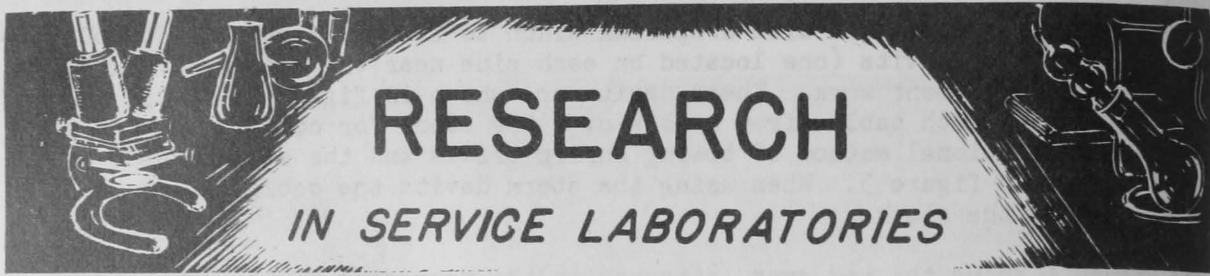

June 1952

REFRIGERATION: Freezing Fish at Sea, Defrosting, Filleting, and Refreezing the Fillets: Test cruises 9 and 10 were completed by the *Delaware*, netting a total of 50,000 pounds of whole scrod and haddock. The fish were sold through the New England Exchange at Boston and apparently will be used by the purchasers to become acquainted with processing and marketing the new product. Instructions for thawing and processing the frozen round fish, based on current knowledge, were developed by the Boston Fishery Technological laboratory and are summarized in Technical Note No. 21, which appears on pp. 18-19 of this issue.

The refrigeration equipment and brine freezer operated satisfactorily under loads equivalent to normal fishing operations. Under peak load when fishing operations provided abnormally high catches, the refrigeration system was rather hard pressed. It is expected that improvements in the efficiency of the operation and in the equipment itself will eventually solve this problem. (Boston)

* * * * *

BYPRODUCTS: Vitamin Content and Nutritive Value of Fishery Byproducts: (a) Work of other investigators seemed to indicate that presence of potassium cyanide favorably affected the microbiological assay for vitamin B_{12}. Tests so far on the effect of cyanide on the vitamin B_{12} assay of certain fishery products indicated no significant results. Addition of potassium cyanide to the sample before extraction, to the assay medium, or to both, did not produce any significant change in the final vitamin B_{12} assay in stickwater or stickwater-and-meal mixture. The effect of potassium cyanide on the vitamin B_{12} assay of pilchard meal will be considered next. (Seattle)

* * * * *

(b) Informal tests were carried out on the effect of feeding a high concentration of fish solubles to chicks on the palatability of the poultry meat. The birds were fed a diet containing about 20 percent condensed fish solubles, 3 per cent alfalfa meal, 1 percent cod-liver oil, and 76 percent yellow corn meal (all by weight). Growth was slow, otherwise the birds seemed to fatten nicely. After 25 days on test, the birds were dressed and distributed to staff members for taste testing. All reports so far indicate no fishy or other off-flavors in the birds. (College Park)

* * * * *

ANALYSIS AND COMPOSITION: Composition and Cold-Storage Life of Fresh-Water Fish: Additional samples of fresh-water fish were obtained for test purposes. These included: (1) sheepshead and carp from the Mississippi River; (2) lake trout from Lake Superior; and (3) sheepshead, yellow perch, yellow pike, and blue pike from Lake Erie.

Cooperative Work with the Association of Official Agricultural Chemists on the Determination of Oil in Fish Meal: The purpose of this project is to find a more accurate and possibly a more convenient method for the determination of the oil content of fish meal. The current edition of Methods of Analysis of the A.O.A.C. presents a rapid and accurate method for the determination of oil in fish meal. An acid-hydrolysis method, employing Mojonnier equipment, is used. Experiments were carried out to determine whether or not this method of analysis is applicable to fish meal. Three procedures were tried: (1) The A.O.A.C. acetone-extraction method, consisting of an acetone extraction of the sample followed by acid hydrolysis and further solvent extraction.

(2) The A.O.A.C. acetone extraction method followed by acid hydrolysis and extraction employing Mojonnier equipment.

(3) Direct acid hydrolysis and extraction of the original meal, employing Mojonnier equipment.

