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TECHNOLOGICAL STUDIES OF THE STARFISH

PART I - STARFISH CONTROL--ITS ECONOMIC NECESSITY AND METHODS USED

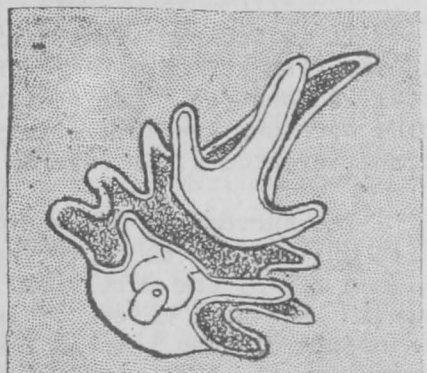
By Charles F. Lee*

INTRODUCTION

The common five-rayed starfish, Asterias forbesi, is a familiar sight in the pools among the rocks of the New England coast. Not so familiar is the fact that the innocent appearing starfish is one of the most destructive enemies of the oyster and that it may cost the oystermen of Long Island Sound over a million dollars per year for control efforts and in seed and market oysters killed.

NATURAL HISTORY AND DISTRIBUTION

In the waters along the shore of Long Island Sound, the lives of the starfish and the oyster are so closely interrelated, that a brief discussion of each is essential to the understanding of starfish control. Galtsoff and Loosanoff (1939) and Loosanoff and Engle (1940) have made extensive investigations of both the starfish and oyster and much of the material presented here represents a summary of information from these sources.



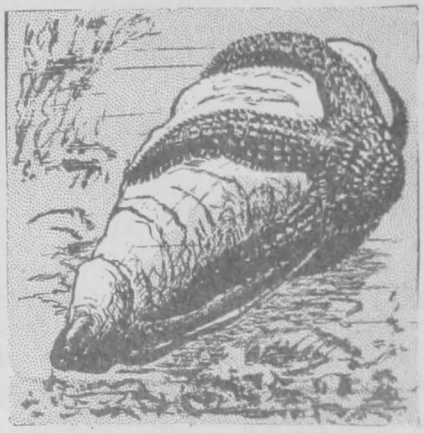
LARVAL FORM OF STARFISH

The starfish will spawn when only one year old if conditions for growth have been favorable. Starfish spawning usually starts in June, some two to six weeks earlier than oyster spawning in the same waters. Both the starfish and oyster in the larval form are free-swimming for several weeks before setting on the bottom. When first changed from the larval stage, the young starfish is only about one millimeter in diameter, but it has a voracious appetite and grows rapidly. Having spawned earlier, the young starfish may consume the newly-set oyster spat to the extent of virtually wiping out a good set. For this reason, it is desirable that the beds on which old shells are deposited for the purpose of catching the oyster spat be cleaned of as many adult starfish as possible before they begin to spawn. This will not entirely eliminate starfish, as the larvae in the free-swimming stage may be carried in from some distance by the tide and currents. Such cleansing limits the set, however, and is generally the practice in seed-oyster areas.

The oyster industry of the Long Island Sound area is based on intensive private cultivation. In contrast, on the South Atlantic coast, and to some extent in Chesapeake Bay, oysters are taken from public grounds. In the Sound, almost all of the oysters are grown on privately leased beds and, frequently, they may be moved three or more times during the four to six years it takes them to grow to market size.

*Chemical Engineer, Fishery Technological Laboratory, Division of Commercial Fisheries, College Park, Maryland.

The Long Island Sound seed-oyster industry, in many cases, is thus a separate enterprise from the growing of market oysters. Seed-oysters, a term which in this area refers to oysters from one to two years old, are grown almost entirely in a strip of water three to five miles wide along a stretch of the Connecticut coast line from Stamford to Branford, where experience has shown conditions are optimum for obtaining a good set of spat. Even here, for reasons not yet apparent, good sets are obtained only about one year in five, and in some years the set is almost a total failure. To maintain the supply of market oysters at a profitable level, every effort is made to protect the spat and young oysters from unfavorable conditions and predatory enemies, such as the starfish.



The starfish opens the oyster by wrapping its rays about the shell and exerting a steady prolonged pull by means of the many "tube-feet" which line the under side of each ray. These tube-feet are capable of considerable adhesion, but it is the duration, rather than the degree of pull, which gradually fatigues the large muscle of the oyster so that it relaxes and the shell is opened. The starfish then turns its stomach literally "inside out," to envelop and eat the oyster meat. Some investigators have suggested that the starfish secretes a substance capable of narcotizing the oyster. This ability, if present, is most probably used after the oyster is opened to prevent further closing of the shells.

It is apparent that smaller oysters are more readily and rapidly subject to starfish attack. Therefore, the seed-oyster grower is greatly concerned with starfish control. Large starfish may attack oysters that are three or four years old, but they are more likely to resort to easier prey such as mussels, small clams, crepidula, or several other species of small mollusks.

