

likewise important in estimating the future abundance of the mullet. The age of many fish can be determined by the markings on the scales, which are caused by different growth rates at different times of the year. It has been widely stated that the scales of fish inhabiting tropical waters do not have these markings. We have collected large numbers of scales from Florida mullet, both from the commercial catches and from tagged fish. A study of these scales is under way to discover whether age can be determined from them. Marks are present and we have hope that we may be able to relate these to the age of the fish.

The size at maturity of the mullet is not well known and this basic information is being obtained. This phase of the investigation, as well as that dealing with the size of mullet caught in various net mesh sizes, is reported in another paper.

Different types of gear used in the mullet fishery are being studied. One report on this has been issued (Idyll, 1949b).

Finally, the gaps in our knowledge concerning the spawning and early life history of the mullet are being filled in as quickly as possible. The results of all these studies should provide the basis for an intelligent management of the mullet fishery, whose objective would be the stabilization of a high level of steady production.

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## Gear Studies In The Florida Mullet Fishery

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DURING THE PAST YEAR the Marine Laboratory of the University of Miami has carried on a study of the Florida mullet fishery. This research was undertaken because of persistent reports that striped mullet, *Mugil cephalus*, were becoming increasingly scarce, and fear was felt that the industry would continue to decline unless some corrective measures were taken. Investigations of fishing methods and gear and studies of the life history of the mullet have accordingly been carried out.

Fishermen and fish dealers, in an effort to explain the causes of the decline, have condemned practically all methods of fishing for mullet on one ground or another. Studies of various methods used in the fishery have been made, with the charges against them in view.

The use of the gill net appears to be criticized less than any other. This net is selective in the size of fish it takes, since fish too small to be gilled pass through it, while fish too large to force their heads into the meshes usually are able to back away and avoid being caught. This type of net is probably the least efficient, especially when used simply as a gill net and not employed as a seine. The only criticism made against gill nets is that so many of them are in constant use that mullet have no chance to occupy an area without being disturbed. In some areas along the coast so many fishermen are active that all available fishing grounds appear to be occupied almost every day or night, and

doubtless each fisherman catches fewer mullet and has less choice as to where he will fish, as a direct result. No harmful effects of this type of net are evident, insofar as damage to feeding grounds or to small mullet is concerned.

The trammel net is a more efficient type of gear than the gill net, in that it will take fish which are too large to gill so that the range of sizes of fish captured is greater. Small fish are able to go through this net. In some localities this gear is used as intensively as the gill net, and draws the same criticism. In addition, many fishermen claim that this net is destructive because it takes such a range of sizes. However, the greater range is only in the direction of larger fish and this net is no more destructive to small fish than is the gill net.

Many fishermen would like to abolish night fishing. They point out that during the war, when night fishing was not permitted, there was great abundance of mullet. This they attribute to the fact that mullet were permitted to rest and feed unmolested during the hours of darkness. It is not known whether the increased abundance of mullet in 1942 and 1943 was due to the curtailment of night fishing or to a natural cycle in which the mullet population was at a peak. Possibly a combination of these factors was at work. Not only was night fishing curtailed, however, but there were considerably fewer fishermen exploiting the mullet resources at that time, since many fishermen were in the service. Restriction of fishing to the daylight hours, coupled with a decrease in the intensity of fishing operations, may have contributed to the large catches per unit effort by allowing time for the mullet to "bunch," thereby becoming easier to catch. In other words, the ban on night fishing may not affect the population of mullet, but it may have aided in making that population more available to the fishermen.

The use of the flambeau, made by wiring a large bundle of rags or burlap to the end of a pole, soaking it in gasoline, and igniting it, has been widely attacked. Burning gasoline drips from the flambeau and spreads over the water. Often more gasoline is poured on the water to increase the burning area. The resulting conflagration is startling and frightens the fish. The flambeau is disliked by all fishermen who do not use it. They claim that its use drives mullet out of the area, that it causes a coating of oily residue to settle on the bottom which destroys feeding grounds, and that it burns off the grasses among which mullet like to feed.

Observations show that the flambeau does cause mullet to scatter, resulting in many of them becoming tangled in the meshes of the net. It is doubtful, however, if it causes the fish to vacate the area for any length of time. The larger number of fish caught by this method than by the use of ordinary lights should not be grounds for outlawing the operation.