The Mojonnier method (3) gave consistently lower values than the acetone extraction procedure (2). It also gave lower results when substituted for the acid digestion following the acetone extraction (procedure 2). (Seattle)

* * * * *

NUTRITION: Study of Cause of Texture Change of Canned Salmon Prepared from Frozen Fish: Freezing and subsequent storage of salmon prior to canning produces adverse changes in the appearance and texture of the canned product. The most important changes are the formation of excessive curd and toughening of the canned product.

Studies have shown that brining the cut sections of thawed salmon prior to canning reduces the extent of these changes. Statistical comparisons of the mean penetration values obtained from three canned salmon packs showed that canned salmon prepared from frozen fish and packed in the normal style with dry salt is significantly tougher than the same fish if given a short brine treatment prior to canning. The fish used in these tests were coho salmon which had been held in cold storage at -20° F. for 28 weeks before thawing and canning. The thawed fish were cut into can-size steaks and divided into three lots. The first lot was given a 10-minute brining in 70° salinometer brine. The second lot was given the same treatment but 2 percent disodiumphosphate was added to the brine. The third lot was prepared in the normal cannery fashion with dry salt being added to the can. A total of 36 cans were packed, 12 in each lot.

Although the data obtained are only representative of a few fish of one species which had been stored under one set of conditions, they show that brining materially lessens curd formation and tends to reduce the toughening associated with canned salmon prepared from frozen fish. The addition of 2 percent disodiumphosphate to the brine did not appear to increase the efficiency of the brine treatment. (Ketchikan)

TECHNICAL NOTE NO. 21--EQUIPMENT AND PROCEDURE FOR THAWING FISH FROZEN AT SEA

These recommendations 1/ for thawing fish frozen at sea are made for the preliminary guidance of commercial concerns considering the possibility of processing fish frozen at sea by the Service's experimental trawler Delaware or by commercially-operated freezing vessels which may follow. Technologists of the Service's Fishery Technological Laboratory at Boston are ready to advise and assist any New England company planning the installation and operation of thawing equipment.

The time required to thaw brine-frozen fish depends primarily on the temperature of the defrosting medium, on how efficiently the medium circulates past each fish, and on the size (and the shape) of the fish. As a defrosting medium, water seems to be the most efficient in all respects. Because a commercial operation normally involves a wide variety of sizes of fish, it is believed that a batch-thawing process is the most practical.

Fish frozen at sea should be thawed in a tank of well-circulated fresh water at 60° F. If the water is at a lower temperature, the time required to thaw the frozen fish would be longer than necessary. It takes approximately twice as long to thaw a given fish at 45° F. as at 60° F. Use of water at temperatures higher than 60° F. is not recommended at this time. (More research is needed on the effects of thawing at high temperatures on fish frozen in the round at sea.)

The relation between the size of a cod or haddock and the time required to thaw it is given in table 1. The most important size measurement is the side-to-side thickness at the widest point on the fish. A flounder, or any other fish that is far from cylindrical in shape, requires a somewhat (about 50 percent) longer time to thaw than the time as shown in table 1. Experimentation showed that a cod or haddock can be filleted even when the backbone and part of the viscoral cavity are still frozen. Therefore, and extra column giving the time required to thaw to a filletable stage is included in table 1.

Table 1 - Time Required to Thaw Whole Round-Frozen (0° F.) Cod and Haddock of Various Thicknesses in Water at 60° F.

Thickness	Approximate Round Weight 2/	Thawing Time at 60° F.	
		Completely	For Filleting
Inches 1/	Pounds	Minutes	Minutes
1½	1-1½	60	50
2	1½-2½	100	85
2½	3-5	150	125
3	4½-7½	210	170
3½	7-10	280	220
4	9-12	360	285

1/ SIDE TO SIDE THICKNESS (SMALLEST DIAMETER OF A CROSS SECTION) AT THE POINT OF MAXIMUM GIRTH.
2/ ROUND WEIGHTS ARE GENERALLY 10 TO 15 PERCENT HIGHER THAN DRESSED WEIGHTS.

To permit the necessary movement of water around each fish, the tank should have a total volume of 70 cubic feet for each 1,000 pounds of fish per thawing load. Wherever space is not at a premium, tanks about 30 inches deep are advisable. If the tank is too deep, the fish may "pack" together excessively. At the start of the thawing process, the frozen fish tend to float; after the fish are partially thawed they generally tend to sink in fresh water. If the tank is not too deep, these tendencies to float or sink can be overcome by a simple circulating system.

