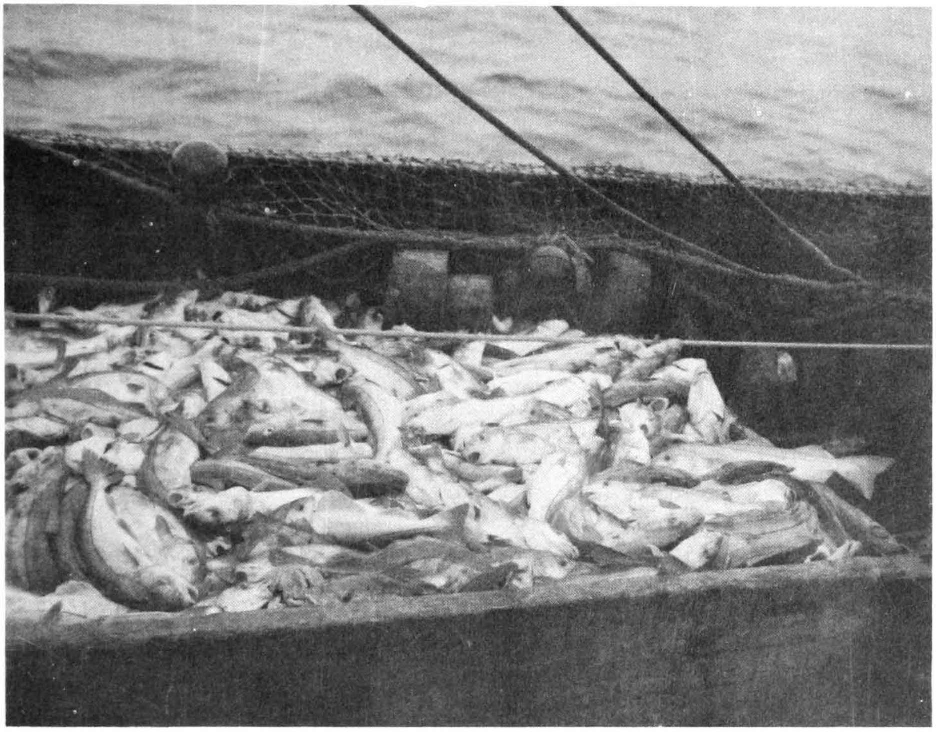
HANDLING FRESH FISH

REFRIGERATION OF FISH - PART 2



UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

Fishery Leaflet 428

United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service - Bureau of Commercial Fisheries

Fishery Leaflet 428

Washington 25, D. C. December 1956

REFRIGERATION OF FISH - PART TWO

HANDLING FRESH FISH

By Charles Butler (Section 1); John A. Dassow (Section 2); and
C. J. Carlson, Joseph Carver, and Martin Heerdt (Section 3)

Table of Contents

(A detailed table of contents is at the beginning of each section)

* * * * * * *

This leaflet is part two in a series of five on "Refrigeration of Fish." Titles of the other four leaflets are:

Part 1 (Fishery Leaflet 427) -- Cold-Storage Design and Refrigeration Equipment
Part 3 (Fishery Leaflet 429) -- Factors to be Considered in the Freezing and Cold Storage of Fishery Products
Part 4 (Fishery Leaflet 430) -- Preparation, Freezing, and Cold Storage of Fish, Shellfish, and Precooked Fishery Products
Part 5 (Fishery Leaflet 431) -- Distribution and Marketing of Frozen Fishery Products

The five leaflets in this series are prepared under the general supervision of Charles Butler, Chief, Technological Section, Branch of Commercial Fisheries, Washington, D. C., and edited by Joseph W. Slavin, Refrigeration Engineer, Fishery Technological Laboratory, East Boston, Massachusetts, and F. Bruce Sanford, Chemist, Fishery Technological Laboratory, Seattle, Washington.

SECTION 1

SPOILAGE OF FISH PRIOR TO FREEZING

By Charles Butler, Chief,
Technological Section, Branch of Commercial Fisheries*

TABLE OF CONTENTS

* Fish and Wildlife Service, Department of the Interior, Washington 25, D. C.

INTRODUCTION

To the qualified wine taster, there is a wide range of aroma, bouquet, color, and flavor within the upper and lower limit of acceptability. Small wonder, then, that with a food commodity as diverse in character as fishery products, there is present a similar range in flavor, aroma, texture, and color. This fact is forcefully brought out when restaurant managers and home economists attempt to introduce a new product or a new method of preparation for an established product. Fishery products that retain these initial desirable qualities provide the consumer with each of the essential ingredients for an appetizing and completely nutritious meal.

The delicate and ephemeral aroma and flavor characterizing each individual member of the large family of fishery products as a treat unto itself is a zealously preserved quality in many countries, such as Denmark where fish often are purchased alive. The lavish care taken to supplement and enhance these characteristics with expert cookery accounts in large part for the "rave" notices Americans give fish eaten there. Without the supreme initial quality of the fish, the dish is something less than the Danes are accustomed to expect. By contrast, we in this country have all too often been painfully aware of the strong odor permeating the apartment house or private home where "fresh" fish is being fried for the evening meal.

Extensive tests by the Educational and Market Development Section of the Fish and Wildlife Service have shown that children at school lunch rooms will overcome a disinterest in fish dishes, possibly developed at home through lack of proper preparation of quality raw materials, or even an unreasoned bias developed through disparagement of fish by parents and companions, when the servings are from high quality materials, tastefully prepared, and appealing to the eye.

Adults, likewise, have developed a liking for fish dishes through demonstrations by Fish and Wildlife Service home economists. For example, at a class of Army cooks and bakers, three lots from the same purchase of ocean perch fillets were prepared by three different recipes and served to a taste panel. Questions were asked regarding the particular species of fish used for each of the three "different" dishes. The participants expressed approval of the servings, although they had been emphatic in their dislike for fish before the taste test.

Family groups participating in taste tests at another laboratory expressed surprise at the excellence of the entree served from frozen fillets. The chief question was: "Where can I get fish like that to cook for my family?"

On another occasion, a group of fishery industry executives were served a luncheon where frozen fillets were prepared as the entree.

First quality fish, prepared with the proper cooking time, seasoned to bring out--not to mask--the true flavor, and served attractively were so well accepted that the cook had several offers for a job to open a restaurant by men who, although in the fish business, seldom found their product available in such an appetizing form.

It is thus evident that there is a real need for the encouragement of highest quality fish production. Persons who now eat fishery products from habit, or for economy reasons, would without question eat them more frequently if better raw materials were made available. That large segment of people who seldom eat seafoods at home could be interested if they were induced to try pan-ready, high-quality products, with a suggested recipe, thereby making the ordinary homemaker into a skilled chef. The even larger group of persons who do not eat fish because they do not like it can never be won over by offerings of inferior servings no matter at what low price. They can be interested when there is offered something of sufficient merit to stimulate their appetites. Then comes the opportunity to open up the wide demand for tasty variety that fishery products are uniquely able to supply.

This section is devoted to a discussion (1) of the various forms and pathways of quality deterioration and (2) of methods of minimizing such losses prior to freezing, in order to obtain a product with the characteristically pleasing flavor and aroma of freshly caught fish.

CAUSES OF DETERIORATION

The dictionary defines "spoil" as "to cause to decay and perish or to become of less or no use, value or the like." There are, in other words, several degrees or stages in the process of spoilage. Obviously, no one would be expected to relish fish that had reached the "decay or perish" state. For a marketable product, then, we would expect to deal rather with the "to become of less use, value or the like" category as the lower limit of acceptability. In practice, this is actually too often the case, as there may be wide differences in the quality of fish offered for sale. They may all be edible in the sense that discomfort or illness will not result from ingestion. Food and Drug inspection may show no criterion for declaring them unfit for consumption. Yet--somewhere, somehow --the top quality has been lost.

To be in a position intelligently to preserve and protect fishery products from this loss, we must have a knowledge of the factors contributing to it. In this section, factors applicable from the point of capture to, but not including, preservation by freezing will be considered.

Quality loss in fish and shellfish is attributable to one or all of three principal causes: (1) enzymatic or autolytic action, (2) oxidative action, and (3) bacterial action. The order of onset for these, and their relative importance in causing deterioration, may vary with such allied considerations as species and maturity, and method used in the capture and in the dressing and icing of the fish. Bacterial action is generally recognized as the most important cause, but the interrelation of all three actions will be described as well.

ENZYMATIC ACTION

All living animals--of which fish, mollusks, and crustacea are a part--derive essential materials for growth and maintenance through the digestion and assimilation of plants or of other animals. The animal, to accomplish this task, must break down the food eaten into a number of constituents that can pass through the walls of the digestive tract. After mechanical breakdown, as by chewing, chemical breakdown by the digestive juices and fluids takes over the task. In these fluids are agents called enzymes, some of which attack fats, others carbohydrates, and still others the protein portions of the food. When the combined physical-chemical process is finished, the food can be absorbed into the body tissues to furnish construction and maintenance materials, energy, or fat reserves. Within the tissues, other enzymes are available to draw upon the stored body reserves for maintenance--or energy-supplying materials if food materials are not available to the animal.

When the animal dies, the balance between the processes of body maintenance is upset. The enzymes, instead of acting on the food normally taken in, continue actively to digest any of the particular types of materials--such as fats, carbohydrates, or proteins--which they are capable of breaking down. The result is the alteration of complex body tissue to less complex forms--a reversal of the normal process of digestion, assimilation, growth, and maintenance. Several names are used to describe this process of breaking down: autolysis, biochemical changes, enzymatic decomposition. The effect on the tissues begins at death; the rate and extent of alteration may be only controlled by some effective preservation method, such as use of heat, cold, or dehydration.

The chief observed effects of enzyme action are the softening of the fish flesh. In the case of some species, however, such as herring taken with food in the digestive tract, the autolytic action is so rapid that the belly walls may be pierced and the visceral mass converted to a semifluid state. Salmon under similar conditions may develop the discoloration called "belly-burn" where visceral organs have been in contact with the abdominal walls. Alford and Fieger (1952) reported that the spoilage in shrimp, known as "black spot," is enzymatic in nature. They reasoned that an enzyme reacts in the presence of air to oxidize the tissue substances and form melanin, with its characteristic black color.

These enzymatic reactions are intimately related to the mechanisms of deterioration that are utilized by bacteria. In fact, enzymes are secreted by the bacteria which act in the same general manner, and their attack is facilited by the fish-enzyme actions. The unicellular bacteria absorb and assimilate the breakdown products formed from the body of the host by the secreted enzymes. The bitter flavors and unpleasant odors, characteristic of spoiled foods, are derived from the breakdown products not absorbed by the bacteria. Fortunately, the same general rules apply for the minimizing of autolytic and of bacterial action in fish prior to freezing. They will be described in detail as part of the section on bacterial action.

OXIDATIVE ACTION

A second cause for deterioration in quality of fish prior to freezing results from oxidation and rancidity. Here again there is overlapping with enzymatic and bacterial activities. The fish contains fatty tissue that is protected during life by counterbalancing agents. At the death of the fish, the fat is attacked by the enzymes that are capable of doing so. Bacterial enzymes likewise react with the fat in the moist tissue. Usually, however, the bacterial action on the protein of the fish so rapidly produces undesirable odors and flavors that those developed as a result of the deterioration of the fat may be masked or of lesser importance, at the iced-fish stage. If, however, high quality fish is frozen, the slow but continuing oxidation and development of rancidity may then become a more serious problem. For example, even fish of very low oil content, such as cod or haddock, will develop the so-called "salt-fish" odor in frozen storage. At the other extreme, very fat fish, such as herring, may exhibit these changes after only a few days in ice. Once a fatty fish is frozen, the exposure of fat to the air during storage may result in surface oxidation of major significance in the development of the bitter flavor, the tallowy feel in the mouth, and the paint-like or "salt-fish" odor so characteristic of oxidized fish oil.

In summary, the oxidation and rancidity of fats can be caused by the single or combined action of tissue enzymes, bacterial enzymes, and exposure to air. The degree of susceptibility among fatty fish varies with species: mackerel, herring, and some of the salmon are quite vulnerable, whereas sablefish are quite resistant. Fish of relatively low fat content, such as cod or haddock, may develop rancidity, although at a much slower rate. Oxidation, besides causing rancidity, can cause other changes in fish. The fading of pigments that is observed in salmon or ocean perch and the development of off-color, such as in the yellowing of halibut and the browning of haddock, are results of oxidation.

Again, as in the case of enzymatic action, the same precautions— to be described under the following section on bacterial action--will serve to minimize the undesirable changes attributable to oxidative action in fish prior to freezing.

BACTERIAL ACTION

Bacteria are usually the most important causes for deterioration in fish, as in other protein foods. They are present in air, water, and soil in innumerable forms, shapes, and species, each with a characteristic method of attacking which, although we do not see the organism with the naked eye, can be noted by the odors, flavors, or colors imparted to material on which they are acting. The effects of bacteria on fish may be described at three principal stages in the taking and processing prior to freezing: (1) in the water, (2) aboard the vessel, and (3) at the shore plant.

Bacteria in the Water

Since bacteria are present in water, the natural environment of fish, we may expect to find bacteria on exposed surfaces. The normal fish, for example, may have a heavy population of bacteria on its skin, gills, and alimentary-canal surfaces. As long as the fish is in robust health, with no major breach in the skin tissues, which act as a barrier to attack, the bacteria can be kept from doing any serious damage. At death, however, the fish ceases to maintain the barriers to bacterial assault. Its tissues offer excellent material upon which the bacteria can feed. Enzymes secreted by the bacteria begin at once to liquify or digest the surrounding tissue so that the bacteria can absorb needed components of the tissue. The type of spoilage observed will be in large measure that attributable to the changes in the tissue caused by the attack of specific types of bacteria and from the byproducts generated by these bacteria when feeding on the tissues. The extent of spoilage is determined, in large part, by (1) the initial load of bacteria, (2) the temperature of the fish flesh, (3) the lapse of time, post-mortem, and (4) the type of sanitary procedures practiced.

Many of the fresh and frozen fish of commerce are taken in water at temperatures not very far above freezing: for example, cod at 35° to 44.6° F., haddock at 37.2° to 50° F., and halibut at 32° to 39° F. The bacteria adapted to these temperatures may be expected to continue their destructive activities on these fish after death, so long as the temperatures of storage are not low enough to provide an unfavorable environment. In the case of meat products, the normal bacterial population is adapted to growth at temperatures in the range of 101° to 107° F. The use of chill storage at 32° to 36° F. has a more pronounced retarding effect on these bacteria. The spoilage of fish is, therefore, a more difficult process to keep in check than is that of fresh meat products.

Although shrimp are taken in relatively warmer waters than are cod and haddock, Fieger, Lewis, and Green (1947) found few bacteria present as the catch was brought aboard the vessel and attributed spoilage largely to bacterial contamination and growth on board the vessel and ashore. Again, on shrimp, Williams (1949) found that cold-loving bacteria were less abundant but that types normal to bottom muds were present.

The presence or absence of food in the alimentary tract of fish may also account for the presence or absence of bacterial populations, according to studies of some workers. Thus, it is probable that the bacterial load in the intestinal tract has been, at least in part, introduced from contact with and feeding on detritus or other animal life found in the bottom muds.

Studies of fish and other sea animals indicate that the number and type of bacteria found at time of capture varies with season, locality, species, water temperature, and method of capture. Analyses of sea water—taken at the surface, the mid-water, and the bottom levels in areas of fishery activities--show that the heaviest bacterial population is found in the bottom mud. We would expect that bottom-feeding species, such as those caught in the trawl fisheries, would have a large bacterial load. This inference is correct, but the effect of the gear enters into the problem, too. As the fish are often squeezed by weight of the mass in the trawl hoisted on deck, the contents of the intestines are expressed, adding to the contamination contributed by the skin and the gill-surface bacteria. This fact is corroborated by a comparison of bacterial counts of identical species of fish, such as cod, taken by trawling and by hand-lining. The latter, landed singly and with relatively careful handling, have a lesser bacterial load. Environmental differences may be shown from a comparison of the high bacterial loads of bottom feeders, such as cod, with the lower incidence for surface feeders, such as herring. Seasonal variations within the same species and the same gear category were found on haddock from the same grounds, the highest bacterial counts being in mid-summer for five successive years, according to Reay and Shewan (1949).

