oysters on a limited scale in ponds there.

The business in Massachusetts, however, is more than an experiment. Oysters spawn, set, grow and mature, and set again. The yield is marketed as set or ultimately as market stock. This oyster culture project has been in operation for five years. Others on Martha's Vineyard have seen the possibilities of growing oysters in salt ponds, and another such pond is now being constructed.