The surveys of Galtsoff and Loosanoff (1939-40) have shown the depth distribution of starfish to be very similar to that of the oyster of the same waters. Almost all of the cultivated oyster beds, as well as the natural public beds, are in less than 30 feet of water and the great majority of the starfish were found in depths of less than 40 feet. In the wintertime, when the water temperature decreases to 41° F. (5° C.) or lower, the starfish become much less active and many stop feeding. Consequently, destruction of oysters is greatest in the warmer months but control efforts may be carried out the year around.

Although found from Maine to Mexico, the starfish (Asterias forbesi) is rare north of Cape Ann. Although present in southern coastal waters, it is not considered to be a menace to the oyster industry of that section.

The starfish is much more susceptible to changes in salinity than the oyster. This is the controlling factor in Chesapeake Bay and in many sections of the Gulf coast. Starfish do not endure a salinity below 16 to 18 parts per thousand for more than a short time. They, therefore, do not penetrate the Chesapeake Bay much beyond Cape Charles and Norfolk (Loosanoff, 1945). There are a few other high-salinity areas in parts of New Jersey, Virginia, South Carolina, and Louisiana where oysters are grown, but the starfish population is controlled by other factors in these areas. In the open waters of Long Island Sound, however, since the salt content is normally above 25 parts per thousand, salinity is not an important environmental deterrent.

Galtsoff and Loosanoff (1939) made several surveys in different seasons at a large number of stations in Long Island Sound, Buzzards Bay, and Narragansett Bay to study the local geographic distribution of the starfish. Generally speaking, there was no evidence of marked seasonal changes in abundance, within the same year, nor of migration from one area to another. Heaviest concentrations were found where food was abundant, in the western end of the Sound, and in Buzzards Bay near New Bedford and Wareham at the head of the Bay. In Narragansett Bay, near Prudence Island, starfish were plentiful, but relatively few were found in Block Island Sound.

ABUNDANCE OF STARFISH

Starfish have been the subject of control measures by the oystermen of the New England area for most of the 100 years since the beginning of the cultivation of oysters there in 1845.

Among these men, it is common knowledge that starfish on the oyster beds show very large fluctuations in abundance from year to year. Many of these men are of the opinion that decreases in the number of starfish are due to the intensive control efforts that are instituted when it is realized that the numbers are on the increase, and conversely, that the periods of great abundance follow temporary relaxation of control efforts when few starfish are to be found. Migrations from uncultivated areas not subject to control measures are considered largely responsible for maintenance of the starfish population (Anon., 1945).

With the exceptions of a 30-year record by a company on Narragansett Bay and one of 7 years by a company in Connecticut, the oystermen do not have records of how many starfish are eliminated by these control efforts. Their primary interest is in the reduction of the number of starfish to the lowest practicable level. Burkenroad (1946) attempted to determine starfish abundance over a period of some 75 years by a study of trade journals, newspapers, and records of public commissions. Fluctuations in starfish abundance appear to have a definite periodic characteristic, with a range of intervals between the peaks of maximum abundance of 11 to 16 years. This information corroborates the limited data from company records that fluctuations in population are fairly uniform throughout the area involved. Based on Burkenroad's report also, the interesting hypothesis is advanced that the variation in numbers of starfish is due predominantly to natural causes, and is not markedly influenced by the control efforts of the oystermen or by the occasional State or Federal financed efforts toward local elimination. If fluctuation in abundance of the magnitude suggested above were proven, it would require careful consideration whether to recommend utilization, nominal control, or an attempt at complete eradication of starfish.

ECONOMIC ASPECTS OF STARFISH CONTROL

An accurate estimate of the damage caused the oyster industry by starfish is difficult to make since it should include not only the direct cost of control efforts, but also the potential value of young oysters killed and the value of marketable seed-stock and older oysters lost. No recent data are available on direct cost of control efforts, but with increased wages and operational costs, it is likely that the total amount spent for this purpose is more than $500,000 annually.

The oystermen continue these costly controls through the years because they realize what would happen if the starfish were permitted to grow unchecked on the oyster beds.

A single medium sized starfish may kill as many as five one-year-old oysters a day (Anon., 1945). It is possible to calculate the potential loss if a conservative estimate is taken that 100 fair sized oysters are killed a season, and the average weight of a starfish in the Sound is 0.28 pound as estimated by Burkenroad. A bushel of 60 pounds will then contain, roughly, 2,000 starfish. Each bushel destroyed, therefore, represents perhaps 200,000 young oysters that may grow to market size. These would be worth about $1,000 as one- or two-year-old seed-oysters.

