brown shrimp in every night drag from 30 to 50 fathoms. No small shrimp were included in the catches and the sizes taken in general increased with depth. The largest shrimp, as large as 6 count, were taken in the deepest water and the smaller sizes, 10 to 16 count, in shallower water. During July and August the greatest concentrations were taken in depths of 38 to 40 fathoms, but after a storm at the end of August the heaviest concentrations were found in depths of 32 to 34 fathoms. Near the outer limits of the range, in the greater depths, fewer but larger shrimp were found.

The extreme limits of the range, where the largest shrimp (mostly females) occurred, would not be profitable to fish, but, in general, a part of this area contained consistently greater concentrations than were found inside the 25 fathom range.

The outer limit at which the brown grooved shrimp were taken was 54 fathoms. Few shrimp were taken in depths from 54 to 150 fathoms and these few were of non-commercial species. A total of four drags in 195 to 258 fathoms produced catches of some interest. Preliminary drags over bottom of unknown roughness have been made with a 40 foot flat shrimp trawl on a bridle to a single cable, and this rig was used in all successful drags in deep water. The trawl doors were provided with extra weight and the length of cable used was approximately 3½ times the depth. Shrimp were taken in each of these drags. The most abundant species by far was a red colored shrimp with very long antennae *Hymnopenaeus robustus*. When taken from the water these animals have the color and general appearance of boiled shrimp. In one drag of 45 minutes duration, 60 pounds of 28 count red shrimp were taken along with 61 pounds of scrap. This rate of capture compares favorably with catches of marketable shrimp made by the same gear in shallower water, where good concentrations of shrimp were found. In the deep water drags, a few specimens of other kinds of brightly colored shrimp were taken.

Although the emphasis in the past months has been on shrimp, data on other fishery items have been accumulated having possible future value. Continued observations of fish at the surface have been made. Black-finned tuna were observed at the surface, near the mouth of the Mississippi, over depths of about 50 fathoms. Spiny lobsters were taken with hook and line on rocky bottom near the continental shelf..

In future work off the coast of Texas, the *Oregon* will continue to concentrate primarily on the distribution of brown shrimp and attempt to locate concentrations of commercial value. A very interesting relation of temperature change to movements of this population has been suggested by the data collected so far. It is hoped to get more information on this problem during the future cruises.

Effect Of The Menhaden Operations On Other Fisheries

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THE EFFECTS of menhaden operations on other fisheries has long been a point of argument, particularly among fishermen who know little about the menhaden

fishery, and many exceedingly misleading statements have been made about the matter.

Most sportsmen and many commercial fishermen are wrongly convinced that:

1. Menhaden fishing is harmful to the spawning grounds of commercial and sporting fish and shrimp.
2. Menhaden fishing destroys large numbers of commercial and sporting fish and shrimp.
3. Menhaden fishing destroys the food of large numbers of commercial and sporting fish.

On the basis of present research, these statements, which will now be discussed in some detail, are almost entirely incorrect.

Effect of Menhaden Fishery on the Spawning Grounds of Fish and Shrimp

Briefly, the menhaden fishery has little or no effect on the spawning grounds or the spawning of any of the common game or food fishes, or in commercial shrimp.

Speckled trout and drum spawn in shallow grassy bays where purse seines are never used. Redfish spawn offshore in October and November, after the menhaden season is over. Spanish mackerel eggs are very tiny, having a diameter of from 1/22 to 1/28 of an inch. When discharged from the parent they rise to the surface, where they float at the mercy of wind and tide until hatched, hence any net would have little effect on their number, especially as one female may discharge in excess of 1,500,000 eggs. Sheephead spawn along sandy shores of the Gulf during the summer. Their eggs are apparently pelagic, hence would be no more affected than those of the Spanish mackerel.

Shrimp, both red and white, spawn offshore, during the entire summer, and their tiny eggs, smaller than grains of sand, immediately sink to the bottom, where they are untouched by the purse seine as it is generally used. Furthermore, the fact that one of our shrimp spawning grounds off Aransas Pass is being constantly disturbed by the nets of the shrimp fishermen, with no apparent harm whatever, would point to the fact that such disturbances cause little damage.

The assertion by many fishermen that the very small shrimp frequently seen on the webbing of shrimp trawls and other nets are the young of the commercial species is incorrect. Microscopical inspection will disclose, in most cases, that these tiny quarter-inch shrimp have egg masses on the outside of their bodies. They belong to the genus *Acetes* which carries its eggs in this manner. The commercial shrimp does not spawn at this size, and it carries its eggs within its body.