Bacterial Problems Aboard the Fishing Vessel

The effects of bacterial action may vary considerably, depending on the species of fish, the form in which they are landed, and the methods employed to protect quality. Some fish, such as mackerel or herring, caught close inshore may be stored on the vessel in the ungutted condition and without icing. Other fish taken in day fisheries by netting or trolling may be eviscerated, but not iced. Shellfish, such as oysters or clams, may be brought aboard and stored uniced in the shell.

For these round fish, careful washing in clean water, storage in clean boxes or shallow pans, minimization of damage from exposure to excessive pressure, and prompt protection from the sun and air temperatures will assist in keeping down bacterial action. Eviscerated fish can be carefully checked to insure removal of all visceral parts and blood, thoroughly washed in clean water, and promptly stowed out of the sun and with the belly cavities down to promote free drainage of wash water. Shellfish must be very thoroughly washed free of mud and debris, promptly placed in clean storage space out of the sun, and preferably kept moistened with clean seawater.

Icing of fish is not a cure-all for quality preservation, but it does offer a considerable measure of protection from bacterial action. The importance of prompt and proper icing cannot be overstressed. Iced cod have been reported by Castell (1949) to spoil twice as rapidly at 37° F. (a common meat-chilling-room temperature) as at 32° F. Since a temperature drop of 5 degrees can reduce the rate of spoilage by 50 percent, it is very important to bring fish, after capture, rapidly to a suitable chill temperature of 32° to 34° F. Fish that can be kept for 14 days and still be edible at 32° F. can be kept for only 4½ days at 50° F. and for only 1½ days at 69° F.

Another reason for chilling fish rapidly is that the growth of bacteria goes through a lag phase or induction period, which increases in duration as the temperature of the flesh is lowered. In the case of Pseudomonas fluorescens, the lag phase is extended from 1 day at 52° F. to 4 days at 32° F. and to 6 days at 27° F.

The storage life of fish held at high temperatures for even a short time before icing is greatly reduced. Fish freshly caught and stored at 69° F. for 16 to 18 hours kept only half as long at 32° F. as did fish chilled to 32° F. immediately after they were caught.

Fish have different keeping qualities depending on species, season, and method of catching. Cod, haddock, flounder, and Norwegian winter herring keep for 12 to 15 days in good condition when chilled to 32° F. immediately after being caught. Pelagic fish with feed, dead shellfish, and those bruised and squeezed in catching spoil rapidly, even when iced.

Fieger, Green, Lewis, Holmes, and DuBois (1950) found that, with shrimp headed and properly washed on capture and then carefully iced, bacterial loads on the shrimp at the top of the pen section were of the order of 1 as compared with 100 for the shrimp on the bottom of the same pen, after 7 days' storage.

Campbell and Williams (1952) found that, with iced shrimp packed to facilitate rapid and direct removal of accumulated water from melting ice, the bacteria present actually reduced in number, after 8 days, but increased, after 12 days, at which time the quality also began to deteriorate.

In summary, icing aboard the vessel can be used to decrease bacterial action by use of bacteria-free ice for prompt, adequate, intimate, and continuing contact on all surfaces of the fish. This means, in essence, reduction of fish temperatures to as near 32° F. as possible, immediately after capture, and the maintenance of these conditions for as long as the ice is needed to protect the fish.

Fish frozen at sea and stored under refrigeration have essentially the most protection possible from the deteriorative action of bacteria. The reasons for this effect can be shown by reference to the work of Bedford (1933). The range of temperature for development of marine bacteria is 18.5° to 80° F. Optimum growth occurs at 40° to 68° F. Bedford's extensive report on this subject presents data on 71 strains of bacteria isolated from sea water. Sixty-five grew at 32° F., 22 grew at 25° F., and 10 grew at 18.5° F. Most of the biochemical activities of marine bacteria continued steadily as the temperature dropped to 32° F. Many grew but could not produce enzymes at temperatures down to 21° F. It can therefore be seen that, below freezing, bacterial activity as a cause of spoilage is somewhat limited.

A differential count of bacterial strains by Haines (1934) showed that Staphylococci ceased growing below 50° F.; most strains of Escherichia coli, Bacillus proteus, and Micrococci did not grow at 32° F.; some strains of Bacillus proteus were capable of growing at 32° F.; many strains of Achromobacter, Pseudomonas, and various yeasts grew rapidly at 32° F., and down to 20° F. on unfrozen media. Thus although some strains of bacteria may continue to grow at the lowest possible temperature (32° F.) of iced fish, their activity drops off sharply as freezing takes place. In the freezing-at-sea studies carried on by the Fish and Wildlife Service laboratory at Boston, Massachusetts, brine at 5° to 10°F. was employed, with frozen storage at 5° F. for further protection of the fish en route to shore. Green (1949) reported a 62-percent reduction in bacterial counts on shrimp after 2 months' storage at 0° F. Although no direct bacterial counts were made on the fish frozen at sea in Boston, the organoleptic evaluations of these fish, at intervals over a 9-month storage period, did show that deterioration from bacterial action was either slight or nonexistent.

Bacterial Problems at the Shore Processing Plant

Fish protected aboard the vessel by careful handling, thorough icing, and good sanitation practices are next subjected to hazards of bacterial contamination during unloading, sorting, and processing ashore. The same factors need to be considered here: namely, time, temperature, care, and sanitation. There are, however, differences introduced in degree and kind at this stage in the handling of the product.

In the transfer from vessel to plant, the use of unclean baskets, boxes, tanks, conveyors, or other equipment, or the inserting of tines of the fork into the edible portion of the flesh offers opportunity for contamination. If the fish are allowed to remain longer than the absolute minimum time unrefrigerated prior to the next processing step--and at all intermediate stages--bacterial growth is rapid. All equipment coming in contact with the fish should be kept free of flesh particles and of slime. The use of a good detergent to remove soil, followed by a wash-down with water containing 25 p.p.m. of residual chlorine, is an acceptable procedure.

Fish unloaded from the vessel should be thoroughly reiced, then held in a mechanically refrigerated cooler at about 30° to 32° F. in the shore plant until the trans-shipping or processing can be started.

Processing at the shore plant can result in serious bacterial contamination arising from contact of the fish with wood or metal surfaces, tools, gloves, or hands of workmen on which bacteria may be picked up through (1) expressing of liquids from the fish intestines, (2) growth of bacteria in slime and in flesh particles strewn about the work surface and not frequently washed away, (3) use of polluted water for washing, or (4) unacceptable personal sanitation habits of the workers. Castell (1948) found from studies in filleting plants that the major portion of bacteria causing spoilage at iced temperatures were brought into the plant on the fish themselves. Here again, the effective weapons against bacterial deterioration are low temperatures, cleanliness, and rapid handling. The following are some of the measures that should be taken to minimize bacteria in the processing of fish fillets and shellfish.

The processing of fish fillets and steaks.--Fillet-plant operations to protect the fish against bacterial action have been described by Hurley (1948). He found that the use of water containing 5 p.p.m. of residual chlorine at all stages from fish washer through the filleting line decreased the bacterial load of the fish by as much as 2,000 times over the previous methods. He also recommended use of water containing 25 p.p.m. residual chlorine for general plant clean-up at the end of each day.

Bacterial control in steak-preparation operations would differ principally in that the skin left on the fish should be even more carefully freed of slime and bacteria. Any protracted lag between the cutting of the steaks and the packaging and freezing stages could offer an excellent opportunity for continued spoilage.

The processing of shellfish.—Shellfish problems with bacterial spoilage are somewhat different from those for fish. Shrimp, taken usually many days from port, must be protected on the vessel. Ashore, continued sanitation, proper reicing, fast handling, and processing by either cooking or freezing is essential to keep the quality of shrimp landed.

Scallops are usually shucked at sea and require essentially the same precautions as do shrimp.

Oysters, clams, and mussels are in a somewhat special category, since the U. S. Public Health Service, in cooperation with the states, has set up recommended practices for sanitation in the harvesting, shucking, and packaging of these shellfish. A manual describing the approved procedures may be obtained from the U. S. Public Health Service. Essentially, the problems are maintenance of low temperature and sanitation, but with products that grow in inshore areas, the possibility of pathogenic bacterial contamination is added to that of spoilage.

Crabs, too, pose serious bacterial problems. The crabs, when steamed, may be sterile, but good sanitation is essential to minimize bacterial contamination during the cooling and hand-picking stages. The use of chlorinated water for plant sanitation, frequent inspection of workers for health and for compliance with good personal sanitation, and rapid packing and chilling or freezing of the picked crabmeat can materially assist in producing an acceptable product.

The packaging of fishery products.--For fish or shellfish that are to be frozen, the packaging materials must be clean and free of bacteria. They should be sufficiently watertight to preclude recontamination of the product once it is packaged. The product to be packed should be at 50° F. or lower when packed, and the packages should be promptly frozen thereafter, to at least 0° F. at the center of the product.

When packaging fish for the fresh-fish trade, proper care must be exercised so that all the good work that went before will not be lost through spoilage at this stage. The fish must be chilled to 32° F. before it is packaged. MacCallum (1949) showed that the temperature of fish boxed at 50° F. and stored in ice had dropped to 44° F. only after 18 hours. The primary reason for the icing of fresh-fish shipments is to maintain the desirable low temperature. The container should, at the same time, protect the fresh fish from recontamination due to seepage of ice water or to other possible sources during transport.

LITERATURE CITED

ALFORD, JOHN A., and FIEGER, E. A.

1952. The non-microbial nature of the black spots on ice-packed shrimp. Food Technology, No. 6, June, pp. 217-219.

BEDFORD, R. H.

1933. Marine bacteria of the northern Pacific Ocean; the temperature range of growth. Contrib. Can. Biol. and Fish, N. S. No. 7, pp. 433-438.

CAMPBELL, L. L., JR., and WILLIAMS, O. B.

1952. The bacteriology of Gulf Coast shrimp. IV. Bacteriological, chemical, and organoleptic changes with ice storage. Food Technology 6, No. 4, April, pp. 125-126.

CASTELL, C. H.

1948. The control of fillet contamination in fish plants. Part II - The relationship between the initial contamination and the subsequent rate of spoilage. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Stations No. 41, January, pp. 10-14.

CASTELL, C. H.

1949. Refrigeration temperatures and the keeping time of fresh fish. Fisheries Research Board of Canada, Atlantic Coast Stations, Progress Report No. 44, January, pp. 8-12.

FIEGER, E. A.; LEWIS, H.; and GREEN, M.

1947. For better shrimp cocktails. Southern Fisherman, 7, No. 3, January, pp. 204-205.

FIEGER, E. A.; GREEN, M.; LEWIS, H.; HOLMES, D.; and DuBOIS, C.

1950. Shrimp handling and preservation. Refrigerating Engineering, vol. 58, March, p. 244.

GREEN, M.

1949. Bacteriology of shrimp. Food Research, 14, No. 5, p. 392.

HAINES, R. B.

1934. The minimum temperatures of growth of some bacteria. Journal of Hygiene, vol. 34, p. 277.

HURLEY, STANLEY P.,

1948. In-plant chlorination gives excellent bacterial reduction at Gorton-Pew Fisheries Company, Ltd. Paper presented at the Fishery Technologists' informal meeting, Boston, Massachusetts.

MacCALLUM, W. A.

1949. Changes in cooling and transportation technique suggested for the marketing of fresh "fresh" fish. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Stations, No. 45, April, pp. 11-14.

REAY, G. A., and SHEWAN, J. M.

1949. The spoilage of fish and its preservation by chilling. Advances in Food Research, vol. 2, p. 349, New York, N. Y. Academic Press, Inc.

WILLIAMS, O. B.

1949. Microbiological examination of shrimp. Journal of Milk Food Technology, vol.12, pp. 109-110.

SECTION 2

HANDLING OF FISH ABOARD THE VESSEL

By John A. Dassow, Assistant Chief,
Pacific Coast and Alaska Technological Research*

TABLE OF CONTENTS

ILLUSTRATIONS

* Fishery Technological Laboratory, Seattle 2, Washington

HANDLING PROCEDURE

The quality of landed fish depends primarily on the care and promptness with which they are handled and stored aboard the fishing vessel. If they are to be held fresh aboard the vessel for more than a few hours, the fish, whether whole or gutted, should be stored in crushed ice or other cooling medium. The best procedure for handling is as follows: (1) remove the fish from the water promptly after catching; (2) wash trawl-caught fish to remove mud, sand, or debris; (3) sort various species or sizes, as required; (4) remove gills and viscera from larger fish (for example, cod, halibut, and salmon) and wash the fish with clean water; (5) store the fish in sufficient crushed ice or other cooling medium to maintain them at approximately 32° F., allowing for proper drainage in ice and avoiding excessive weight on the fish. If these steps are carried out carefully and promptly, fish of optimum quality are obtained, and subsequent deterioration is minimized. Crowther (1951) pointed out that the secret of fish preservation is to make sure that favorable conditions for bacterial growth, such as high temperatures (those above 32° to 36° F.), do not exist.

For the proper production of fish from an offshore resource, three essentials are necessary: (1) a method of catching the fish, (2) a vessel for transporting the fishermen and fishing gear to and from the fishing grounds, and (3) a means of returning the fish to the dock in marketable condition. As fishing methods have gradually been developed and brought to a high degree of efficiency, the various effects of the fishing methods on the quality of the fish have become recognized. There follows a more detailed account of the principal factors considered of importance in the delivery of fish of optimum quality by the first point of landing by the fishermen.

EFFECT OF FISHING METHODS ON QUALITY

There are two basic commercial methods of catching fish: (1) use of a net to surround or enmesh the fish and (2) use of a hook with bait or an attached lure. These gear may be fished at the surface or in deep water and may be fixed (that is, set at a definite location) or moving. Many variations of each method are used, but over 90 percent of the total fisheries catch is obtained by the use of one or the other. Stansby (1952) has pointed out that methods which permit the least alteration in the fish during the act of catching provide fish of the best keeping quality.

In considering the effects of the fishing method on the quality of the fish, the following are important:

(1) Manner of death. It is well known that an animal killed suddenly and cleanly will be in better condition than will one that dies slowly, possibly struggling a long time in the process. Certain types of fishing gear are superior to others in this respect. In trolling or

in tuna-boat fishing with hook and line, the fish is caught and promptly brought into the boat, where it is killed, bled, and dressed soon after. In a seine or gill net, the fish may become very excited, struggle, and die in a frenzy. Such fish go through rigor mortis prematurely, and a diminished keeping quality is the result.

(2) Interval between time of catch and time fish are removed from the water. If the interval between the time of catching and the time the fish are removed from the water is long, the fish will die before being taken aboard the vessel, and spoilage will have already commenced. With some types of gear, death may occur shortly after catching; for example, the fish in a gill net often suffocate. In the trawl fishery, most of the fish may be dead when brought on deck, owing to crowding of the fish in the net, especially while the net is being raised to the surface of the water and lifted aboard the vessel. If the fish are not crowded in the net, as in a pound net or large seine, they may be held in good condition and removed at a time when they can be handled conveniently or when it is thought to be most suitable. Sardines, for example, are sometimes left in the net until their intestines are empty.

(3) Water temperature. If the fish die in the gear before their removal from the water, the temperature of the water is very important. In southern areas where water temperatures of 75° to 85° F. are common, fish may spoil before they are removed from the gear, in instances of long delay. In the cooler northern waters, where temperatures of 45° to 50° F. are common, the danger of spoilage, if the fish die in the water, is not so great.

(4) Selectivity of gear. With seines, trawls, and gill nets, specific species or sizes of fish may be taken because of mesh-size limitations. The smaller fish of a given species tend to spoil more rapidly than do the larger ones (Stansby 1952): for example, small tuna spoil faster than do large tuna. In trawl fishing, the use of a larger mesh may exclude both young or immature fish and species of small fish of no commercial importance.

(5) Biological factors. Some types of gear, such as that used in salmon trolling, are designed to take fish when they are feeding actively. Other types, such as salmon gill nets, are designed for the same species but are used in locations where fish are not feeding. Considering the effect of sexual maturity, and again using salmon as an example, trolling gear will take fish far from the spawning grounds in the open ocean. Such fish taken by offshore salmon trollers are in prime condition. The same fish taken several weeks later by a gill net at the mouth of a river will no longer be of the same high quality.

Along with the effect of the fishing methods on quality, the differences among the various species or groups of fish in relation to handling problems have also been recognized.

