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United States Department of the Interior
Fish and Wildlife Service

Fishery Leaflet 169

Chicago 54, Ill. March, 1946

NATURAL HISTORY AND METHODS OF CONTROLLING THE STARFISH, ASTERIAS FORBESI (DESOR)

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Starfish have long been regarded as the most destructive enemies of shellfish on the Atlantic Coast of North America. The greatest part of the loss caused by these pests is borne by the oystermen who often find their stock depleted or entirely destroyed. Beds populated with young oysters are especially vulnerable. At present, according to the estimates of prominent oyster men, the destruction of oysters in Long Island Sound alone reaches several hundred thousand bushels annually. These pests also kill large quantities of oysters in the States of New York, Rhode Island, and Massachusetts. Scallopbeds, as in Buzzards Bay, are often invaded and their population partially or fully destroyed by starfish. One phase of depredation, the extent of which is very difficult to estimate, is the great destruction of oysterspat caused by newly set starfish. In regions where heavy setting these pests precedes or coincides with that of oysters, the latter may be devoured in a very short time.

DISTRIBUTION AND OCCURRENCE

Of the several species of starfish found on the oyster beds only two present danger to the industry. These are Asterias forbesi (Desor), the common starfish, and Asterias vulgaris (Verrill), known as the purple starfish. The range of distribution of the first species extends from Maine to Florida and to the Gulf of Mexico. This form, however, is most abundant between Cape Cod and Virginia. It is found at all depths ranging from the low water mark to 250 feet, but the majority of these animals lives near the shores in comparatively shallow water. A. vulgaris is found from Labrador to Cape Hatteras, N. C., and from the shore line down to the depth of 170 fathoms. This species is common in water of moderate depth but prefers deeper and cooler water than A. forbesi and, consequently, is rarely found in shallow places where oysters are grown. Therefore, only A. forbesi, the species causing the most damage to the oyster beds is discussed in this article.

Surveys by the Fish and Wildlife Service have uncovered great concentrations of starfish in Buzzards Bay, Mass., Nar-

ragansett Bay, R. I., in the waters of Long Island Sound, and in Chesapeake Bay. In all cases the majority of the animals was found to live in comparatively shallow water not deeper than 40 feet, their number decreasing with increasing depths. Usually large concentrations were found near the shores where natural and cultivated oyster beds are located. Starfish appeared to be equally abundant on hard, sand, and soft bottoms, where food was available. In Chesapeake Bay they were concentrated chiefly in the areas where an abundant supply of the small clam, Mulinia lateralis, was found.

Starfish cannot exist in water containing less than 1,8 percent of salt. However, they are capable of withstanding, without serious injury, a sharp reduction in salinity provided the animals remain in water of low salt content for relatively short periods. Prolonged exposures result in the subsequent death of the starfish. Because of the inability of these animals to adjust themselves to water of relatively low salinity they do not penetrate deep into the heads of many harbors and bays where the water is very brackish.

Surveys on the occurrence and distribution of starfish conducted semi-annually in Long Island Sound during the last ten years failed to support the opinion prevalent among the oystermen that seasonal migration of starfish regularly occurs from shallow to deep water, and vice versa. The results of the surveys indicate that the distribution of these animals in relation to depth is fairly constant and that in many instances large groups of starfish found in inshore areas remained there for a period of several years. Studies of specimens which were treated with Nile Blue Sulphate, a harmless dye staining the starfish blue, and released from a definite point showed that the greatest distance any of the animals traveled in ten months was about 5,000 feet. The stained starfish dispersed in all directions. Laboratory observations also showed that the movements of starfish are irregular and quite slow usually not exceeding a few inches per minute. In the winter time, when the temperature of the water is near the freezing point, locomotion is slowed down considerably, or ceases entirely.

FOOD AND FEEDING

In addition to bivalves, such as clams, oysters, and mussels, the food of starfish also consists of sea snails, small crustaceans, worms and various dead marine animals. The starfish opens the shells of the mollusk by pulling them apart with its tube feet, and possible with the aid of some secretion capable of paralyzing the prey. However, the small size of the starfish mouth, which in adult animals is about 1/4-inch in diameter, does not permit taking in large pieces of food. To compensate for this handicap nature provided starfish with a very unique method of feeding. After the shells of the attacked mollusks are open, the starfish protrudes its

stomach outside and digests the soft meat of its prey. As soon as the mollusk is eaten, the stomach of the starfish is withdrawn. It has been found that a single medium-sized starfish may destroy as many as five one-year-old oysters per day. Older and stronger mollusks are better equipped to withstand the attack. However, even large oysters become easy prey of starfish if they are in a weakened condition.