The fish can be conveniently loaded into and out of the tank in large basket constructed of metal mesh on angle iron frames.

1/ BASED ON RESULTS OF EXPERIMENTATION TO BE REPORTED IN DETAIL IN A FUTURE ISSUE OF THIS REV

To secure most rapid thawing, the water must be continuously circulated past each fish. When the water is not well circulated, the fish in the center of the mass may require several times the usual period to thaw. After such long periods in the tank, the quality of the thawed fish on the outside of the mass may have deteriorated.

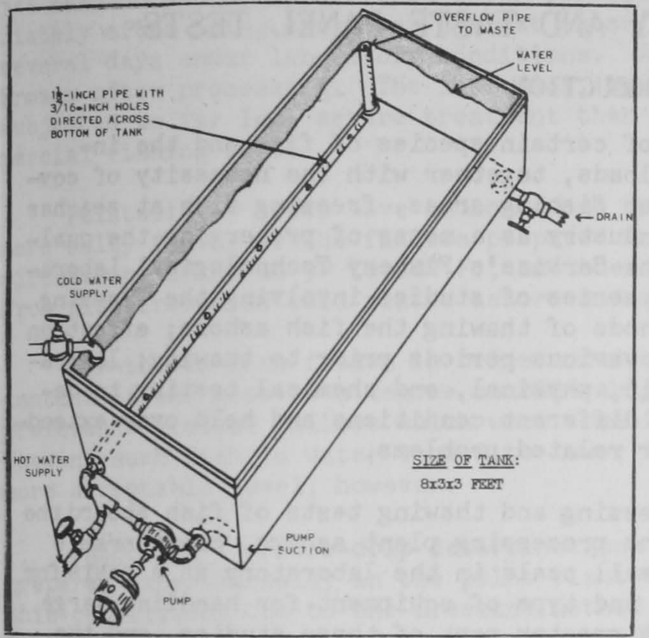

FIG. 1 - OUTLINE DRAWING OF TANK FOR WATER THAWING FROZEN FISH IN THOUSAND-POUND BATCHES.

In some areas, and at certain times of the year, the fresh-water supply might be sufficiently warm to provide the heat for thawing (150,000 B.T.U. per 1,000 pounds of fish). Generally, however, the water is not warm enough to make it practical to thaw without specially added heat. It is recommended that heat be added to the water as it passes through the circulating system. The controlled addition of hot (150° F.) water to the circulating water has proved successful in small commercial-sized trials. Reheating the water by means of steam coils in a supplementary tank should also be quite satisfactory.

For the most effective use of the equipment, it is suggested that a load of large cod or haddock be thawed at night. The circulating system should be operated but no special heat should be added. In 16 hours the heat received from the enviroment and the heat dissipated by the circulating system would be sufficient to thaw the fish completely. However, during the entire period the water would be relatively cool (near 38° to 40° F.). Then, during the regular working day three to five lots of fish could be thawed at 60° F.

Figure 1 illustrates some of the details of a semi-movable tank large enough to thaw about 1,000 pounds per batch. The tank (8 feet long, 3 feet wide, and 3 feet deep) can be constructed of 16 gauge galvanized iron, reinforced with angle irons. Of course there must be a drain in the bottom for cleaning, but there should also be an overflow pipe to maintain the proper water level and to skim off foam and floating debris. The recirculating system would consist of a 1/3 hp. centrifugal sump pump connected to a 1½-inch pipe manifold lying along one side of the bottom of the tank. In the manifold there should be five or six 3/16-inch holes directing the flow of the water across the bottom of the tank. At a T in the line, hot water would be added as required. It would be advantageous to have the hot water supply valve automatically controlled by the temperature of the thawing water. Hot water can be supplied by a simple gas-heated hot-water system. The tank, as illustrated, could hold three baskets, 25 by 31 by 33 inches in size, each capable of holding 340 pounds of frozen fish.