RELATION OF FISH SPECIES TO HANDLING METHODS

As was pointed out in the section on spoilage, the basic characteristics of fish make them highly vulnerable to loss in quality during handling--much more so, for example, than is beef. The resistance of fish to spoilage and the handling and storage methods employed on the vessel vary according to the species and to the particular fishery.

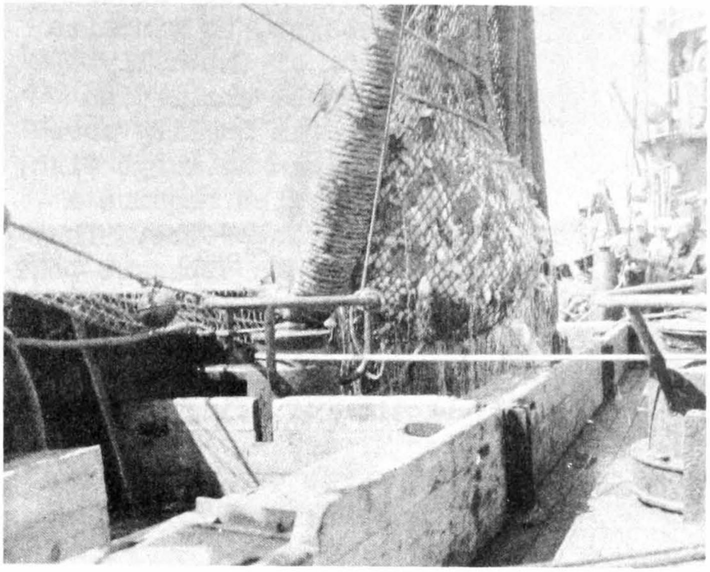


Figure 1.--Dumping a load of groundfish aboard a North Atlantic trawler.

Groundfishes

Cod (Gadus morhua, Gadus macrocephalus), ocean perch (Sebastes marinus, Sebastodes alutus), whiting (Merluccius bilinearis), haddock (Melanogrammus aeglefinus), flounder (Pseudopleuronectes and related genera), hake (Urophycis sp.), and pollock (Pollachius virens) are the most important species of groundfish. These inhabit the bottom of the ocean and are caught throughout the year in the New England trawl fishery. Three of the group--cod, ocean perch, and flounder--are also taken in the North Pacific trawl fishery.

As a group, the fish are similar in that they are lean fish, caught in a trawl, dumped on deck, sorted as to size and species, iced in pens partitioned in the hold of the boat, landed mostly 5 to 12 days after being caught, and usually filleted and skinned for marketing. Some, such as whiting and ocean perch on the Atlantic coast and most bottom fish on the Pacific coast, are iced in the round, whereas other fish in the group are gutted aboard vessel before being iced.

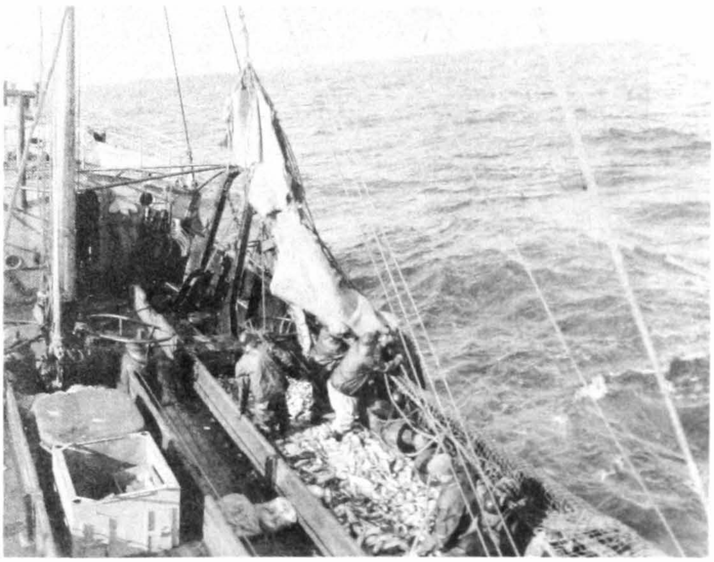


Figure 2.--Putting trawl bag back over the side after discharge of a load of groundfish.

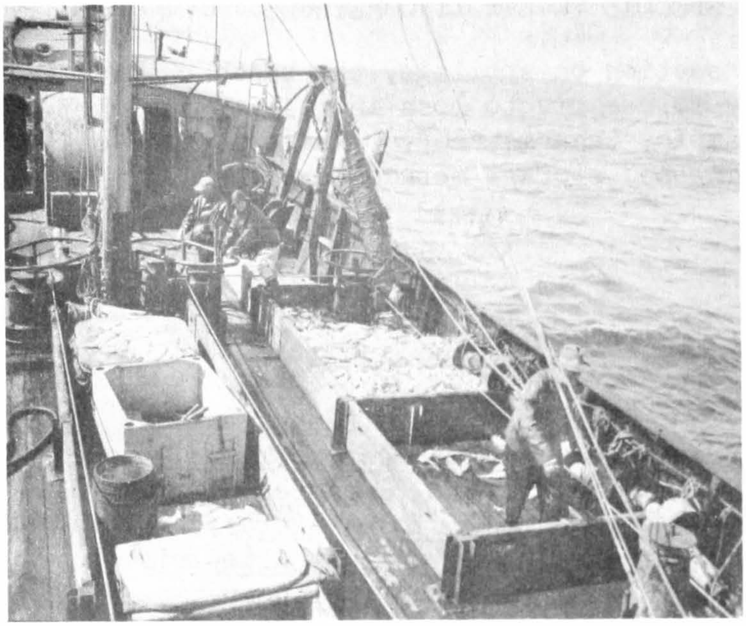


Figure 3.—A load of groundfish aboard a North Atlantic trawler. The fish are ready for sorting, dressing, and icing.

Feeding activity and sexual maturity of the fish at the time of catching influences the quality and the handling methods. For example, "feedy" fish must be gutted shortly after being caught, to minimize softening of the belly wall. Since small fish tend to lose quality more quickly than do large fish, the small fish require a higher ratio of ice. They are placed in separate pens or in the top iced layers to minimize crushing and excessive shrinkage. This practice of icing small fish separately is especially true of scrod haddock and cod.

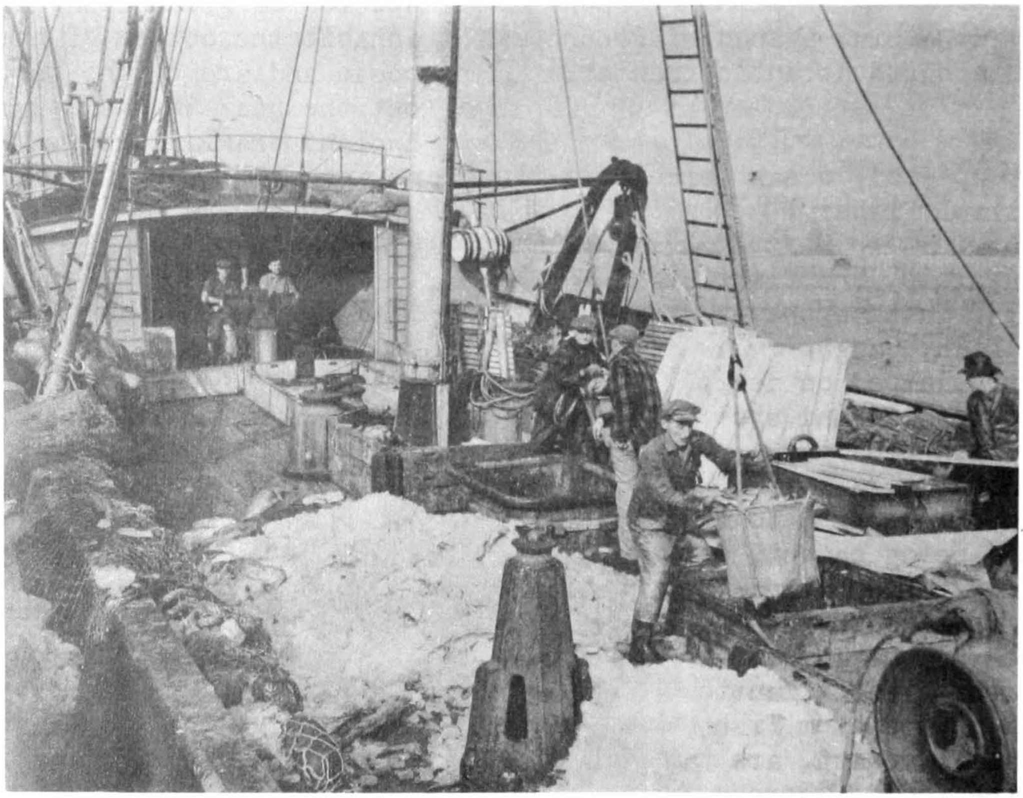


Figure 4.—Unloading groundfish from a North Atlantic trawler. Note that the ice is removed along with the fish and that the pen boards have been removed and stacked on deck to be washed.

Hake and pollock are softer in texture as compared to cod and haddock, and will not keep as well in crushed ice. On the Pacific coast, hake and arrowtooth flounder are two species not commonly fished, because of their soft texture and of their poor keeping quality. Only a few species of Pacific rockfish are taken, since most rockfish species have poor keeping quality in frozen storage.

Occasionally unknown environmental conditions on certain fishing banks greatly affect the quality of the fish, and the fishermen must either move to other banks or risk taking a loss in their catch. Several of these conditions along the Pacific coast are chalky halibut; slimy or soft-bellied sablefish; greenish-colored flesh in pointed-nose flounder; occurrence of abnormal flavors, like iodoform, in flounder; and excessive numbers of parasites or flesh worms in cod and rockfish. Both the fishermen and the fish buyers recognize these special quality problems, which are minimized by inspection both aboard vessel and ashore.

Halibut

Although properly a member of the groundfishes, the Pacific halibut (Hippoglossus stenolepis) deserves separate mention because the fishery differs in major respects. The halibut are large fish, ranging to over 80 pounds, and are found in the cold bottom waters of the North Pacific. In accordance with regulations of the International Pacific Halibut Commission, halibut are caught only on baited long lines laid along the ocean bottom and cannot be taken by means of a trawl. The seasons and area catch limits are regulated yearly. The halibut, after being caught on a long line, are brought over the rail of the fishing vessel, taken off the hook, and then placed in the "checker" on the deck for dressing. The belly wall is slit, the viscera are removed, the gills are cut away, and the halibut, with the head and nape still intact, are passed into the hold for icing.

Ice is packed in both the belly and gill cavities after which the fish is laid on a bed of ice in the bin so that the water from the melting ice will flow around and away from the fish. It is important that the fish be laid so that any water in the belly cavity drains away from the fish and does not form a pool of blood and slime along the dorsal part of the cavity. Otherwise, halibut become sour smelling. Ample ice is placed around the halibut, with care being given to provide extra ice adjacent to the sides of the vessel and to the pen partitions. This practice avoids exposure of the halibut to the air as the ice melts.

Sablefish

Sablefish (Anoplopoma fimbria), which are another of the species of groundfish, are caught in the North Pacific along with halibut. Sablefish, however, differ from other commercial species of groundfish, in having a high oil content. The sablefish are dressed and iced in the same way as are halibut except that the head, which is large, is cut off. Although rich in oil, sablefish keep well in ice, showing but little tendency to become yellow and turn rancid.

Salmon

Pacific salmon (Oncorhynchus sp.) are caught by means of seines, gill nets, traps or pound nets, and trolling gear. Normally, the salmon taken by seines or nets are caught fairly close to the cannery or cold storage and therefore ordinarily require no refrigeration aboard the vessel. As is discussed later, the use of refrigerated sea water has been tried successfully for holding cannery salmon, where more than a day's delay is involved in delivery of the vessel's catch to the cannery.

Figure 5.—Removing salmon from a drift gill at the mouth of the Stikine River in southeastern Alaska.

Trollers, on the other hand, fish commonly for a week to 10 days for their king and silver salmon catch, and handling and icing is an

Figure 6.--Unloading salmon taken by purse seine gear near the San Juan Islands in Washington. Since these salmon were caught close to the cannery, refrigeration was not necessary.

important part of their job. As the salmon are taken from the water, they are stunned by a sharp blow on the head and are lifted into the boat with a gaff hook. The salmon, soon after being caught, are bled and gutted, and the gills are removed, leaving the nape uncut just below the pectoral fins. This procedure keeps the belly walls closed during handling and icing, and minimizes unnecessary exposure to air. A blunt implement is used to remove the kidney or blood clot, which lies below the backbone in the belly cavity. Excess blood is wiped away, and the salmon are iced similarly to halibut, using ice in the belly and gill cavities with ample ice outside and placing the salmon to allow free drainage of water, blood, and slime away from the fish.

It is important that exposure of the salmon to air be prevented by protecting them with melting ice; otherwise, yellowing of the cut belly flesh and flesh around the nape will occur. Larger king salmon (from 15 to 40 pounds) must be handled with special care to avoid breaking the flesh along the backbone and to keep the skin and scales intact. This careful handling is important if the salmon are to meet the grade standards of the high-priced mild cure salmon destined for later smoking.

Tuna

Only a relatively small amount of tuna is iced aboard vessel, as most tuna are caught far offshore by bait boats and must be frozen for preservation during a trip of 2 to 3 months. Handling and freezing of tuna at sea aboard bait and seine boats are discussed in section 1, Fishery Leaflet 430.

Tuna caught closer inshore by the trollers are often iced for 1 to 2 weeks before being delivered to the cannery. The tuna for cannery use are not bled or gutted. After being caught, they are left on deck until a slack in the fishing intensity allows time for icing. The best practice is to keep this delay to a minimum and to less than 6 hours in any case. Many boats have their holds partly cooled with overhead refrigerated coils or plates to lessen losses in ice during warm weather or long trips. The use of mechanical refrigeration as an ice auxiliary is discussed later in this section.

GOOD "HOUSEKEEPING" ABOARD THE VESSEL

Fish buyers know from experience that, under comparable conditions, the cleanest boats bring in the best quality fish. "Good housekeeping" aboard the vessel is associated with careful handling methods because the fisherman who keeps the fish hold, gear, and deck clean is apt to be quality-conscious when he comes to icing his fish. Contamination from any source will affect fish quality. Dirt, slime, fuel oil, rust, grease, blood, scales, and bits of viscera and flesh must be removed and washed away constantly in order to keep the deck and the hold clean.

The problem of sanitation and housekeeping aboard a boat depends greatly on its design and construction. A little thought and work during the off season can often be used to good advantage for the improvement of sanitation on many older boats. The use of concrete, mastic, or metal (corrosion-resistant types) to eliminate the hard-to-clean corners in the hold saves many hours of labor and cleaning during the busy season. In recent trials, aluminum alloys have been found satisfactory for construction of the lining, stanchions, shelves, and pen boards in the holds of large trawlers (Plummer 1950). On sound wood, there is no substitute for a smooth paint job, using one of the many improved marine finishes now available. To avoid a sour-smelling hold, soft or "logy" wood should be replaced or repainted. Bilges should be cleaned frequently during the fishing season, using a good detergent or bilge-cleaning compound to remove accumulated dirt, oil, and slime. Pen boards should be scrubbed and allowed to dry after each trip. Metal pen boards of corrosion-resistant aluminum have been introduced and save much effort in maintenance, although the higher initial cost compared to wood must be considered.