The charge that an oily residue covers the bottom is groundless. There is practically no residue left when gasoline burns, and what little soot or gasoline may remain is quickly dissipated by the tide. When used in grass the flambeau does scorch and doubtless kills much of the vegetation. In such an area it is possible that the feeding grounds are affected to some extent. It has not been determined just how burned grasses may affect mullet. At any rate, grasses are temporarily damaged, and until it can be proven what effect this has on mullet, this charge must be considered. A more serious charge can be brought against the flambeau. It is exceedingly dangerous to the fisherman who uses it, and to his boat. Furthermore, there constantly exists the danger that grasses and trees on shore may be set afire and result in considerable property damage.

Stop-nets are the targets for much criticism by fishermen all along the coast,

and even many men who use them claim that they should be abolished. The critics believe that "stopping" operations destroy feeding grounds because they involve so much disturbance of the bottom. They claim that mullet will leave an area that has been stopped and not return for days or weeks. It is charged that stop-nets destroy many fish which are not used. The chief complaint is that stopping operations spoil an area for fishing by the crews who come later, and that they encompass too large an area.

Stop-netting was especially studied because complaints against it are so persistent. Damage to the grounds was carefully noted and found to be exaggerated. The stirring of the bottom caused by walking on it or dragging a small seine over it is probably less than that done by choppy water and strong tides. Footprints and other marks are usually obliterated on the next set of tides. The slight churning of the bottom may actually be beneficial, serving to bring more nutriment within reach of the mullet and the microscopic plants upon which they feed.

The scarcity of mullet in an area that has just been "stopped" is probably due to the fact that most of the resident fish have been removed, and it takes some time to repopulate the area. The fact that a stopping operation has recently taken place can hardly be said to bar the entrance into the area of other mullet after the tide has obliterated all signs of the operation, which is usually within twenty-four hours. Mullet are very wary, however, and apparently avoid crossing net marks and tracks of seines as long as they are detectable.

A stop-net effectively blocks the escape of all the fish within its compass that are too large to go through its meshes. This usually includes a great variety of fishes, many of which are of little or no commercial importance. Most of the captured fish make their way into a deep area that is usually purposely included within the "stop" to provide a gathering place. Some fish remain in shallow water along the landward side of the net. Others are stranded in small pools left by the receding tide. Usually very few are left high and dry. Some of the stranded fish are destroyed by birds that are invariably attracted to a stopping operation. Some others fall prey to raccoons and crabs. The numbers so destroyed are small. The greatest destruction is by the fishermen, and it is willful. They have good reason to dislike catfish, rays and porcupine fish, all of which can inflict painful wounds, and their objection to sharks, crabs, and other creatures which tear holes in nets is understandable. But their dislike of many fishes stems simply from the fact that they must be removed from the net, and hence are a nuisance. For these reasons many fishermen kill all fishes which are taken in the nets, regardless of species. This habit justifies the charge of destructiveness levelled against them. It could be remedied by individual effort.

Stop-nets do cover large areas, it being quite common for several miles of shoreline to be included in one operation. The gear also takes a greater percentage of the fish from the place where it is used than does any other type of equipment, resulting in few fish being left for the fishermen who follow. Unless other conservation methods fail, and it becomes advisable to reduce the pressure on the mullet stocks by limiting the production of the fishery, the abolition of stop-nets cannot be recommended on grounds that they are harmful to mullet.

Drag-seining is frowned upon by many because, it is charged, seines damage the bottom and kill too many fish unnecessarily. Several types of drag-seining operations have been observed, ranging from the use of small gill nets and gill and stop-net combinations to heavy seines of almost a thousand yards in length operated by twelve-man crews.

The seining operations were checked particularly for signs of bottom damage.

Some of the smaller seines were used over grass and mud bottoms. It was noted that a small amount of grass and mud was brought up in each case, and most of the grass that was brought up was dead. It was evident that the lead lines passed over, rather than through, the grass and mud. These small seines were pulled by the cork lines, so that the lead lines were slack and did not dig into the bottom. The large seines were used over sandy or grassy bottom in each case observed. There was some digging in of the lead lines, especially near the working ends, since both cork and lead lines were pulled, and a man "footed" the lead lines at each end, thereby keeping them down. Even so, there was very little grass in the nets, and sandy bottoms contained very little evidence of the seine's passing. Those seines which were dragged ashore did bring with them a number of so-called trash fish, and these were left to die on the beach in many cases. While probably of little commercial consequence, the accumulation of dead fish upon a beach following a seining operation creates the impression of wastefulness and gives rise to justifiable criticism, especially from sportsmen, who may not consider such fish as useless. Much of this destruction could be eliminated by the simple expedient of returning unwanted fish to the water. The areas where seines can be employed are limited. Oyster bars, mangrove roots, rocky and uneven bottoms all curtail or prevent seining. For this reason, though seines may be efficient where they can be used, they cannot affect a large percentage of the feeding grounds of mullet.