Effect of Menhaden Fishing on Commercial and Sporting Fish and Shrimp

Interest in the effect of menhaden fishing on the adult population of commercial and sporting fish and shrimp has always been keen, as can be shown by an examination of findings from various locations where purse seining for menhaden is a common fishery. Space does not permit more than a brief review of this research at this point. However, those interested in the matter can inform themselves more fully by reference to the bibliography at the end

of this article. Smith (1896) found that in 1078 sets of a menhaden purse seine, far less than one-half of one per cent of the fish taken were either food or game fish. Greer (1915) saw only eight mackerel and ten bluefish taken in one day's fishing in which 240,000 menhaden were caught. Filipich (1947) made surprise visits to various menhaden operations in Mississippi. In one boat which unloaded 70 tons of menhaden, *there was not a single game or commercial fish.* Eight boats inspected by him and a group of sportsmen had no game or commercial fish. Two boats unloading 70 tons of menhaden had one mackerel and six sand trout. That is, out of a total of eleven boats inspected, only one mackerel and six sand trout.

Simmons (1949) saw, in 62 days, during which 59 hauls of a purse seine were made, 42 bluefish, 3 drum, 7 flounders, 1 redfish, 77 sand trout, 107 mackerel, 2 speckled trout and 7 whiting. During these same sets 2,500,000 menhaden were taken.

Breuer (1950) saw, in 95 days, during which 143 hauls of a purse seine were made, 205 mackerel, 304 bluefish, 3 speckled trout, 242 sand trout, 8 whiting, and 5 flounder.

Certainly such small catches of these fish are insignificant. Moreover, actual attempts to utilize the purse seines along the Gulf coast as a means to catch game and food fish, especially Spanish mackerel, have resulted in failure. Purse seining was tried unsuccessfully at Galveston a short time before the war, and a similar attempt was made at Grand Isle, Louisiana, in 1945. The Grand Isle attempt resulted in over $6000 loss to the operator (Gowanloch, 1949).

In the shallow water of the bays, which are the nursery grounds of most of our game and food fish, purse seines cannot be operated. In deeper water, where a set can be made, it has been observed that game fish enclosed in the net sound and escape below the lead line before the seine can be pursed.

Effect of Menhaden Fishing on the Food of Game and Commercial Fish

Since the "History of the American Menhaden," by G. Brown Goode, published in 1879, and republished in 1880, there has been little comprehensive material published on the menhaden. Goode's work was an enlargement of manuscript notes left by Professor Baird, based upon *opinions and information elicited by means of circulars to fishermen, manufacturers, custom officers, light keepers, etc., supplemented to some extent by observations of U. S. Fisheries agents, but not upon a scientific study.*

Goode himself admitted that it was found necessary to make allowances for many inaccuracies of statement on the part of his correspondents, and that some of them, having been unable to obtain exact information, had ventured to guess at what they did not really know from experience or research.

It is these theories of Goode and his correspondents that have in many instances been repeated by the uninformed and that have taken the place of actual knowledge until this day. This is particularly true with regard to the use and importance of menhaden as a food by other fish.

The list of fish enumerated by Goode (who has been quoted by Jordan and Evermann and the Encyclopedia Brittanica) as destructive enemies of menhaden does not comprise all the species that at times eat menhaden, *and it includes some not known to feed upon them at all.*

The assumption that they do is made partly from the fact that they are built on the model of predaceous fishes, and partly because they are sometimes caught on menhaden bait. The first part is to some extent justified, since it is safe to assume that a species which to any extent eats other fishes will eat menhaden if it can get them; but it is not safe to infer that it eats enormous quantities, as its habits may be such that it is not brought into contact with such numbers of menhaden, or food which it prefers may be present at the same time and hence taken instead of these fish. That a fish is caught on certain kinds of bait or that the bait is the most successful to use does not signify that the principal food of that fish is the bait used. Certainly fresh water black bass do not subsist on artificial flies and plugs, yet great numbers of them are caught on these baits.

Neither is it justifiable to assume that all of the predaceous fishes listed by Goode feed exclusively and daily upon menhaden, even during the time they are concurrently on the coast. Among fishes concerning whose habits we are well informed, it is known that they change their diet from time to time, and that there are periods of days when they do not feed at all (Kendall, 1910).

When the Texas Game, Fish and Oyster Commission undertook the present survey of the food of fishes, reference was made to earlier published scientific reports from this coast. There were only two of these.

The first of these was made by John C. Pearson of the U. S. Bureau of Fisheries, and in his results, based on 14 months of continuous field observations, he does not list menhaden as forming any portion of the food of trout, redfish or drum, the three main food and sporting fishes of the Texas coast.

Gunter (1945) did not find menhaden in the stomachs of either redfish or drum. He found trout eating menhaden in small quantities.