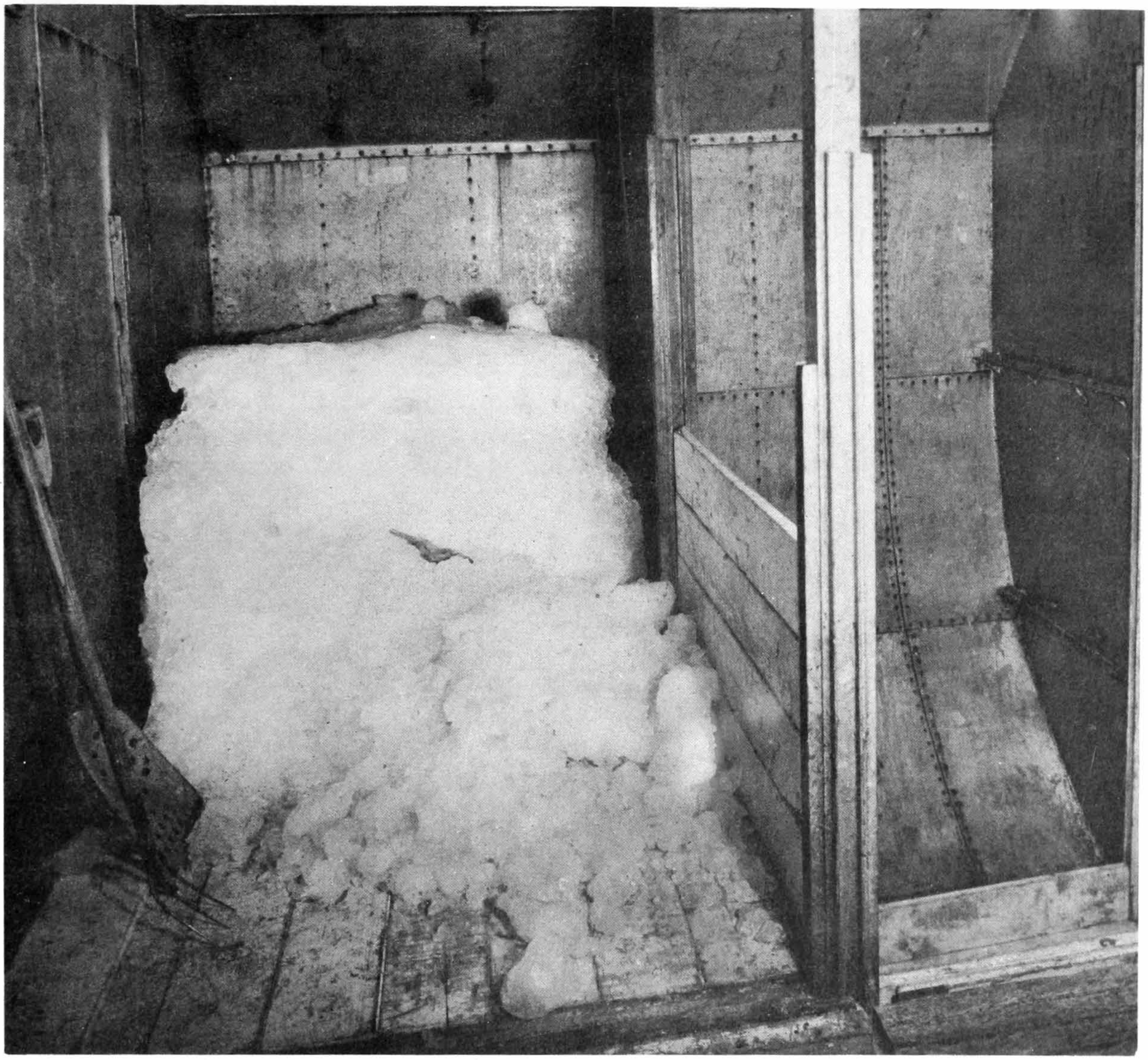


Figure 7.—The fish bins in the hold of a North Atlantic trawler after the fish have been taken ashore. Note the removable pen boards on the transverse partition. The smooth liner in this vessel makes it easier to wash down the hold after the fish and ice have been removed.

Deck areas used for sorting and cleaning fish should be scrubbed frequently. If possible, the sorting deck should be used only for fish and not for deck gear because fish thrown against rough corners or projections will bruise and blood clots in the flesh will result. Nets, lines, and miscellaneous fishing gear should be cleaned and preserved properly, not only as a matter of housekeeping, but also to insure long life for the gear.

Although the cold-storage plants prepare the ice from clean potable water, ice can be contaminated with dirt or bacteria during crushing and delivery at the dock and during handling aboard the vessel. Since the ice comes in intimate contact with the fish, it must be kept clean. Shovels and scoops should be cleaned at frequent intervals, and gloves should be washed often and rinsed in chlorinated water if used over long periods.

Personal cleanliness on the part of the fisherman is essential. As a primary handler of a food product, he bears great responsibility.

SORTING, DRESSING, AND WASHING FISH ON DECK

In the troll and set-line fisheries, sorting is continuous as the fish come over the rail. If the catch is plentiful, the fish are placed in checkers according to size or species and held until there is a lull in the fishing, when the fish can be dressed and iced. These fish are generally handled quickly, and the delay on deck is of only short duration.

Figure 8.—Bringing a king salmon aboard a troller in southeastern Alaska. Note the "checkers" or sorting bins immediately in front of the fisherman.

In the trawl fishery, sorting is often a problem, since the fish are caught in large quantities and are dumped all at one time on the deck. Such items as logs, starfish, scrap fish, shells, and mud are often included with the desired fish. In addition to the sorting of the market fish from the unwanted material, different species and sizes are separated for icing. Since small fish are more difficult to keep in good condition than are large ones, the small fish are commonly iced in separate pens. Some species of trawl fish such as hake and pollock are soft, and they spoil more readily than do other species of a comparable size. Thus, they should also be iced separately.

Figure 9.—Dumping a catch of mixed bottom fish aboard a trawler off the Oregon coast. The catch is mostly rockfish.

If the fish have considerable mud or debris on them, they are usually washed with clean water, preferably drawn by pump while the vessel is running. Harbor water should not be used, since it is often contaminated with oil, sewage, or garbage. During the sorting and washing operations, many of the fish will still be alive, and care should be taken not to bruise them. In any case, the fish should not be stepped on or thrown bodily. The use of a chute to transfer the fish to the hold is preferable and eliminates dropping them. The fish, after death, are not as susceptible to bruising, but they still must be treated with care to minimize crushing or tearing of the flesh. Pews, forks, and fish hooks are handy for sorting fish, but they must be used with skill. The fish should be pewed only in the head, since a hole in the flesh introduces slime and bacterial contamination. The flesh under the skin of live healthy fish is almost free of bacteria, and any contamination introduced after landing will therefore shorten the storage life of the iced fish. For this reason, it is better to sort the market fish by hand whenever practical.

If a delay between the time the fish are landed and the time they are iced is unavoidable, care should be taken to see that the fish are protected from spoilage. If the sun is shining and the deck is hot, for example, the fish should be either covered with a tarpaulin or kept cool and wet with clean sea water. When the fish are iced, small fish and the more perishable species should be handled first.

The following factors are important in determining whether or not the fish should be dressed:

(1) Time between catching and landing. Fish held for more than a few days in ice are usually dressed. With fish that spoil readily or with those that are feeding actively, the fish should be dressed immediately; otherwise, softening of the belly wall (belly burn) may be very rapid. This softening is caused by the stomach enzymes, which remain highly active after the death of the fish.

(2) Size. Large fish, in comparison with small ones, require less time to dress per unit of weight, and fewer are usually caught for a given day's operation. Small fish are tedious to dress by hand and, in many cases, are impractical to eviscerate because of the great number in the catch. Large fish cool slowly in ice, and dressing exposes more area to the cooling effect. Hence dressing becomes a matter of cooling efficiency as well as preventing belly burn.

(3) Industry requirements. Many plants prefer fish in the round, since automatic machinery is used for the dressing and washing operation.

(4) Economics. The economic return to the fisherman may not justify the extra labor of dressing. In some cases in the past, the demand for the fish has exceeded the supply. Under these conditions, buyers have been reluctant to insist on extra measures in handling.

At present, custom dictates the practice in some fisheries. Large buyers or companies may specify the handling procedures, including dressing. Especially in the trawl fishery, the practice varies from one section of the world to another, depending on local custom, regulations, or buyer's specifications. After the fish are dressed and before being iced, they should be washed free of blood with clean sea water. In some fisheries, this preliminary washing is omitted, since the fisherman believes that the subsequent bathing action of the melting ice during stowage in the hold removes the blood and superficial slime. This belief is not entirely correct, even for properly iced fish. Studies with gutted cod on the Atlantic coast (Dyer, Dyer, and Snow 1947), for example, have shown that the muscle along the backbone becomes contaminated both from the skin and from the large blood vessel or kidney lying just below the muscle, next to the belly cavity. Thorough cleaning and washing of the gut cavity reduce the extent of this contamination and minimize the rapid growth of bacteria. This decrease in bacterial growth in turn helps materially to improve the quality of the landed fish.

FRESH-WATER ICE

Keeping Time

One of the most important facts to bear in mind concerning the use of ice for preservation of fish is that spoilage is only retarded, not stopped. Under proper conditions of handling, fish such as prime halibut may be preserved in ice for 8 to 12 days before a noticeable lessening in quality occurs. Cod similarly iced will keep well for over 7 days. On the other hand, bottom fish left on deck for 12 to 18 hours and iced improperly in a deep hold without the use of shelf boards may show appreciable loss in quality after only 4 to 5 days.

How Ice Aids in Preservation

Ice, when properly used in adequate amounts, aids in preservation in two ways: (1) the temperature of the fish is lowered to approximately 32° to 36° F., which slows the bacterial and the enzymatic changes; and (2) the melting of the ice bathes the fish in clean cold water and, with proper stowage, washes away considerable slime, blood, and bacteria. The resulting contaminated water accumulates in the bilge of the boat and, at intervals, is pumped overboard.

Insulation

Every pound of ice, on melting, absorbs 144 B.t.u. of heat from its surroundings. This absorption of heat is sufficient to lower the temperature of 19 pounds of fish 10 degrees Fahrenheit (assuming that the fish has a specific heat of 0.760 and that no external heat were absorbed in the process). In actual practice, the heat transfer from the boat hold and air equals or exceeds the heat transfer from the fish. Dunn (1946) showed that, on a 6-day trip, the heat gained by a trawler hold with a capacity of 100 tons of fish and 30 tons of ice caused about the same amount of ice to melt as was required to cool the fish. This transfer of heat demonstrates the desirability of insulating the hold, which would make possible the saving of a substantial quantity of ice during long trips.

Ice Contamination

Chlorination is recommended for treatment of the water at the ice plant to insure that only sterile ice is produced. Unfortunately, during storage, crushing, and handling, ice can become contaminated with bacteria, which in turn contaminate the fish and accelerate the bacterial spoilage (Castell and Triggs 1953). In addition, ice becomes contaminated in the hold from the drainage of fish packed above it. For this reason, unused ice should be discarded at the end of the trip, and the hold should be washed before new ice is loaded.

Subcooling

In the best practice, ice is subcooled to about 0° to 10° F. during cold storage at the ice plant. Such ice on being crushed, breaks cleanly, and the resulting crushed ice is sized, from irregular chunks an inch or two across to fine grains. This subcooled crushed ice flows freely and is easily loaded into the separate pens or sections of the fish hold. One or two pens are usually left free so that they may be used to ice the first fish of the trip. The ice is shoveled or scooped from one pen to another as needed. It is important that the ice flows freely even after 5 to 10 days in the hold. Properly sized ice loaded at a temperature of 5° F. will melt around the outside and form a crust; however, the ice, on being broken through, is found to be loose and easily handled and well below the melting point. This subcooled ice lasts longer than does ice at 32° F., under comparable conditions. In a few geographical areas, crushed ice is delivered to the fishing boat at a temperature very close to the melting point (32° F.). Such ice tends to fuse into a solid mass and is more difficult to use.

Particle Size

Since both close contact with the fish and drainage through the ice are necessary, the ice must not be too coarse or too fine. With too finely crushed ice, slime and water tend to accumulate through it in layers. On the other hand, large chunks are undesirable, for they yield poor contact cooling of the fish. Also, they bruise and mar any tender skin or flesh pressed against them. If the ice is prepared from blocks, a crushed ice with graduated particle size is best.

In recent years, flake ice prepared by continuous freezing of a film of water on a refrigerated drum has proved very satisfactory. The ice consists of irregular flat plates. Such ice is convenient for use in that it requires no crushing for delivery and that it may be precooled to 0° F. and stockpiled in the flake form. Flake ice tends to be a little bulky and, if not confined with pen boards, to shift in the hold. Drainage and cooling characteristics of this ice are as good or better than are those of crushed ice; however, precooling well below 32° F. is especially important with flake ice to minimize its tendency to fuse into a solid mass.

Ratio of Ice to Fish

Every fisherman soon learns how much ice to "take on" in order to carry him through a trip. The expected duration of the trip, the temperature of air and sea water, the insulating value of the sides and deck head of the vessel, and the expected quantity of fish to be obtained are all factors to be considered in estimating the amount of ice to be loaded. Ice is cheap compared to the other expenses of a fishing operation; hence no fisherman should cut short his estimated need. The exact ratio of weight of ice to weight of fish to be carried varies commonly from 1:4 to 1:1. In northern waters in uninsulated holds of wooden vessels, a ratio of 1:2 is common. Recent studies showed that more rather than less ice should be taken by fishing vessels because it was found that additional ice (compared to present practice) should be allowed at the sides of the vessel and adjacent to the wing boards of each pen. Any exposure of fish at these points due to melting of ice contributes substantially to quality losses.

Correct Icing

To correctly ice the fish in the hold, three things should be accomplished: (1) the fish should be placed with sufficient ice around them to cool them as promptly as possible and to maintain their temperature as close to the melting point of the ice (32° F.) as is practical for the duration of the trip; (2) the ice and fish should be arranged to allow accumulated water, blood, and slime to drain through the mass into the bilge; and (3) the fish should not be subjected to great pressure from the weight of fish and ice placed above; otherwise, the physical damage as well as the shrinkage or loss of weight by the fish will be excessive.

Correct icing requires considerable care and experience, and every vessel is a separate problem depending on the construction, hold and pen layout, and the relative heat transfer from the water and air outside the hold. Knake (1946), in discussing the correct icing of fish at sea, has pointed out that from 50 to 60 percent of the profit of a trip may be lost if the quality of the catch is reduced through inadequate or incorrect icing. Ample ice should be placed on the floor of each pen, 8 to 12 inches deep, for a trip of 8 to 12 days. A like amount should be placed at the skin of the vessel and on top of the fish. A smaller amount should be used at the wing boards (the transverse partitions) and sides of each pen to keep the fish from contacting the board. For eviscerated fish, the gut cavity or poke of the fish should be well filled with ice, taking special care to pack the ice in the gill cavity and around the nape. Preferably, each fish should be surrounded by ice or the fish placed in alternate layers such that the ice is in actual contact with the greater portion of each fish.

The practice of using a bed of ice, then layering 10 to 12 inches of fish, followed by a thin layer of ice and another thick layer of fish results in most inefficient cooling. Two to three days may be required, in this case, to lower the temperature of the fish to 36° F. In some instances, improperly iced fish does not cool appreciably throughout the entire period of storage. Under proper conditions, however, not over 3 to 6 hours should be required to lower the temperature to 36° F. of fish weighing about 5 pounds.

Fish should be placed on a rounded layer of ice so that the melt water drains away from the fish to the sides of the pen. In placing the fish on the ice, the belly cavity should be turned in such a manner that there will be adequate drainage from it. A good icing job has been done if, at the end of the trip, sufficient ice remains on the bottom and at all sides so that the entire load has been maintained at a temperature not higher than 36° F. (or 32° F., ideally).