An arrangement suitable for a plant handling only 8,000 to 10,000 pounds of frozen fish per day would include two of the semi-movable tanks described, a 200,000 B.T.U.-per-hour hot-water heating system, an overhead monorail and hoist, and eight (2 extras) baskets. It is estimated that this equipment, including two 1/3 hp. pumps and two temperature regulators, would cost in the neighborhood of $1,500. Approximate operating costs, attributable to the thawing process, would be: Water, 5 cents; fuel (gas) 43 cents; electric power, 2 cents; a total of 50 cents per 1,000 pounds of fish thawed. This figure does not include the cost of labor and the costs connected with the storage of the frozen fish.

-- BY H. W. MAGNUSSON, FISHERY PRODUCTS TECHNOLOGIST, FISHERY TECHNOLOGICAL LABORATORY, BRANCH OF COMMERCIAL FISHERIES, U. S. FISH AND WILDLIFE SERVICE, BOSTON, MASS.

TECHNICAL NOTE NO. 22--FISH FROZEN IN BRINE AT SEA: PRELIMINARY LABORATORY AND TASTE-PANEL TESTS

INTRODUCTION

In view of the apparent scarcity of certain species of fish and the increased time required in obtaining payloads, together with the necessity of covering greater distances to reach present fishing areas, freezing fish at sea has aroused considerable interest in the industry as a means of preserving the quality of the fish. With this in mind, the Service's Fishery Technological Laboratory at Boston, Mass., has under way a series of studies involving the freezing and frozen-storage of fish at sea; methods of thawing the fish ashore; effect on quality of holding the frozen fish for various periods prior to thawing; laboratory examinations involving organoleptic, physical, and chemical testing to determine quality of fish prepared under different conditions and held over extended periods of frozen storage; and other related problems.

Prior to beginning large-scale freezing and thawing tests of fish aboard the experimental trawler Delaware and in the processing plant ashore, considerable preliminary work had to be done on a small scale in the laboratory as a basis for designing and planning the proper size and type of equipment for handling large quantities of fish. The results of the greater part of these studies, and the experimental procedure used, have been given in previous reports (Hartshorne and Puncochar 1952; Magnusson, Pottinger, and Hartshorne 1952).

Further preliminary studies of freezing and thawing fish were later conducted on a somewhat larger scale. A larger tank for water-thawing the fish permitted more closely-controlled studies of this phase of the operation. Also, facilities were developed for making quality evaluation studies of fish to determine the effects of various freezing and thawing procedures on the quality of the resulting products. The results serve as a guide in developing adequate procedures. The procurement of iced and brine-frozen fish of known history from the Delaware enabled controlled studies to be made of the effects of refreezing and frozen storage on the quality of the fillets prepared from these fish. Some of the preliminary laboratory findings, not previously reported, are given in this report.

RESULTS OF PRELIMINARY LABORATORY TESTS

Some of the fish used in the preliminary tests were of unknown history and often of questionable freshness. They were, however, quite satisfactory for use in developing procedures and obtaining certain preliminary data relative to small scale freezing and thawing tests, setting up procedures for conducting palatability tests, determining salt penetration, and other tests to be used in the project.

PALATABILITY TESTS: Palatability tests have been made on a number of the samples of fillets prepared in the course of these preliminary tests conducted in the processing plant ashore. These fillets were prepared under strict experimental conditions in determining freezing rates, salt penetration, thawing rates in air and in water, and such other problems under consideration.

The palatability tests on the samples prepared in the pilot plant and laboratory have not indicated any definite preference for fillets prepared from unfrozen fish as compared to fillets from previously frozen and thawed fish. The fillets in both cases were frozen immediately after processing. There likewise has been no decided preference shown for fillets prepared from fish frozen immediately after being caught as against those prepared from fish held in ice for several days under laboratory conditions. Again the fillets in both cases were frozen after processing. The iced fish, however, were considered to have been subjected to far less severe treatment than would be encountered aboard a commercial fishing boat.

Palatability tests have indicated no particular objections to the slightly more salty flavor of the fillets prepared from fish frozen experimentally in circulating brine at 5° to 10° F., and then air-thawed over fillets prepared from fish frozen on cold plates ashore and air-thawed.

Air-thawed fish frozen in brine under conditions which increased the salt content of the meat to a degree considerably over the minimum threshold of salt preference yielded fillets which were sometimes objectionable to the taste panel. Thawing such fish in water tended to lower the salt content of the meat to a more acceptable level, however.