The starfish of Long Island Sound manifest decided seasonal differences in their feeding habits. Indifference to food is shown throughout the pre-spawning period, extending from the end of May until July. Active feeding begins again after spawning and starfish become voracious eaters between the months of August and December. The low water temperatures of winter and early spring interrupt their feeding activities.

REPRODUCTION

The sexes of starfish are separate. The animals are able to breed when only one year old, provided the first year of life was spent in a favorable environment. The animals become ripe during late spring, and in the summer the sexual products of males and females are discharged into the water, where fertilization of eggs occurs. The spawning period may vary in different localities, but it usually begins soon after the water temperature reaches 60°F., and continues throughout the summer, ending some time in late September.

Fertilized starfish eggs develop into very small, delicate, freeswimming organisms called larvae which subsist upon algae and other microscopic forms. The change from the larvae to the juvenile stage occurs two or three weeks after fertilization depending upon the water temperature and food supply. The young starfish, about 4/100-inch in diameter, sets on the bottom where it begins to feed upon small oysters, clams and other marine animals. In Long Island Sound setting starfish occurs at all depths, from the mean low water mark to 100 feet, being most intense in water less than 40 feet deep. It continues from July throughSeptember or early October.

If food is abundant, young starfish may grow very rapidly reaching the size of 3 inches by the end of November. Generally, however, the rate of growth is slower. Old, fully-grown starfish are known to reach the size of 8-1/2 inches in diameter.

METHODS OF CONTROL

Eradication of starfish on oyster bottoms has been practiced ever since the cultivation of oysters was begun. Various methods of cleaning oyster beds of starfish are now employed by oystermen but the following are most commonly used:

Mechanical Methods

(a) Starfish mop.--At present the most common device for

destroying starfish is the mop. It consists of an iron bar 8 to 10 feet long to which are tied 12 to 16 light chains with attached large bundles of rope yarn each about 5 feet long. Each boat usually carries two mops which are raised and lowered from each side of the deck. As the mops are dragged over the oyster beds, the starfish, whose bodies are covered with numerous spines, are entangled in the yearn and brought to the deck, where the mops are dipped into wooden vats of hot water. After the starfish are killed and removed from the mops the latter are again lowered overboard.

(b) Oyster dredge.--During the regular dredging for oysters many starfish are also caught later destroyed. In some instances oystermen prefer to use the dredges instead of the mops.

(c) Suction dredge.--The suction dredge is a comparatively new implement placed in operation about ten years ago. The dredge is designed on the principal of an ordinary suction vacuum cleaner. Starfish and other materials are drawn from the bottom by means of a suction pump, carried through a flexible pipe and finally are forced into an enclosed rotating drum made of wire mesh of different sizes. Small objects pass through the mesh and drop to the sediment tank the content of which, including small starfish, is later taken ashore. Large objects are droppedon the conveyor, where the adult starfish are separated from the oysters, which are returned to the beds. The efficiency of the dredge is very high and the catch is much greater than that of a regular starfish boat. It is unfortunate that regardless of the great efficiency of the suction dredge it is not more widely used.

Chemical Methods

Since the mechanical control of starfish over oyster beds is expensive and only partially effective, attempts to discover some cheaper and more efficient means of destroying starfish have led to consideration of the use of certain which might cause the death of these pests. Among the substances tried were different concentrations of copper sulphate and its mixture with nitre cake. The use of these substances, however, proved impracticable for beds of any size since only a small percentage of starfish was killed while the others were driven to adjacent bottoms. In addition, in a few instances the shells of the mollusks of the treated area became discolored and the oysters were found unfavorably affected. Since the introduction of metal salts over the oyster bottoms may result in an accumulation which may eventually prove dangerous to aquatic animals and plants, such methods cannot be recommended for the control of starfish.