The daily "take" of a vessel engaged in starfishing will vary widely with the type of gear used and the density of starfish on the area worked. Sweet (1946) states that control efforts are carried out even when the amount taken is as low as 10 pounds of starfish per hour per vessel or little more than a bushel per day. On the other hand, in seasons of abundance, the daily average yield may be 25 bushels per vessel per day with maximum yields of 50 to 100 bushels. The usual catch is about 6 to 10 bushels per day on cultivated beds.

Operating costs of a starfishing vessel have mounted rapidly since 1935. A minimum estimate would be $50 daily when the larger oyster vessels are shifted to these operations. The maximum may be three times this estimate. Depending upon the abundance of starfish, from 5 to 20 or more craft may be used for control purposes. These costly control operations for a non-productive purpose are justified by the potential damage each bushel of starfish is capable of causing if the more than 2,000 starfish it contains are left to continue their depredations throughout the season.

METHODS OF CONTROL

Mopping, dredging, and liming are the methods of starfish control in most general use. Control by other chemical agents; such as, copper and zinc sulfate or chromium salts, has been studied, but none of these methods has proven practical (Galtsoff and Loosanoff, 1939).

Mopping is mostly used both because the mop causes little damage to the delicate seed-oysters and because it effectively and thoroughly cleans areas where few starfish are located. Dredging can be used to clean uncultivated areas free of oysters where the starfish population is very heavy. The regular oyster-dredging operations incidentally capture numerous starfish. These are killed with lime before the oysters are replanted. Liming can be used on either seed or "growing" oyster beds, the chief disadvantage of this method being the difficulty of distributing the lime in proper amounts over the desired areas.

The starfish mop, or tangle, is usually a home-made rig which does not follow any standard design. It is essentially a long bar to which are secured, at regular intervals, 6 to 12 short lengths of chain. Along each chain are tied the "mops," or bunches of string or twine. This outfit is slowly dragged over the bottom at the end of the dredge cable. The starfish become entangled in the mops, are unable to escape, and the mop is hauled up at intervals to remove the starfish.

Starfish may be hand-picked from the mops but the operation is slow and expensive because extra deck-hands are required. Hand-picking may be used on vessels

engaged in abundance-survey operations or on oyster vessels which do not have hot water tanks when pressed into starfish control during emergencies. Most of the seed-oyster companies operate one or more vessels exclusively for starfish control and these are generally equipped with long vats or tanks into which the whole mop frame may be dipped. These tanks are filled with water at a temperature of about 150° F. (66° C.). At this temperature, the starfish are not only killed, but are softened so that they are washed out of the mop as it is lowered for the next dragging operation. Two mops are used, one on each side of the boat, and only about two minutes are required for the hot-water dip. Thus, the mops are in use most of the time and a large area can be covered more effectively than with the dredge or hand-picked mop.

Lime has been found to kill starfish even when only a few small particles settle on the aboral surface. The chemical is only slightly soluble in water and is quite cheap and readily available. The lump lime may be shoveled over the boat rail to be disintegrated and dispersed as it settles to the bottom. Effective coverage in this manner is difficult, as some quantity may be carried away by tide and currents. Loosanoff and Engle (1942) developed an apparatus for distributing a lime suspension immediately over the bottom. A stream of water from a centrifugal pump picked up the fine lime and the suspension was forced through a hose line to a distributor pipe which was carried a short distance above the bottom on a pair of wheels. This apparatus permits even distribution with little loss to tide and currents, but its use has not been widely adopted because of the expense and difficulty of obtaining the required new equipment.

A fourth control method, the Flower suction dredge, utilized the principle of the vacuum cleaner. A wide funnel-shaped collector was carried on wheels at a short distance above the bottom. The distance could presumably be adjusted to permit removal of either light material only or almost anything loose, including mud and sand. A large centrifugal suction pump discharged this mixture into a rotating screen which separated the larger solid material and dumped it onto a conveyor. It was reported that the desired selectivity of bottom material was hard to obtain and that operating costs were excessively high. Its use would not be justified except in periods of maximum abundance of starfish.

There have been intermittent efforts over a period of years to find some use for starfish, interest in the subject being stimulated by recurring periods of abundance.

The benefits to be derived from the discovery of some economically practical or even profitable means of using starfish would be threefold:

(1) The oystermen would receive some return for starfish brought in, and inasmuch as all are now discarded, anything received would cut control cost by that extent.

(2) The creation of a market for starfish would, it may be assumed, lead to independent efforts towards their capture and to new sources of income for certain groups.

(3) Theoretically, at least, there would be a reduction of the starfish population in the whole area to a point where the peaks of abundance would no longer occur. This event would, of course, simplify the control of starfish on the leased beds and a second, and probably even larger saving to the oystermen would result thereby.

To this end, the Fish and Wildlife Service undertook an investigation of some of the possibilities of starfish utilization. The information obtained in the course of this investigation will be reported in detail in other papers of a series on this subject.

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