The third survey, that of the Texas Game, Fish and Oyster Commission, extended from June 7, 1948 to September 1, 1949. During this survey 26,005 fish were opened, and their stomachs analyzed. From these stomachs, only 581 menhaden were taken.

Included in the above total were 13,288 speckled trout, 3,137 redfish, 3,428 Spanish mackerel, 2,237 kingfish, 26 sailfish, 204 dolphin, 1 wahoo, 25 pompano, 77 ling, 28 jackfish, 27 bluefish, 9 jewfish, 1 warsaw, 374 redsnapper, 46 sheephead, 111 flounder, 75 tarpon and 647 gaff-topsail catfish. The balance were fish of neither commercial or sporting importance.

Space does not permit a complete breakdown here of the stomach contents. However, roughly speaking, 67 per cent of the food of all fish was shrimp; 30 per cent was scrap fish of the kind generally taken in shrimp trawls; 3 per cent was menhaden.

Shown below is a list of the more important stomachs analyzed and the numbers of menhaden found in them.

Species	*Number Analyzed*	*Number with Menhaden*
Trout	13,288	361
Redfish	3,137	9
Spanish mackerel	3,428	30

CONCLUSIONS

Because of the nature of the purse seine and the method by which it is used, purse seine operations cannot materially harm game and food fish in waters deeper than the maximum depth of the seine. Numerous investigations of all

types have shown that these seines do little harm to food and game fish populations. It is likely, by the same token that they do little good as a control for sharks. Seining operations have not materially lowered the level of the menhaden population. The production figures over a period of years, show a continuous and sustained yield, although it is possible that the catch per unit of effort may have dropped slightly because of the increased number of boats now in operation.

A total of 26,005 fish stomachs have been analyzed. Of these, 13,288 were speckled trout (*Cynoscion nebulosus*), 3,137 were redfish (*Sciaenops ocellata*), and 3,428 were Spanish mackerel (*Scomberomorus maculatus*). The balance were various species from the Gulf Coast of Texas. These fish were caught over a period of 15 months, from June 1, 1948 until September 3, 1949, during which period 3 separate stomach analysis projects were carried forward. The results tabulated from the three projects were in close accord with one another, and with the findings of two previous investigations.

Of the 19,583 fish examined belonging to these three species, 12,505 contained food, including the remains of 400 menhaden. The percentage of the 6,433 individuals of other species, besides the three named, that had included this species in their diet was roughly the same. They had eaten 181 menhaden.

In all five investigations dealt with in this paper, shrimp were found to be the preferred diet of the three favorite food and game fishes. The work of Knapp and his associates, of Miles, and of Kemp, established that, during their investigations, shrimp had been eaten by 60 to 70 per cent of all fish examined.

The fact that these projects covered and overlapped all seasons of the year is significant as establishing a positive trend in the diet of the species discussed. Trout, redfish, and Spanish mackerel do eat menhaden in small quantities, but do not necessarily search for them because they are a preferred food as is shrimp.

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Control Of Fish Spoilage By Icing And Freezing

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THE AVERAGE PERSON who handles fish, from the fisherman on the boat to the clerk in the retail store, knows through experience, that in order to keep fish from spoiling, some form of refrigeration must be used. But it is probably safe to say that 80 per cent of the people who chill or freeze fish do not know why the lowering of temperature preserves the fish, or what a marked effect a few degrees change in temperature can have on the fish. Perhaps, if those concerned did know they would be much more careful with the icing and freezing operations.

The information given in this paper is not entirely new. It is known by a number of people but most of them are technologists—and technologists, themselves, handle very little fish. On the chance that some of this information may reach those who actually handle or supervise the handling of fish and shellfish, a brief description of the spoilage processes of fish at various temperatures will be given.

The principal causes of fish spoilage are bacterial action and autolysis. Although bacteria are extremely small and may be seen only with the aid of a microscope, they can produce almost unbelievable results. A single bacterium can do little by itself—the power of bacteria lies in their number, for they grow or multiply at an enormous rate. Bacteria grow not by becoming larger but by multiplication. Under ideal conditions for growth bacteria multiply about once every 20 minutes. At this rate one bacterium would produce 8 in one hour, 262,144 in 6 hours, and about 68,000,000,000 in 12 hours. This phenomenal growth of bacteria is probably the reason that prompted Dr. L. B. Jensen of Swift and Co. to state that food packing operations are likened to a race between the micro-organism and man to see who gets the food first. Unfortunately, there have been too many times when the microbes have won the race by an obvious margin, but the fish dealers have not conceded defeat. The secret of preservation is to make sure that favorable conditions for bacterial growth, such as high temperatures, do not exist.

Cooperating with bacteria in the spoilage processes is autolysis or self-