Better results can be expected from a method based on the use of insoluble, or only slightly soluble material which is harmful to the starfish when in direct contact with its body. The solution of this problem was found in using calcium oxide, commonly called quicklime, which has the valuable advantage of having an almost immediate effect upon the starfish. Because of its low solubility, a comparatively small quantity of quicklime is sufficient to cover a relatively large area of oyster bottom.

Spread over the beds in powdered or lumpy form particles of the quicklime drop down and imbed in the upper surface of the starfish, which is covered with delicate membranes serving as the respiratory organs. The caustic action of lime causes surface lesions which quickly deepen and after a few days may penetrate throughout the bodywall of the starfish exposing their internal organs and finally causing death.

Once spread on the bottom, the lime retains its effectiveness for some time. Starfish which are not directly hit by the falling particles will eventually come in contact with them while crawling on the bottom. Thus, in the course of time the lower surfaces of the starfish also become affected and disintegration of their bodies begins. Starfish weakened by the wounds are attacked and eaten by crabs and other animals, which adds to the number of pest eventually killed. Lime is also used when oyster set is transplanted from one bed to another. By spreading several handfuls of powdered lime over each dredgeload the majority of the starfish found among the oysters will be killed. This method prevents transplanting starfish from one area to another.

To cause injury to starfish it is necessary to create actual contact of the particles of lime with bodies of these pests. Therefore, the efficiency of the method depends primarily upon the uniform distribution of the lime over the area treated, and also upon the quantities used. An apparatus insuring uniformity of distribution of lime has been devised by biologists of the Fish and Wildlife Service and successfully tried on the cultivated beds of Long Island Sound. In all cases when lime is used the direction and speed of the tide currents should be taken into consideration. If properly applied, even small quantities of lime (500 to 750 libs. per acre) will be sufficient to destroy the majority of the starfish present. Sometimes, however, larger quantities may be needed. It is fortunate that the concentrations of lime harmful to starfish do not seriously affect many other commercially important forms of marine life. When used in concentrations employed in the experiments lime does not kill nor noticeably injure oysters, clams or other mollusks commonly found on cultivated bottoms.

The possible future value of quicklime as a practical method for eradication of starfish is attested by the ease of application, its effectiveness and the cheapness of the product. Its comparative harmlessness to oysters and many other commercial species also indicates that the method provides a practical weapon against starfish.

DISCUSSION

Studies of the biology and distribution of starfish conducted by the Fish and Wildlife Service during 1935-45 provided information much needed for the effective application of control measures. Results of the surveys made in Buzzards Bay, Narragansett Bay and, especially, in Long Island Sound, where the surveys are conducted

semi-annually, have shown that there is no general well-defined migration of starfish. No concentrations of hordes of these animals were discovered in deep regions adjacent to these bodies of water. However, there were aggregations of the pests found in inshore areas, where they remained throughout the year. Movements of local character of large numbers of starfish usually originate from these points. It is evident, therefore, that eradication efforts should be first applied to such focal areas.

The centers of infestation are very often found on abundant oyster beds and public bottoms. These areas are left almost entirely unattended by the oystermen, who confine their efforts to their own grounds, and by the state or municipal shellfish authorities having jurisdiction over the public beds. The neglect of these areas constitutes the greatest weakness in the present method of starfish control which is very ineffective, not so much because of the mechanical faults of the starfish mops and dredges or the inefficiency of the lime method but because of the lack of the lack of organized efforts among the oystermen and lack of assistance on the part of the local shellfish authorities. The eradication of starfish could be carried on more economically and efficiently if the oystermen would join their forces and with the assistance of the local shellfish authorities clean out the abandoned private and neglected public bottoms instead of confining their efforts exclusively to their own lots. Unless such measures are taken the cultivated bottoms will be continuously invaded by starfish from the adjacent uncultivated grounds, which will continue to serve as centers of propagation and dispersal of the pests. Satisfactory progress in controlling starfish will be possible only when this fact is recognized both by the state shell fish authorities and the individual oyster cultivators. In planning a comprehensive program of control each body of water should be considered in its entirety. Good results cannot be expected if eradication efforts are confined only to a small portion, disregarding the conditions in the adjacent areas where starfish continue to live and multiply unmolested.

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Supersedes I-119

March, 1946
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