The core of the problem lies not so much in the type of gear used or the methods of its employment, but rather in the size of the mesh of all types of nets, which governs the size of mullet taken. In order to ascertain what sizes of fish were taken by various mesh sizes, a number of samples of mullet, caught in nets of different mesh sizes, were measured throughout the past year. Also, in order to determine the size of mullet at maturity, records of the lengths of both male and female mullet which yielded roe or milt upon being stripped have been and are being gathered. This latter work was begun late in the spawning season last spring, and has just recently been resumed as the new spawning season is beginning. A larger sample needed before definite conclusions can be reached upon the minimum sizes at which both male and female mullet are mature. However, measurements taken so far indicate approximately what these minimum sizes are. All lengths referred to are from the tip of the snout to the fork of the tail.

From fourteen samples, three hundred and six sexually ripe mullet were obtained, of which two hundred and seven were males, or "white roes," and ninety-nine were females, or "red roes." The mature males ranged in length from ten and one-quarter inches to sixteen inches. The females ranged from eleven and three-quarters inches to nineteen and three-quarters inches. Approximately 87 per cent of the mature females were thirteen or more inches in length, while less than 30 per cent of the males were as long as thirteen inches.

These results indicate that the males seldom reach maturity until they are at least ten inches in length, while the females cannot be expected to mature at a size much under twelve inches. It also appears that the mature females are generally larger than the mature males.

Measurements of mullet caught in nets of various mesh sizes were made during all seasons of the year, but most samples were taken during the winter and spring months of 1948 and 1949. A mullet full of roe or milt, or heavy with pre-spawning fat, will become enmeshed in a net which a spent or thin mullet of the same length will pass through, so that at some seasons of the year the average size of fish taken by any net will be greater than at other seasons.

During the spawning season, especially after the first month of spawning, there are many spent mullet, or "spikes," in company with mullet still heavy with roe, and the pre-spawning season mullet vary considerably in their condition, so that it is difficult to determine when any one mesh size will take a larger or smaller class of fish. The change is gradual, and for this reason there has been no attempt to subdivide the samples into seasons. Any such division would be arbitrary at best.

The entire catch of 103 fish was measured from an illegal 2 5/8 inch stretched mesh. It was found that only 44, or less than 43 per cent, of the fish were under twelve inches in length. Of nine samples, each consisting of the entire catch of a 2 6/8 inch stretched mesh net and totaling 1460 mullet, 912, or over 62 per cent, were under twelve inches in length. Two samples of fish captured by 2 7/8 inch stretched mesh nets, a type seldom used, contained 174 fish, of which 92, or almost 53 per cent, were under twelve inches. Fifteen samples taken from 3 inch stretched mesh, and totaling 1728 fish, contained 862, or approximately 50 per cent, mullet under twelve inches. Of seven samples measured from landings of 3 1/4 inch stretched mesh nets, and numbering 795 fish, 237, or less than 30 per cent, were under twelve inches. One sample was obtained from a net rarely used at Cedar Key (where all samples were taken) of 3 7/8 inch stretched mesh. This sample consisted of 86 fish, all of which were twelve or more inches in length.

The legal minimum size limit on mullet for the state of Florida is now 10 1/2 inches. This permits the taking of fish, especially females, which are too small ever to have spawned. In some counties the minimum limit is further reduced. Levy County permits the taking of ten-inch mullet, and in the area west of the Aucilla River the limit is eight inches.

Fifty-one market samples (samples measured without regard to type of gear used in their capture, and selected at random) included a total of 7,049 mullet; 3,496, or almost 50 per cent, of these were under twelve inches in length.

It would appear, therefore, that the fishery is at present taking many mullet before they are allowed to mature. Further study is necessary before recommendations can be made as to regulations of size limits of fish or mesh sizes.

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## The Florida Sponge Industry

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ALL OF THE NATURAL SPONGES produced in the United States come from the coastal waters of Florida.

In past years sponges occurred in commercial quantities all along the coast of Florida from Biscayne Bay south to Key West and along most of the west coast north almost to Carabelle.

An average of over one million dollars worth of sponges has been marketed annually for the past fourteen years. In 1943, 1944, 1945 and 1946 the sales of wool sponges alone were well over two million dollars per year.

Production declined sharply after the sponge disease of 1939-1940, and by 1947 the landings were markedly smaller. The University of Miami Marine Laboratory, at the request of the Florida State Board of Conservation, undertook in December 1947 a brief survey of the sponge grounds north of Anclote