PRESS DRIP: Press-drip determinations made on samples of frozen fillets prepared experimentally in the pilot plant have indicated some differences in this constituent due to the freezing method. Whole haddock brine-frozen at 5° to 10° F. were thawed in water at about 50° F., filleted, and the fillets refrozen on cold plates. These fillets from brine-frozen fish showed a press drip of 18.8 percent. Plate-frozen whole haddock were thawed in water at about 50° F., filleted, and the fillets refrozen on plates. These fillets from plate-frozen fish showed a press drip of 13.5 percent. Fillets (processed in the same manner as the haddock) from brine-frozen whole cod showed a press drip of 25.1 percent; while fillets from plate-frozen whole cod showed a press drip of 19.6 percent. Cod and haddock fillets prepared from plate-frozen fish showed less press drip than fillets prepared from brine-frozen fish.

Fillets from large fish showed a greater percentage of press drip than the fillets from small fish. This variation may possibly be related to the degree of freshness of the fish at the time of freezing. Further tests to be made on fish frozen at sea immediately after they are taken from the trawl should provide pertinent information on this matter.

A study also was made of the effect of refreezing and frozen storage on the amount of press drip obtained from haddock fillets. A batch of reasonably fresh, iced, eviscerated haddock obtained for the tests from the market was filleted. A small lot of the fillets tested before freezing showed a press drip of 8.0 percent. The balance of the fillets was frozen on plates at 0° F. Immediately after freezing, samples of these frozen fillets showed that the press-drip value had increased to 19.8 percent. The remainder of the frozen fillets were wrapped in moisture-vaporproof cellophane, divided into two lots, and stored at 0° F.

After two weeks of storage, samples from the first frozen lot showed that the press-drip value had increased to about 24.0 percent. Further storage for several days, or a total of about three weeks, dropped the press drip to about 21.5 percent.

Samples from the second lot of frozen fillets were removed from storage, thawed, and refrozen progressively five times over a period of about three weeks. Thawing was done in air at a temperature of approvimately 70° F. Refreezing was done on plates at 0° F. After the initial freezing, samples from this lot showed a press-drip value of 19.8 percent. The value rose to 26.1 percent after the first thawing and refreezing. Another slight rise to 27.1 percent was noted after a second thawing and refreezing. After two weeks of storage, the samples were thawed and refrozen a third time, and the press-drip value was 31.0 percent. A slight decrease in press drip occurred after a fourth thawing and refreezing. After the fillets were thawed and refrozen for the fifth time, the press-drip value dropped to 29.4 percent. A further drop to 27.3 percent was noted after the sixth thawing and refreezing. All of the fillets were thawed in the wrappers and again refrozen in the same wrappers. Only a negligible, if any, loss of liquid occurred between the thawing and refreezing of the fillets.

The two lots of fillets (one held constantly in frozen storage and the other subjected to repeated thawing and refreezing during a period of frozen storage) showed the same trend--an increase in percentage of press drip during about the first two weeks of storage, after which a decrease occurred. There is roughly a direct relationship between the values obtained for drip from the fillets frozen only once and held in storage and those refrozen several times during storage; that is, the press-drip values for both lots rose during the first two weeks of storage, then showed a decline. However, the rate of rise in press drip up to the time the decline occurred was greater for the group frozen several times than for that of the fillets frozen only once. Therefore, the results seem to indicate that refreezing does have some effect on the quantity of press drip. There might be some significance to these observed changes in press-drip values in relation to the period of time frozen fish are held in storage prior to thawing and filleting, and to the quality of the fillets prepared from them. Further experiments are being scheduled to shed light on this aspect of the problem.

FREE DRIP: Preliminary values for free drip for random samples of frozen fillets have not shown variations as extreme as those for press drip. Free-drip values are much lower, however, as might be expected, and generally have remained at about 3 to 4 percent, regardless of the treatment the fillets received.

SALT CONTENT: The salt content of the skin of the fish increases considerably as a result of brine-freezing. Penetration of the salt through the skin and into the meat of the fish has not been found to be too great, however, under optimum conditions of brine-freezing. A comparison was made of the salt content of iced, dressed cod and haddock with that of fish frozen in about 80° salinometer brine at a temperature of about 6° F. The salt content of the skin of the fish showed an increase from an initial value of about 0.4 percent to 1.3 percent, respectively, while that of the first one-quarter inch of meat beneath the skin increased from approximately 0.2 percent initially in iced fish to only 0.4 percent in brine-frozen fish. The second one-quarter inch of meat beneath the skin had an initial salt content of slightly under 0.2 percent for iced fish and increased to only about 0.3 percent in brine-frozen fish. As mentioned previously, palatability tests have shown no particular objections on the part of the taste panel to the slightly more salty flavor of brine-frozen fish which were not subjected to water-thawing.