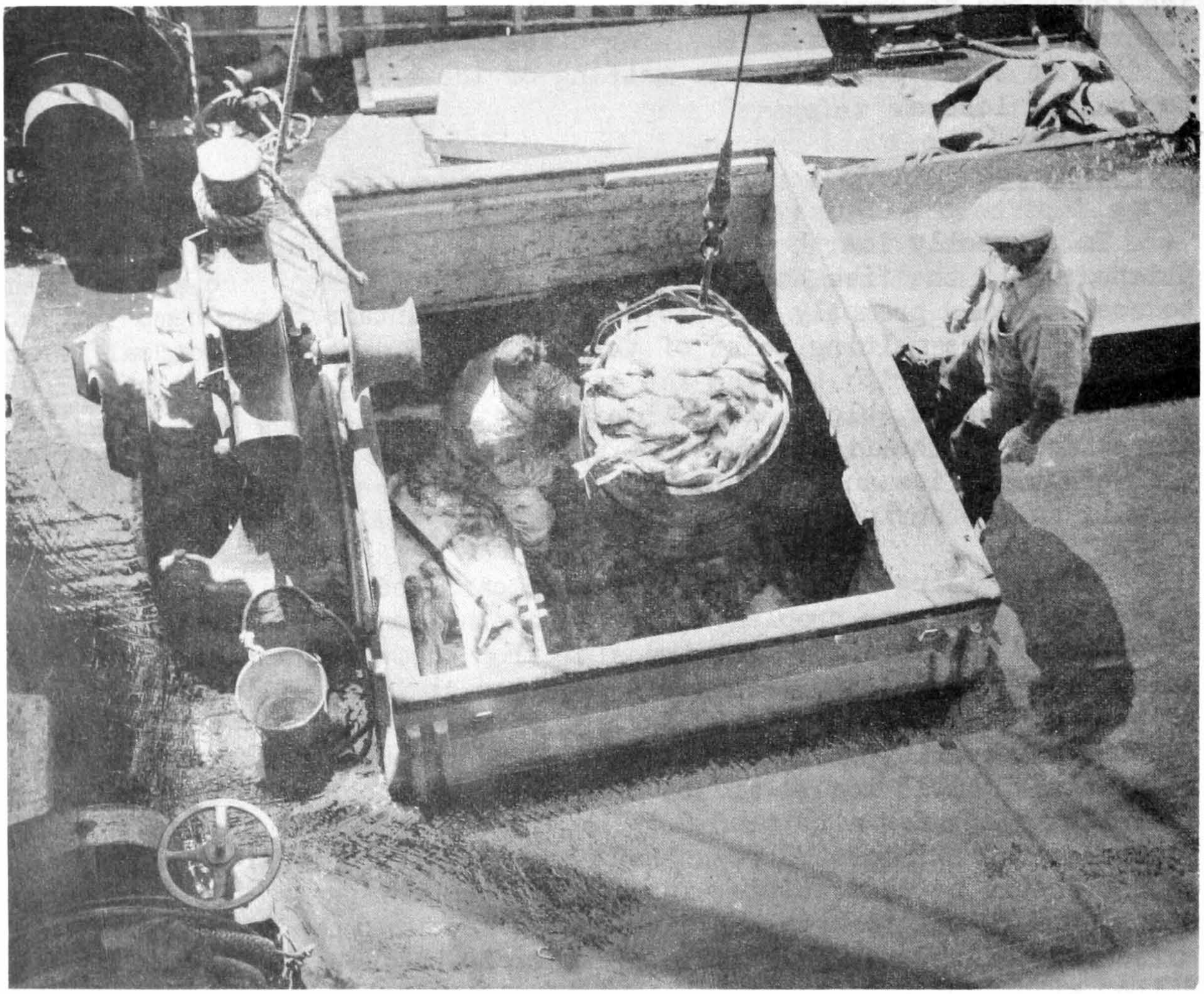


Figure 10.--Unloading a catch of bottom fish from a trawler at a Seattle dock. Note pen with remaining ice and fish in the hold.

Fish do not freeze at one point in the temperature scale, as water does at 32° F. Rather, they begin to freeze at about 30° F. and gradually harden as the temperature drops. At 23° F., the fish have passed through the zone of maximum ice-crystal formation but are still not solidly frozen. The lower freezing range of fish means that an ice melting at a lower temperature than 32° F. can be utilized to lower the holding temperature further.

SALT-WATER ICE

Tests on the effect of temperatures close to that of freezing on the storage of fish (Castell and MacCallum 1950) showed that a reduction in the temperature of the fish from 37.0° to 31.5° F. increased their keeping time in ice as much as did a temperature reduction from 77.0° to 37.0° F. The lower temperature of the fish was obtained through the use of salt-water ice (about 3 percent sodium chloride), which has a melting point of approximately 28° F. Salt-water ice is best prepared by the flake-ice method in order that the salt may be distributed uniformly through the ice. In a pilot-plant study, subcooled flaked salt-water ice and ordinary crushed fresh-water ice were used in icing similar lots of fish, both held under otherwise similar conditions of storage (Field 1953). The flesh temperatures of the salt-water-iced fish ranged from 30° to 32° F., which was 6 degrees lower than the temperature range of the fish iced with crushed fresh-water ice. The fish stored in the salt-water ice were superior in quality at the end of the test.

BACTERICIDAL ICE

In efforts to improve the keeping quality of fish in ice, experimenters have incorporated a number of preservatives or germicides in the ice. Sodium benzoate, benzoic acid, chloramine compounds, fumaric acid, sodium hypochlorite, sodium nitrite, carbon dioxide, hydrogen peroxide, calcium propionate, disodium phosphate, and various antibiotics are among the many substances tried (Tarr 1946). Generally speaking, the best of the germicidal ices produced a very minor improvement in keeping quality. Their use has not become widespread because of their limited value and the extra cost to the fisherman. More recent experiments by Boyd, Brumwell, and Tarr (1953) on the use of the antibiotic aureomycin in ice have shown that, in quantities of 2 to 4 parts per million, aureomycin ices effected a very marked improvement in keeping quality of dressed lingcod during storage for a period of 15 days in ice.

In planning the use of any preservative or germicide in the icing of fish, the potential user should bear in mind that any such substance must meet the approval of the U. S. Food and Drug Administration for use with food products. At present, few additives have been approved by that agency. Proper care in the handling and storage of fish, with adequate amounts of ordinary crushed or flaked ice will yield as much or more improvement in keeping quality than will the casual use of any preservative-treated ice tested and accepted for use with food fish to date. Any bactericidal ice that has been accepted for use on fish will be of greatest value only if its use is combined with the best handling practices.

MECHANICAL REFRIGERATION AS AN ICE AUXILIARY

For extended trips, mechanical refrigeration of the fish hold for keeping ice on the outbound trip without loss by melting has been quite successful. The principle is simple in that only enough refrigeration need be supplied to absorb the heat entering the hold through the sides of the vessel and through the deck head. The actual freezing of the fish is not intended, as once the fish are iced, the refrigeration is turned off or set above 32° F. so that the normal melting of the ice will cool the fish.

This use of mechanical refrigeration, to yield best results, must be combined with 4- to 6-inch-thick insulation in the hold. In some cases, the reduced requirement for ice results in an increased stowage capacity of the hold for fish. On the Pacific coast, one such successful installation on an 82-foot halibut boat has been reported (Anonymous 1950). The use of mechanical refrigeration, according to the owner, not only allowed the boat to stay out longer but also assured fish of better quality than had previously been found with the fish that were protected by ice alone on shorter trips made prior to the use of the mechanical refrigeration.

In this type of installation, no attempt should be made to freeze the fish, and the stored ice should be allowed to melt and supply the refrigeration needed to cool the fish to 32° to 35° F. The melting of the ice not only provides proper cooling but also provides the moisture and the bathing action so essential in retaining the freshness of the fish. Cutting (1949) reported that, in careful laboratory tests, it was found that the rate of cooling of fish (from 55° to 33° F.) packed in ice was independent of temperature of the surrounding air (from 27.5° to 55° F.). Therefore, the only advantage of refrigerating the hold of a boat using ice is to conserve the ice.

OTHER METHODS OF HOLDING FRESH FISH ABOARD THE VESSEL

Refrigerated Sea Water

The cooling of fish in circulating chilled sea water at 32° F. is more efficient than is cooling in crushed ice (Konokotin 1949). In icing fish aboard the vessel, the best results are attained if ice completely surrounds each fish. In practice, this ideal icing is difficult to attain, and a layer of fish tends to build up through which the melt water from the ice percolates. The cooling medium in the case of circulating refrigerated sea water surrounds the fish entirely, and thus the transfer of heat from the fish is more rapid in the chilled sea water. Moderate circulation of the chilled sea water through the mass of fish and past the cooling coils can be adjusted to achieve a uniform temperature of 32° F. (or lower if desired) at all times. The sea water excludes free air from around the fish and there is less opportunity for oxidation of the fish surface, as often occurs in the surface fat of fish held for long periods in ice.

Refrigerated sea water or dilute brine has long been used in holding sardines and herring at the shore plants prior to processing. Sigurdsson (1945) stated that herring stored in refrigerated brine at 32° F. showed superior keeping quality to those held either in crushed ice or in air at 32° F. Konokotin (1949) demonstrated that sprats could be cooled more efficiently in refrigerated sea water than in crushed ice. Studies with Gulf of Mexico shrimp (Higman, Idyll, and Thompson 1954) showed that shrimp held in sea water chilled to 29° to 32° F. were superior from the standpoint of flavor and appearance to those held in crushed ice.

Recently, tests by two salmon-canning firms in holding Pacific salmon in refrigerated sea water have shown considerable promise, and one firm has installed refrigerated sea-water tanks aboard a barge for the purpose of holding salmon for several days at the cannery or during several-day trips to the fishing grounds where fish are purchased. A 42-foot salmon trolling boat, fishing in Alaska, was converted during the past year and successfully used refrigerated sea water for holding fresh king salmon. The canners have found that the use of refrigerated sea water for holding salmon has reduced weight losses (Bloomberg 1955).

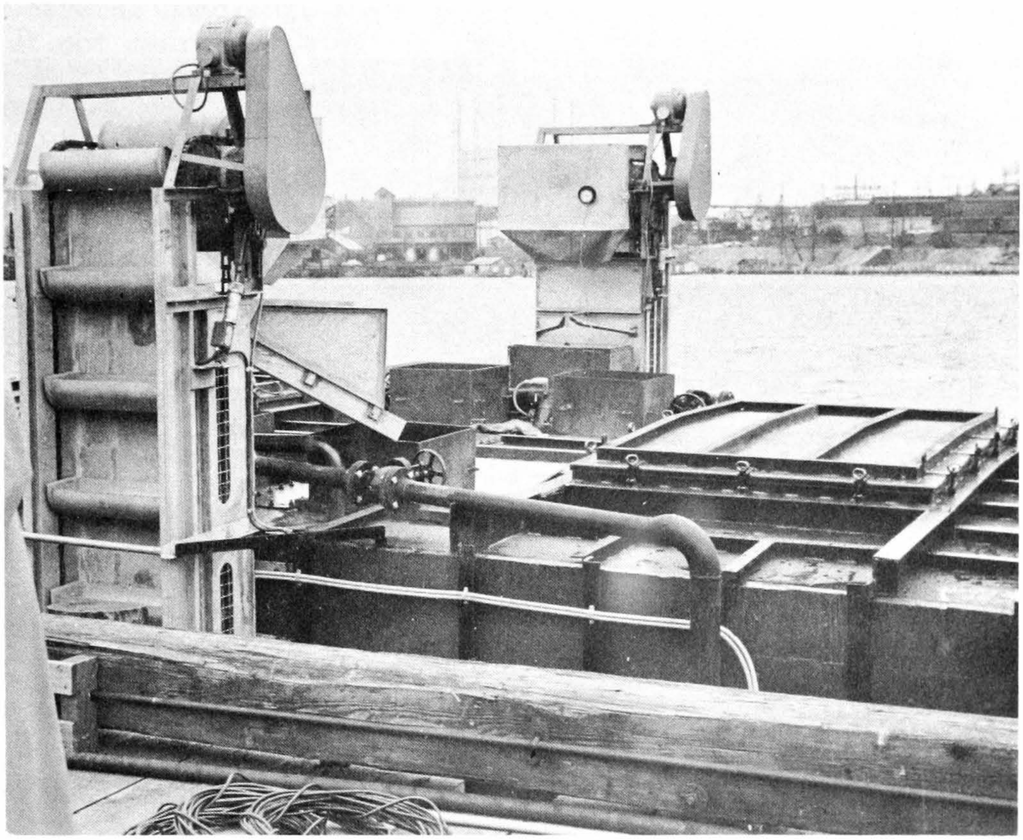


Figure 11.--Barge with refrigerated sea-water tanks for holding salmon. The elevators are used to raise the salmon and chute them into the tanks through the built-in "chimneys." (Photo courtesy of Pacific Fisherman)

The problems of refrigerating a hold for sea-water storage are somewhat greater than are those for ice storage, as the hold must not only be constructed water-tight but must be subdivided into sections or tanks with suitable baffles. Large centrifugal-type pumps are needed for pumping water in or out of the separate tanks and to and from the brine chiller or heat exchanger. Special equipment must be designed for discharging and unloading the fish. The water in the tanks is precooled to about 29° F. prior to being loaded with fish. Ice may be carried to supply additional refrigeration if large volumes of fish must be handled in a short time. If preferred, 3 percent of salt (0.25 pounds of sodium chloride per gallon of water) may be used instead of sea water.

Live Wells

Crabs and lobsters cannot be held in ice satisfactorily, yet they must be delivered to the shore plant alive. For this purpose, the hold of the fishing vessel is flooded with sea water in which the crabs or lobsters can be kept alive and healthy for 3 to 4 days. With crabs, the sea water is circulated continuously to keep them in good condition.

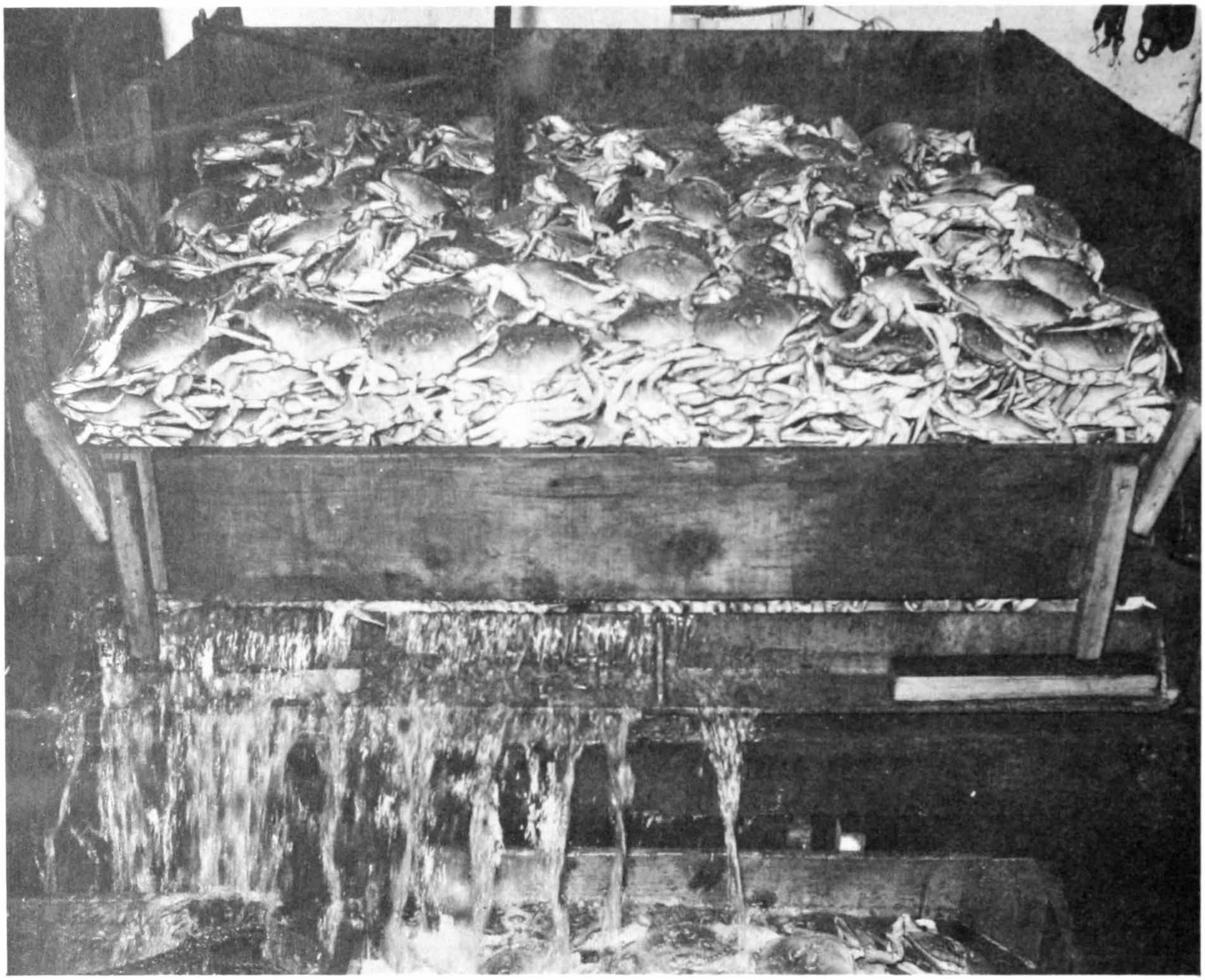


Figure 12.--Unloading live dungeness crabs from the well of a crab boat at Ketchikan, Alaska.