Samples of brine-frozen fish thawed in fresh water have indicated that the salt content of the meat will be reduced to approximately that of the meat prior to freezing. Thawing in air will, of course, not change the salt content of the fish appreciably.

Results have indicated that salt will continue to penetrate the meat if the fish, after being frozen, are allowed to remain in the brine. For frozen fish held in the brine at about 6° F. for 20 hours, the salt content of the second quarter-inch of meat was found to be slightly over 1.5 percent as compared to onl about 0.3 percent for the fish removed immediately after freezing. Fish that were frozen and then allowed to remain in the brine for about 36 hours with the refrigeration turned off, permitting the temperature of the brine to rise slowly to about 18° F., had a salt content exceeding 5 percent in the first one-quarter inch of meat, which is considered excessively high. In general, fish that have been allowed to remain for any length of time in brine at temperatures above 10° F. have shown a very high salt content.

TRIMETHYLAMINE CONTENT: As the relative state of freshness of many marine fish decreases, there is an increase in the quantity of trimethylamine that is formed in the meat of the fish. In the case of certain bottom fish taken in the northwest Atlantic area, a value of 15 mg. of trimethylamine nitrogen in 100 g. of fish is generally considered to indicate that the fish is not salable.

In developing the technique for determining trimethylamine in fish by a spectrophotometric method, some samples of fish that had been frozen for some time, then thawed, and held at a temperature of about 40° F. were at first used in an attempt to determine the increase in trimethylamine content at intervals as spoilage progressed. It was noted, however, that only very small increases in trimethylamine occurred, with a maximum of only about 8 mg. of trimethylamine nitrogen per 100 g. of fish even when the fish were judged to be badly spoiled on the basis of odor and appearance. After repeating the tests several times with other similar samples and obtaining much the same results, it was thought that freezing may possibly have been responsible for the failure of trimethylamine to form after the fish were thawed and held until spoiled. After again repeating the tests, but this time with fish that had not been frozen, a significant rise in trimethylamine content occurred. Under these conditions, fish that had been held at a temperature of 40° F. until spoilage occurred had a trimethylamine nitrogen content of about 46 mg. per 100 g. of fish.

These results may have some significance in that trimethylamine determinations are relied upon to some extent for indicating relative freshness of certain varieties of fish. If the results reported above are found to be generally true, and the trimethylamine test does not appear to be valid for indicating the freshness of fish that have been frozen and then thawed and held at temperatures somewhat above freezing, the value of this determination will, of course, be definitely limited. Further tests along this line are planned in order to determine the effects of freezing and frozen storage on trimethylamine formation in the thawed product.

The trimethylamine determinations will be used in this project primarily to obtain some indication of the relative freshness of the iced fish prior to being frozen. Tests will also be made on the fillets being held in frozen storage to determine whether there is any appreciable change in trimethylamine content over a long period of storage. Although some results of this type were reported previously (Hartshorne and Puncochar 1952), the storage period was limited to only five months.

LITERATURE CITED

HARTSHORNE, JEAN C., AND PUNCOCHAR, JOSEPH F.
1952. FREEZING FISH AT SEA--NEW ENGLAND. PART 1 - PRELIMINARY EXPERIMENTS. COMMERCIAL FISHERIES REVIEW, VOL. 14, NO. 2 (FEBRUARY), PP. 1-7.

MAGNUSSON, H. W.; POTTINGER, S. R.; AND HARTSHORNE, J. C.
1952. FREEZING FISH AT SEA--NEW ENGLAND. PART 2 - EXPERIMENTAL PROCEDURES AND EQUIPMENT. COMMERCIAL FISHERIES REVIEW, VOL. 14, NO. 2 (FEBRUARY), PP. 8-15.

--BY S. R. POTTINGER, TECHNOLOGIST,
JOHN HOLSTON, CHEMIST,
GRACE MCCORMACK, BACTERIOLOGIST,
FISHERY TECHNOLOGICAL LABORATORY,
BRANCH OF COMMERCIAL FISHERIES,
U. S. FISH AND WILDLIFE SERVICE, BOSTON, MASS.