If the crabs are held in the same water for more than a few hours, however, the water should be aerated. The installation of baffles or tanks is necessary if the boat is to be operated safely with the hold full. During rough weather, vessels that have the entire hold flooded may experience difficulty. In actual practice aboard the vessels used in the dungeness crab fishery on the Pacific coast, the vessels do not usually run with the hold full of water. Sea water is pumped in and out at sufficient intervals to keep the crabs cool and moist. Fortunately, they can survive several hours out of water. After 3 to 4 days of this treatment, however, dungeness crabs tend to lose weight and become sluggish. Recently, king crabs have been successfully transported from Alaska to Puget Sound ports in vessels equipped with live wells.

Lobsters may also be handled in live wells, although it is necessary to plug their claws in order to prevent them from maiming one another. With careful handling, lobsters may be held alive for short periods in moist air at not over 50° to 55° F. Moss (1952) reported that a new method of carrying lobsters alive in portable wet-tanks in the dry hold of the vessel was satisfactory, even in heavy weather and over long hauls. The portable tanks were arranged in the hold in such a manner that water pumped into the top tanks of each bank overflowed into the lower tanks and then into the bilge, from which it was pumped overboard. The water in each tank was controlled at the proper level by standpipes, which maintained enough water to keep the lobsters alive.

LITERATURE CITED

ANONYMOUS

1950. Mechanical refrigeration effective for halibut. Pacific Fisherman, vol. 48, No. 3, February, p. 63.

BLOOMBERG, RAY

1955. Reefer tanks keep fish fresh, cut weight loss. Food Engineering, vol. 27, No. 9, September, pp. 111 and 159.

BOYD, JOHN; BRUMWELL, C.; and TARR, H. L. A.

1953. Aureomycin in experimental fish preservation. Fisheries Research Board of Canada, Progress Reports of the Pacific Coast Stations, No. 96, October, pp. 25-28.

CASTELL, C. H., and MAC CALLUM, W. A.

1950. The value of temperature close to freezing on the storage of fish. Journal of the Fisheries Research Board of Canada, vol. 8, No. 2, May, pp. 111-116.

CASTELL, C. H., and TRIGGS, R. E.

1953. Contaminated ice in the boats at sea. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Stations, No. 55, March, pp. 24-26.

CROWTHER, H. E.

1951. Control of fish spoilage by icing and freezing. Commercial Fisheries Review, vol. 13, No. 3, March, pp. 6-10. Also Sep. No. 274, Fish and Wildlife Service, Department of the Interior, Washington 25, D. C.

CUTTING, C. L.

1949. The cooling of trawler's fish in ice. Report of the Food Investigation Board (Great Britain) for the year 1939, pp. 41-42.

DUNN, A. F.

1946. Heat transfer in trawler holds. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Stations, No. 36, December, pp. 3-6.

DYER, W. J.; DYER, F. E.; and SNOW, J. M.

1947. The spoilage of gutted cod stored in crushed ice. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Stations, No. 37, January, pp. 3-7.

FIELD, CROSBY

1953. Recent experiments show value of flaked ice frozen from salt-water ribbons. Fishing Gazette, vol. 70, No. 8, August, pp. 54-55.

HIGMAN, J. B.; IDYLL, C. P.; and THOMPSON, J.

1954. Holding fresh shrimp in refrigerated sea water. Southern Fisherman Yearbook, vol. 14, March, p. 95.

KNAKE, BORIS O.

1946. Icing of fish at sea. Fish and Wildlife Service, Washington 25, D. C., Fishery Leaflet 189, July, 3 pp.

KONOKOTIN, G.

1949. Cooling and preserving fish in sea water and in tannin solutions. Kholodilnaja Technica (Russian), vol. 26, No. 2, April-June, pp. 66-69. Abstracted in Refrigerating Engineering, vol. 57, No. 12, December, pp. 1186-1187.

MOSS, FRANK T.

1952. New system of portable wet tanks stops lobster losses. Maine Coast Fisherman, vol. 6, No. 12, July, p. 5.

PLUMMER, H. C.

1950. Aluminum holds protect fish. Food Industries, vol. 22, No. 5, May, p. 121.

SIGURDSSON, G. J.

1945. Studies on the storage of herring in refrigerated brine. Proceedings of the Institute of Food Technologists, pp. 91-114.

STANSBY, MAURICE E.

1952. Handling fresh fish. Fishery Leaflet 115, Fish and Wildlife Service, Department of the Interior, Washington 25, D. C., February, 4 pp.

TARR, H. L. A.

1946. Germicidal ices. Fisheries Research Board of Canada, Progress Reports of the Pacific Coast Stations, No. 67, pp. 36-40.

SECTION 3

HANDLING FRESH FISH AT THE SHORE PLANT

By C. J. Carlson, Chief, Fishery Products Laboratory; Joseph Carver, Fishery Products Technologist; and Martin Heerdt, Chemist*

TABLE OF CONTENTS

* Ketchikan, Alaska; Fishery Technological Laboratory, East Boston 28, Massachusetts; and Fishery Technological Laboratory, Seattle 2, Washington, respectively.

Page

ILLUSTRATIONS

Page

TABLES

GOOD HOUSEKEEPING PRACTICES

Operators of fish shore plants in the United States and its territories are guided by federal, state, and territorial sanitary codes and regulations that require observance of certain minimum health standards. In general, the aims in good housekeeping at the shore plant are the maintenance of clean facilities and freedom from possible contamination. These objectives can be obtained through (1) proper construction of the plant, (2) efficient design and layout of equipment, amd (3) good management.

Plant Construction

Good housekeeping practices with regard to the construction of the plant include such factors as the covering used for floors, walls, and ceilings; drainage; ventilation; lighting; rodent and insect control; personnel restroom and washroom facilities; and provisions for cleaning the plant.

Coverings and drains.--The floors of any fish shore plant should be covered with a hard smooth-surfaced material such as concrete or tile. The construction should be such that the floor is waterproof, watertight, and structurally strong so that cracks do not develop. With this type of floor covering and with adequate cleaning, there is little opportunity for growth of bacteria, for development of their attending foul odors, and for their possible contamination of food. An important factor in the construction of the floor is good facilities for drainage. The floor should be designed with adequate slope (usually 1/8 to 1/4 inch per linear foot) so that refuse and liquids can be led easily to the drains. These floor drains should have traps and should be located at convenient intervals, depending on the type of operation and on the load and area they are expected to serve. In all cases, the slope of the floor and the number of drains should be adequate and should meet sanitary codes. In the building of the floor, care should be taken to insure that all floor and wall junctions are rounded off and made watertight. Square junctions, especially corners, are difficult to clean and, in a short time, can present a sanitation and odor problem.

The walls of the shore plant should be watertight, smooth, and painted. Waterproofing should be used on the wall from the floor level to a height of several feet, depending on the type of plant operation. In plant areas where water or fish may be splashed, the entire wall surface should be waterproofed. This precaution insures a dry surface on which bacteria and resulting off-odors do not develop.

Ideally, the ceiling of the shore plant should be completely covered so that foreign material cannot fall from overhead pipes, machinery, and beams. Properly designed modern plants with high trussed roofs and without covered ceilings, however, have been found to be satisfactory.

In smaller plants with low roofs, the ceilings should be covered.

Lighting and ventilation.—Adequate lighting within the plant is necessary for efficient operation. According to Waidelich (1951), fluorescent lighting varying in intensity from 35- to 100-foot candles is usually required. Maximum use should be made of natural lighting by incorporating advantageously located windows and skylights into the design of the building.

There should also be adequate ventilation. The same windows and skylights that allow for natural lighting may be used for this purpose. Exhaust fans or roof vents utilizing natural air currents are sometimes employed to advantage in plant areas where cooking operations are carried out. Blower-type unit heaters may be used to circulate the air in cool climates or during the winter. In warm humid climates, mechanical air-conditioning is the best method for cooling and circulating the air. Before any type of mechanical system of ventilation is installed, however, a competent engineer should be consulted.

Restrooms.--Separate clean restrooms, water-flushed toilets, and washrooms for male and for female employees should be placed in appropriate areas in the plant. Based on the maximum number of employees of each sex hired in a season, table 1 gives the number of separate water-flushed toilets that should be installed for each sex (Anonymous 1947a).

Table 1.--Recommended restroom facilities

No. of persons	Minimum number of toilets
1 to 9	1
10 to 24	2
25 to 49	3
50 to 100	5
Each additional 30	1

The restrooms should be provided with toilet paper, washing facilities, hot and cold water, soap, paper towels, and waste receptacles. These rooms should be well ventilated, should be kept clean at all times, and should be well posted with signs concerning personal cleanliness and hand washing after an absence from work. Some plants provide bactericidal-type liquid or powdered soaps and detergents for use in the washroom. Their use, however, must be accompanied with diligent washing and scrubbing. An excellent plan used in some plants to promote clean restroom facilities is to furnish each employee with a locker, where he may keep personal property and clothing. Care then must be taken to police the restrooms, however, in order that the lockers do not become catch-alls and, in themselves, a sanitation problem.

Provisions for cleaning.--An important point to observe in constructing a plant is to make certain that it is designed for ease in cleaning. Such factors as smooth walls and floors, good ventilation and lighting, and adequate floor drainage have been mentioned previously. In addition to these provisions, water outlets should be located throughout the plant to provide a good supply of clean fresh water. The diligent use of water, cleaning compounds or detergents, scrubbing brushes, special cleaning equipment, bactericides, and manual labor is essential in controlling bacterial contamination.

Because there are many types of detergents, the selection of the right detergents or combination of them for a specific cleaning job is important. In a single plant, three or four types of detergents may be used. Somers (1949) reported that the desirability of a detergent usually is determined by the degree to which it exhibits the following characteristics:

1. High wetting or penetrating action, which effects rapid washing away of the soil.
2. Good rinsibility, which results in the detergent and soil being rinsed from the equipment freely and rapidly after the desired cleaning has been accomplished.
3. High emulsifying power for oils.
4. High deflocculating or dispersing power, to bring deposits or precipitates into suspension so that they can be washed away.
5. Good water conditioning or sequestering properties in alkaline solutions, to prevent deposits, on the equipment, of the calcium and magnesium compounds from the water.
6. Good dissolving and neutralizing power, for the purpose of dissolving or neutralizing tenacious deposits and of saponifying fats to make them soluble in water.
7. Low corrosiveness to the surfaces on which they are used.

Brushes are important tools for cleaning shore-plant equipment and facilities. A variety of brushes for regular cleaning and for cleaning in hard-to-reach places should be used.

Special cleaning equipment such as high-pressure spray units are good tools for use in cleaning. They are effective in removing tenacious slime and other deposits from equipment, and they save considerable hand work. Hot water or hot detergent solutions may be used in these units. (A word of caution: as this equipment operates under high pressures, it should be used with care to avoid damage to equipment or injury to personnel.) Another piece of equipment used to clean floors is the wet pickup vacuum cleaner. Some of these cleaners scrub the floor, rinse it, and then pick up the dirty water.

After the cleaning operation has been completed, the work areas and equipment should be disinfected with a germicide. Chlorine-liberating compounds have proved to be effective and economical germicides. The concentrations of chlorine solutions shown in table 2 have been suggested for use in fish plants (Anonymous 1947b).

Table 2.--Suggested concentrations of chlorine solutions for use in fish plants

Use	Available chlorine
	(Parts per million)
Wash water (sea or fresh)	1 to 10
Rinse water for hands	100
Clean, smooth surfaces (washbasins, urinals, glassware)	50 to 300
Clean, smooth wood surfaces (new boxes, new table tops)	300 to 500
Rough surfaces (worn table tops, old boxes, concrete)	1,000 to 5,000

Little information is available concerning the effectiveness of quaternary ammonium compounds as disinfectants in fish plants. Salton (1948), however, has reported that a solution containing 200 parts per million of such compounds was found to be adequate as a sanitizer for utensils in a milk plant, after the equipment was properly washed.

Another method of disinfecting in a large fish plant has been reported by Hurley (1949). In this method, the entire water supply was chlorinated. A chlorine residual of 5 to 10 parts per million was maintained during processing, and a residual of 25 parts per million was maintained during the cleanup periods. The method was effective in reducing the bacterial load throughout the plant.

No plant cleaning program can succeed without the services of good, conscientious, hard-working personnel. They must supply the "elbow grease" and have the pride in their work to see that the job is done well.

Provisions for rodent and insect control.--In constructing the shore plant, the builder should take special precautions for the exclusion of rodents and insects. Rodents are considered to be one of the most serious sources of contamination in the seafood industry (Kaylor 1950). Control can be established by rodent proofing ingredient rooms and by covering windows, doors, and other openings with rustproof metal screens. Clean plant facilities also aid in rodent control by eliminating possible sources of food. Routine inspections of beams for evidence of rat runways or nesting areas should be made.

Dry ice has been used as a successful rodenticide in food plants where rodent infestation has occurred (Anonymous 1952a). The area to be treated is emptied of food products, sealed off, and sufficient dry ice is placed in the area to produce a concentration of 20 percent carbon dioxide. This concentration should be maintained for at least 12 minutes. The carbon dioxide forces the rodents out of their holes and nests and into the open where they die by suffocation. Since carbon dioxide can kill plant personnel, warning signs should be posted, and workers entering the area should wear oxygen masks until the air is safe.

If serious rodent infestation in a plant requires the use of poison for control, an expert familiar with the proper selection and use of rodent poisons around a food plant should be employed. No untrained person should be entrusted with this highly hazardous job. Should the foods become contaminated, many fatalities could result.

Except for the common house fly, insects are not a major problem in the seafood industry. The screens over windows and other openings for the control of rodents, will also control insects. Clean plant and plant facilities and elimination of breeding places also assist in controlling insect contamination. When the plant interior and exterior are painted, an insecticide that can be incorporated with the paint may be used (Anonymous 1952b). This insecticide is claimed to retain its effectiveness for the life of the paint.

Plant Equipment

Choosing the right type of equipment and making the proper installation are important factors in plant sanitation. The mechanical equipment should be designed so that it can be cleaned thoroughly and easily. Wherever possible, tubular construction should be used in lieu of angular construction. Table tops on which fish are handled should be constructed of a hard nonporous material that will not absorb the juices and refuse from fish. Table tops made of noncorrosive metals, replaceable hardwood cutting boards, and synthetic rubber-thermoplastic materials (Anonymous 1951) have been used with good success. Plain wooden tables are completely unsatisfactory because of the difficulty in cleaning them.

Conveyors should be constructed of metals that are resistant to corrosion and should be so designed that they can be cleaned easily. Construction that will result in hidden corners and recesses should be avoided. The carrying surface of conveyors should be constructed of such nonabsorbent materials as rubber or metal.

A well-planned layout of equipment is an important aspect of plant sanitation. There should be adequate working space for each operation, with no crowded machinery. A common error in plant expansion is to install additional machinery and equipment without a corresponding increase in floor area. Such expansion usually results in more hazardous working conditions as well as in adding to the sanitation problem.

Figure 1.—Well designed equipment for unloading salmon.

Plant Management

For a sanitation program to succeed, the plant management, of course, must support the program. In larger plants, a sanitation inspector should be appointed. In smaller ones, the owner or the superintendent of the plant should be responsible for sanitation.

The inspector should be able (1) to determine the sanitation requirements of the plant, (2) to prepare a sanitation program, (3) to check on sanitation as a routine daily operation, and (4) to evaluate the results of the program. He should make certain that the machine equipment, small equipment (such as pans and knives), floors, walls, tables, stools, and any item or area that may have become soiled are cleaned properly. He should inspect washroom and restroom facilities for cleanliness and should insist that workers wash their hands after each absence from the work area. Obnoxious personal habits of workers such as spitting on floors, smoking in work areas, and wearing soiled clothing should not be tolerated.

The sanitarian should also inspect the entire plant routinely for signs of rodents, insect infestation, and physical plant failures such as cracked paint and flaws in other surface areas. He should then see that immediate steps are taken to remedy any failure in the sanitation program.

GRADING FISH AND SHELLFISH FOR QUALITY

The usual practice when fish and shellfish are delivered to the shore plant is to inspect and grade them for quality immediately. A good starting point in determining quality, before one actually inspects the fish or shellfish, is to observe the housekeeping practiced aboard the vessel that delivers the fish. A clean-appearing, shipshape vessel usually indicates that care has been taken to insure the delivery of good-quality fish and shellfish.

As the fish or shellfish are unloaded from the delivering vessel, they are graded for quality by an experienced member of the shore-plant crew, by a fish buyer in certain fisheries, or by a professional full-time inspector.

Fish

Methods of determining the quality of fish as they are landed at the shore plant are based, for the most part, on observed characteristics. The general characteristics that the fish should exhibit are listed below:

1. The fish should have bright shiny scales and characteristic colorings and markings. (As the quality of the fish deteriorates, these colors and markings fade and become less pronounced.)
2. The eyes should be bright, transparent, and protruding. (As the quality of the fish deteriorates, the eyes become sunken and cloudy, and sometimes become covered with a pink slime.)
3. The gills should be bright red and clean appearing. (As the quality of the fish deteriorates, the gills usually fade to pink, then to gray, and finally to brown or to dark green.)
4. The fish should have a characteristic mild fresh odor and no off-odors. (As the quality of the fish deteriorates, the odor changes from the characteristic mild fresh odor to a disagreeable off-odor.)
5. The flesh of the fish should be firm and elastic. (Fish that have been poorly handled or cared for and that have been held for an extended storage period aboard the vessel exhibit various degrees of soft texture.) Fish frozen at sea and then thawed exhibit, in most instances, the same general characteristics as do fresh fish.
6. The fish should show no signs of body damage. (Fish that have not been properly handled may show body damage from rough handling, from fish pews, or from use of too coarse pieces of ice in preservation.)

In the quest for an objective test to determine the freshness of fish, workers at the Torry Research Station, Aberdeen, Scotland, have carried out experiments on judging the freshness by the glaze in the eyes of the fish. In this method, the fish eyes are compared with a series of glass eyes filled with liquids of different cloudiness, each corresponding to the eye glaze of fish of known out-of-water history (Anonymous 1954).

Shellfish

In most operations, shellfish 1/ should be active and alive when delivered to the shore plant. There are a few exceptions, however, as in the case of shrimp that are iced or frozen at sea and as in the case of king crab that may be processed and the meat frozen at sea. The Manual of Recommended Practice for Sanitary Control of the Shellfish Industry (Anonymous 1946) should be referred to by those who inspect shellfish during unloading. Characteristics that the various shellfish should exhibit when delivered to the shore plant are as follows:

1. Clams should be alive. (A live clam will close its shell when disturbed.)
2. Crabs of all species should be alive and active.
3. Shrimp should be preserved in ice. They should have a mild characteristic shrimp odor. (Stocks of shrimp with strong off-odors, marked softening of body texture, or severe black-spot discoloration should be discarded.) Shrimp frozen at sea, when thawed, should exhibit the same characteristics as do fresh shrimp.
4. Lobsters should be alive and active.
5. Scallops are shucked at sea, and only the muscle meats, packaged in bags and preserved in ice, are brought to the shore plant. The fresh meats should have a mild odor. (Stocks with strong off-odors should be discarded.)
6. Oysters should be alive. (Live oysters will keep their shells closed when disturbed.) (This industry is under the sanitary supervision of the U. S. Public Health Service, and its inspection codes should be followed.)

DIVERSITY OF METHODS OF HANDLING FISH AND SHELLFISH

The fishermen of the United States take their catches from the waters of the Atlantic Ocean, Pacific Ocean, Gulf of Mexico, Bering Sea, Great Lakes, Mississippi River, and many of the smaller lakes and rivers of this country. Therefore, to describe how all species of fish are handled after being landed would be an immense undertaking. Thus, of necessity, the following discussion has been limited to the topics that are believed to exemplify best the handling of fresh fish and shellfish in the United States.

1/ The various species of shellfish are discussed individually in Fishery Leaflet 430, section 2.

PREPARATION OF ROUND AND DRESSED FISH--HANDLING OF FRESH-WATER FISH AS AN EXAMPLE

The commercial fresh-water fisheries are concentrated primarily in the Great Lakes, other large inland lakes, and the Mississippi River and its tributaries. The more important species in terms of value of fish landed are catfish and bullheads, carp, chubs, whitefish, yellow pike, blue pike, lake trout, lake herring, yellow perch, sheepshead, smelt, and suckers. The fish are caught principally in trap nets, seines, and gill nets. In general, as the fish are removed from the nets, they are sorted according to species into 50-pound or 100-pound wooden boxes, which are kept on the deck of the fishing vessel. Usually, the fish are not iced aboard the vessel but are landed on the same day that they are caught.

Figure 2.--Dipping smelt from net in winter.

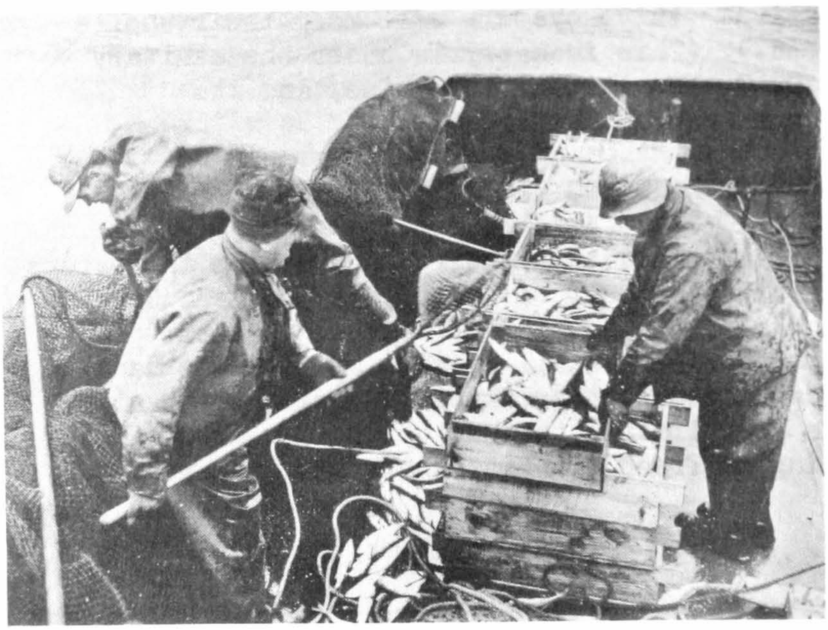


Figure 3.--Removing lake herring from trap net and placing them in boxes. (Photo courtesy of Detroit News.)

Methods of Unloading Fish from Vessel to Shore Plant

The boxes of fresh-water fish are hoisted mechanically or are lifted by hand from the fishing vessel to the dock. They then are taken to the fish house on carts or hand trucks if the fish house is located near the dock or are hauled by motor truck if it is located at a distance.

Figure 4.--Unloading lake herring at the shore plant. (Photo courtesy of Bay Port Fish Company, Bay Port, Michigan.)

Handling Procedures at the Fish House

Many of the fish companies serve as combination fish producer, fish processor, wholesaler, and retailer. The handling of the fish at the shore plant therefore varies and depends upon how the fish are disposed of. In the fish house, the boxes of fish are first weighed. One convenient practice is to weigh into each box either 50 pounds or 100 pounds of fish. (The fish are less likely to undergo subsequent damage from crushing if they are held in the smaller boxes.) Fish that are sold to local fish dealers may be iced or may leave the fish house without further handling. Fish that are sent to fish dealers in distant cities are repacked and surrounded by ice in wooden boxes and then are shipped to the market by truck or by rail. Fish that are to be processed or that are to be sold in the firm's retail store are iced in boxes and stored in a cool room until needed. Care is taken not to bruise or break the flesh by rough handling. Other fish are

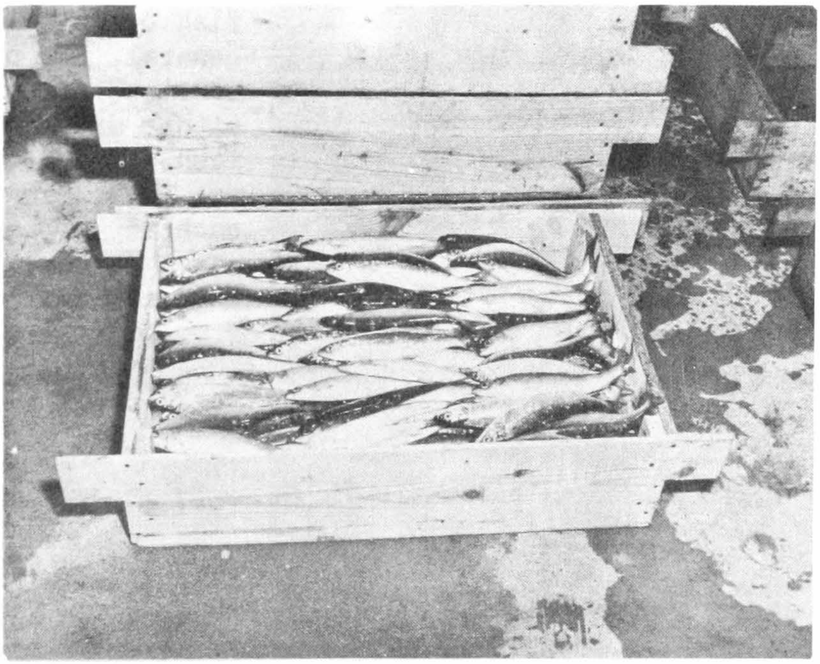


Figure 5.--Fifty pounds of lake herring. These fish have been laid in a bed of ice and now are ready for top icing. (Photo courtesy of Bay Port Fish Company.)

packed surrounded by ice in 100-pound-capacity wooden boxes, are frozen, and are placed in cold storage. When fresh fish are scarce during the off season, these frozen fish are thawed, processed, and sold to the institutional trade or in the firm's retail store.

Much of the fresh-water fisheries is highly seasonal and is characterized by short periods of large catches. During these periods of gluts, a delay in icing or inadequate icing of the fish may result due to shortages in labor and in facilities for handling the fish.

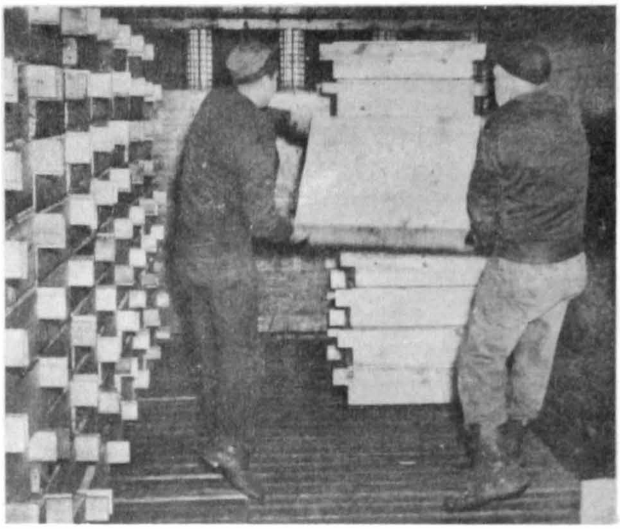


Figure 6.--Stacking boxes of iced lake herring in a refrigerator car. (Photo courtesy of Bay Port Fish Company.)

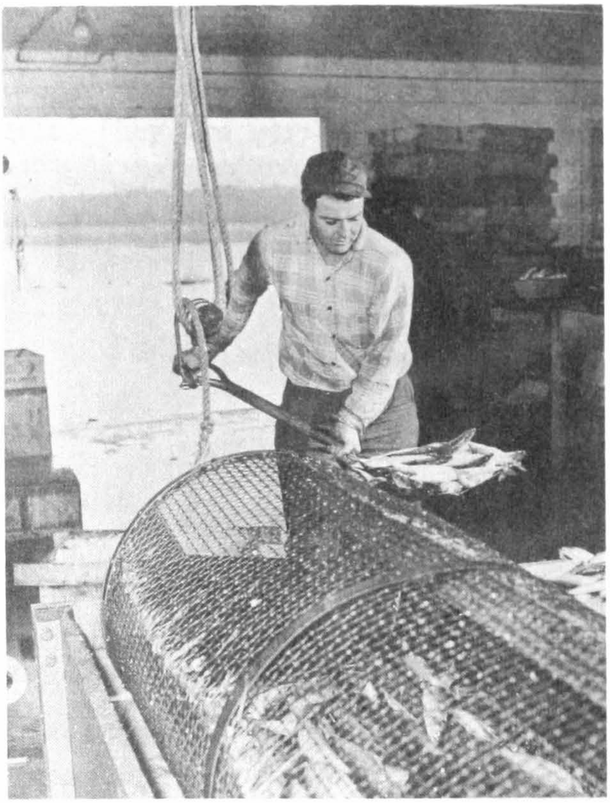


Figure 7.--Scaling lake herring. (Photo courtesy of Bay Port Fish Company.)

Preparation of Fish for Use in the Fresh-Fish Trade

Most of the catch of fresh-water fish is marketed as round fish or as eviscerated fish. In general, the processing of the fish consists of scaling, washing, and either dressing or filleting the fish. The dressed fish and fillets are packed in various containers such as 30-pound fillet tins, waxed cartons, and wooden boxes. They are stored either in a cool room or in ice and usually are sold to the institutional trade or in the retail store of the firm.

Handling Procedures for Certain Species

The various species of fresh-water fish are handled in several different ways. Catfish and bullheads, for example, are eviscerated, headed, skinned, and washed before being shipped to the fresh-fish market. Other species, such as lake trout, are not skinned. They are simply eviscerated and gilled immediately after being landed and then are carefully iced in wooden boxes before being shipped.

Figure 8.—Dressing lake herring. (Photo courtesy of Bay Port Fish Company.)

Some species of fresh-water fish are used largely to produce a smoked product. Typical of this type of operation is the chub fishery The chubs are eviscerated and are packed in wooden fish boxes (50-pound or 100-pound capacity) aboard the vessel. On shore, they are washed and are prepared for smoking. The surplus chubs are placed in waxed cartons of varying capacities, are frozen, are ice glazed, and then are stored for use during the off season. Best results have been obtained by using a polyethylene bag liner inside the cartons to help preserve the ice glaze during the period of cold storage. Chubs that are to be smoked in distant cities are taken directly from the vessel, are iced in wooden boxes, and then are shipped by truck or by rail.

Certain species of fresh-water fish are used both for human food and for animal food. Typical of these species are the lake herring, which are caught in gill nets.

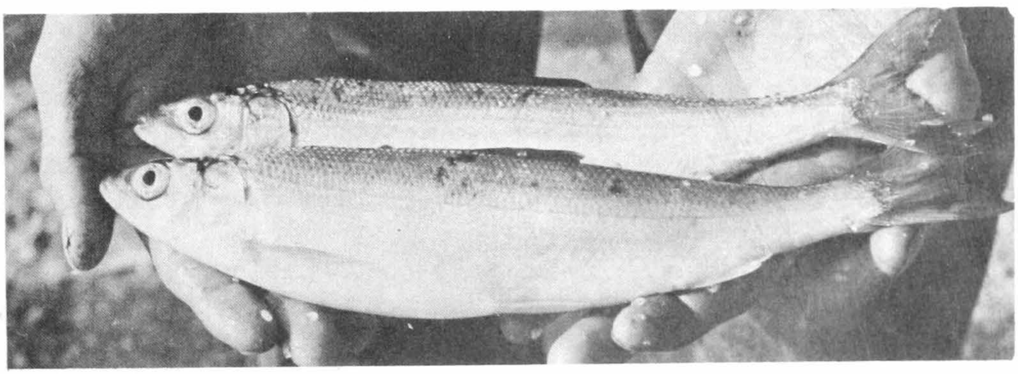


Figure 9.—Lake herring (Leucichthys artedi). (Photo courtesy of Bay Port Fish Company.)

The lake herring that are used for human food reach the processing plant usually in 100-pound wooden boxes. They are scaled and are washed. Some are processed into headed and dressed fish, and others are cut into fillets. They are sold mainly on the fresh-fish market, but some are packed in 1-pound and 5-pound waxed cartons and are frozen.

The lake herring that are used for mink food are taken primarily in Lake Superior, where they are caught in great abundance during the winter months. These fish are left in the gill nets until the vessel has docked, at which time they are picked from the nets either aboard the vessel or in a small building built alongside the dock. These fish usually are packed in wooden boxes or bushel baskets and are frozen.

PREPARATION OF FILLETS--HANDLING OF NEW ENGLAND GROUNDFISH AS AN EXAMPLE

Groundfish may be defined as those fish that normally live at the floor or the bottom of the sea and that are taken for human consumption. These fish are the demersal or bottom-dwelling species, such as codfishes and flatfishes, as contrasted to the pelagic species, such as tunas, herring, and menhaden. Although groundfish are caught off the Pacific coast, they are taken in largest quantities off the New England and the eastern Canadian coasts. The methods employed in landing these fish for shore processing are generally similar in all of the New England ports and are the ones that will be described here.

Methods of Unloading Fish from Vessel to Processing Plant

The larger species of fish such as cod, haddock, pollock, and the flatfishes are transferred from the storage pens of the vessel into canvas unloading baskets by one- or two-tined pews. The worker, in pewing the fish, should pierce them only in the region of the head to avoid wounds in the edible flesh. The unloading baskets, which are constructed of a canvas liner within a steel framework, have a capacity of 90 to 100 pounds of fish. The baskets, when filled, are hoisted onto the dock by means of a winch and then are emptied into a tared 500-pound-capacity wooden box that has been placed on platform scales. In some ports, weighing boxes are not used; instead, the fish are weighed in the unloading baskets or on pan scales. The fish, after being weighed, usually are pewed into large two-wheeled wooden carts, of about 1,000- to 2,000-pounds capacity, which then are pushed into the processing plants. In some instances, the loaded weighing boxes are moved into the plant on a tractor-drawn trailer.

Smaller species of fish such as ocean perch, whiting, and flatfish are usually shovelled out of the pens of the vessel into the unloading baskets. The workers, in shovelling the fish and even in pewing, inadvertently include considerable amounts of ice with the fish. In some ports where the fish are weighed and sold as they are unloaded, a five-percent or larger discount in weight is allowed to take care of the extra ice. The more common practice, however, is to empty the unloading baskets directly into a de-icer on the dock. This de-icer is a cylinder that is 2 feet in diameter and 12 feet in length and that is made of expanded metal or screening of $1\frac{1}{4}$-inch mesh. The cylinder rotates about a central spray pipe and is inclined downwards at a small angle. As the fish and ice tumble toward the lower end of the cylinder, the ice is washed through the sides of the machine. The de-iced fish then fall onto a rubber belt and are conveyed to the weighing boxes. The fish, after being weighed, are either conveyed by belt directly into the shore processing plant or are loaded into wooden boxes, with ice for transportation to distant markets.

Figure 10.—Unloading fish from a hold of the ship by the use of a canvas basket and a winch. Note the basket in the air being swung out of the hold. (Boston, Massachusetts)

Figure 11.--Dumping fish from a canvas unloading basket into a tared weighing box. A large two-wheeled cart partly filled with fish is shown in the lower right-hand corner.

Figure 12.—Loaded weighing boxes on a tractor-drawn trailer on the way to a processing plant.

Plant Storage Prior to Processing

At times, the shore processor will receive a glut of fish, necessitating their storage prior to processing. The storage time involved may be from a few hours up to an overnight period. Storage bins, chill rooms maintained at 35° F., or a designated floor area within the shore plant are used to store these fish. If the processor receives the fish in boxes, the usual practice is to add crushed ice and to store them in a chill room or other designated area of the plant. In those plants in which the fish are received by conveyor belt or by two-wheeled carts, the fish are layered with ice either in storage bins or on a section of the floor.

Recommendations for Controlling Quality before Processing

Because of the rapid deterioration of fish flesh and because only fish of the highest quality bring premium prices, it is vital to the shore processor to take steps to maintain fish at the highest quality possible. The processor should acquaint himself thoroughly with the bacterial and enzymatic deterioration occurring in fish flesh and with the methods of retarding such actions (section 1 of this leaflet). The processor should also acquaint himself with the quality control recommendations for handling fish at sea (section 2) and demand that those vessels supplying him with fish comply with these recommendations.

Preparation of Fillets

A fillet is a piece of flesh, substantially boneless, cut away from either side of the fish along the backbone from behind the pectoral fin down to the tail section of the fish. If that portion of flesh that lines the visceral cavity remains with the fillet, the fillet is called a full-nape fillet. Most high-quality fillets do not contain the nape.

The first commercial preparation and shipment of fillets was made on December 21, 1921, and is credited to Mr. Dana Ward. Fresh haddock fillets individually wrapped in vegetable parchment were packed in 20-pound-capacity hinged wooden boxes.

Although the fillets kept well during the winter, they tended to spoil rapidly during the summer because of the lack of refrigeration. This problem was solved by packing them in tin containers, which in turn were packed with crushed ice in wooden shipping boxes. Since the inception of the first commercially packed fillets, the Massachusetts production of fillets has grown from an insignificant quantity in 1921 to almost 34 million pounds in 1952.

Fresh fillets are generally marketed in one of the following ways: skin on, in which the skin of the boneless fish flesh is left on, as in ocean perch and whiting; skinless, in which the skin is removed as in cod, haddock, cusk, and the flatfishes; and butterfly fillets, in which the fillets are left adhering together by the uncut skin of the belly, as in whiting.

Filleting by hand.--Before the fish are filleted, they are washed with chlorinated water, either in wash tanks or under sprays, in order to remove the slime, blood, and ice. The chlorinated water also has the effect of greatly reducing the number of surface bacteria. If the fish are to be sold as skin-on fillets, the scales are removed with a small, powered hand scaler. The fish, after being scaled, are rinsed under running water. All fish, whether scaled or not, are carried by a rubber conveyor belt to a large hopper that feeds the filleting tables. When the cutters need fish, a conveyor system from the hopper to the filleting table is started, and each worker removes a supply of 50 to 100 pounds of fish from the moving belt.

Figure 13.--Filleting ocean perch by hand.

The hand-filleting cuts for all fish are quite similar. The filleter, using a very sharp and flexible knife, makes his first cut behind the pectoral fin across the body and down to the backbone. When the backbone is reached, the knife is held flat, and a second cut is made along the backbone parallel to the dorsal fins, from the first cut to the tail. The cut is then opened, by the filleter's free hand, at the junction of the first two cuts. The filleter next cuts along the backbone around the visceral cavity down to the vent, and then down to the tail in one motion (see illustrations of filleting in Fishery Leaflet 431, section 3). The fish is turned over, and the operation is repeated. The fillets are finally placed on a moving belt that conveys them to a brining tank. The waste portions are thrown onto another conveyor belt emptying into a central waste-storage hopper.

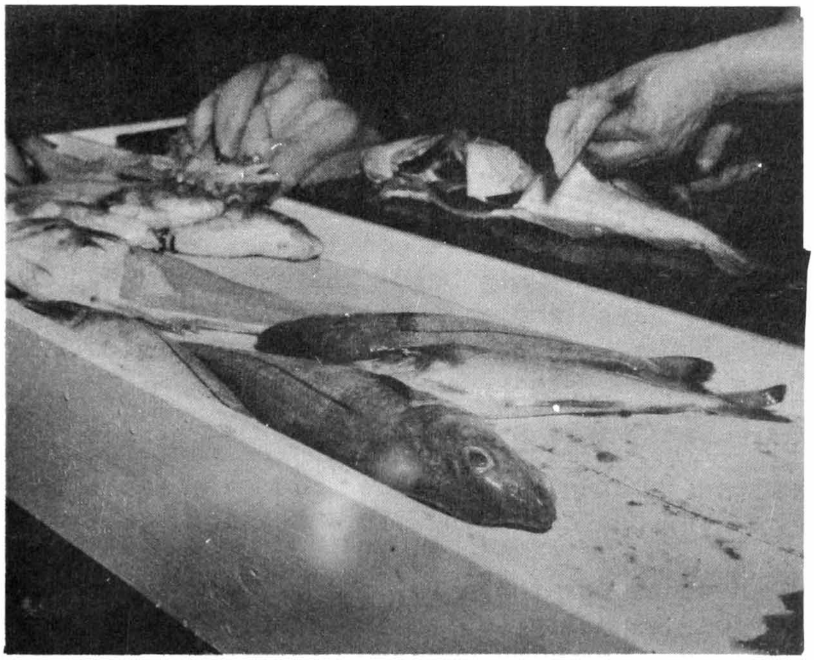


Figure 14.--Hand filleting haddock. The filleter is making the last cut, from the vent to the tail along the backbone.

If the fillet is to be skinned, it is placed on the table skin side down. A cut is made across the fillet down to, but not through, the skin at about 1/2 inch from the tail end of the fillet. The filleter then grasps the tail end of the fillet with his free hand and pulls while cutting with the knife just above and horizontally to the skin. The skin and its adhering scales are thrown onto the waste conveyor, and the skinless fillet is placed on a rubber conveyor leading to the brining tank.

Brining has a twofold purpose: (1) it helps the fillet to retain water, by lowering the amount of drip, and (2) it enhances the appearance of the flesh. Some processors chlorinate the brine solution in order to reduce the number of bacteria on the surface of the fillets.

The period of time the fillets remain in the brining tank depends upon the concentration of the brine. For a 10- to 15-percent brine, a dip of 20 seconds is used, and for a 3-percent brine, a dip of up to 2 minutes is used (Holston and Pottinger 1955). The period of time that the fillets are in the brine solution is regulated by the length of the tank, which usually is about 4 feet, and by the speed of the conveyor belt that moves the fillets through the tank. The conveyor belt usually is made of stainless steel or of some other metal that is resistant to the corrosive action of the brine. In some plants, the brine solution is continuously filtered to remove broken pieces of flesh.

The fillets, upon emerging from the brining tanks, are drained and are conveyed to the packing tables and, before being packed, are inspected for bruises, fins, and bones, which, if found, are removed. Iced fillets usually are wrapped individually in vegetable parchment paper or in cellophane and then are packed into tinned slip-covered metal fillet cans of 20-pound capacity. Five-, ten-, and twenty-pound waxed chipboard or fiberboard cartons with telescoping covers also are used. The fillets are sometimes quickly cooled to about 30° F. by placing the containers in an air blast at 0° F. To maintain the fillets at 32° F. during shipment to market, the processors pack the containers in crushed ice in large wooden boxes. Fiberboard cartons are used at times instead of the wooden boxes when prechilled fillets are rushed to market by air or, over short distances, by truck.

Ocean-perch fillets are candled before they are brine dipped and packed. The candling table consists of a sheet of Plexiglas illuminated from below by a 100-watt bulb. Here the individual fillets are inspected for bruises, fins, and parasitic contamination. If any of these undesirable features are detected, they are trimmed out, if possible, or else the fillet is rejected.

Filleting by machine.--Within the past few years, there have been several new labor-saving devices made available to filleting plants. These devices consist of heading, scaling, filleting, and skinning machines.

Fish received at the filleting plant are conveyed into hopper bins, of 400-pound capacity, which are mounted on scales. Weighings are made continuously. From the hoppers, the fish are carried by a flight conveyor under sprays of potable water and then to a belt system leading to a battery of heading machines. The fish are placed by hand 1 foot apart, with the gills facing an angle-iron stop, on metal cleats attached to a chain-type conveyor that feeds into the heading machine. The fish are forced against a rotary knife, which cuts off the heads. The capacity of the heading machine is 100 fish per minute. After the heads are removed, the body is conveyed to an automatic scaler, and the heads are conveyed to a waste bin on the outside of the plant.

The scaler may consist of a revolving expanded-metal drum such as is used on ocean perch and on whiting, or it may consist of a unit in which the fish are drawn head first against a high-speed coarse-metal cylinder. A scaler of the first type is capable of processing 15,000 pounds of ocean perch per hour, and one of the second type is capable of processing 4,000 pounds of scrod haddock per hour. Both types of scalers employ liberal amounts of water to wash away the loosened scales.

From the scaler, the fish are conveyed to a filleting machine that is provided with high-speed rotary knives and parallel ribbing knives.

Fish entering this machine are grasped by the tail mechanically and are guided past the two kinds of knives. As the fish travel past these knives, the fillets are removed. One machine is reported to be capable of processing 75 fish per minute. The filleting machines can be so adjusted as to cut the fillets with the nape on or with it off, the latter being the general practice. The frame or skeleton is conveyed to a hopper for the storage of waste, and the fillets are sent to a skinning machine.

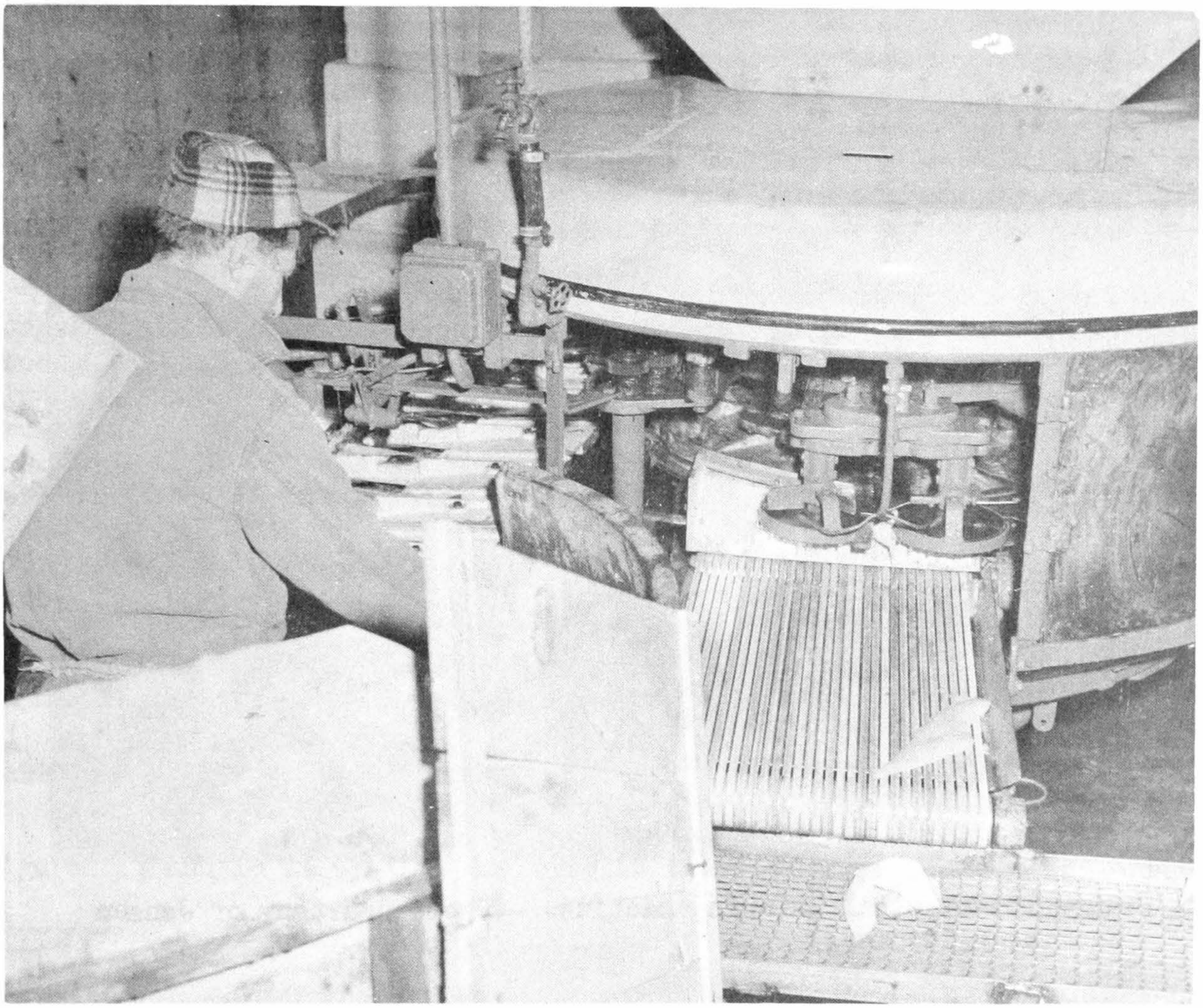


Figure 15.--Filleting machine cutting haddock. The feed is on the left side of the machine, and the fillets, with skins on, come out on the belt on the right side. (Photo courtesy of Shamrock Fisheries.)

Species such as cod, haddock, and pollock are usually sold as skinless fillets. On one type of skinning machine, the fillets are placed skin side down on a rubber belt. Above the belt is a high-speed band knife so installed that the distance between the belt and the knife can be adjusted easily. A second belt is placed above the knife and the lower belt in such a manner as to apply an even, firm pressure on the fillet.

As the fillet moves between the belts, the knife slices off the skin. This machine also can be used to split thick fillets that would come from large cod, haddock, or pollock. The capacity of such a machine is reported to be between 3,000 and 4,000 pounds of fillets per hour.

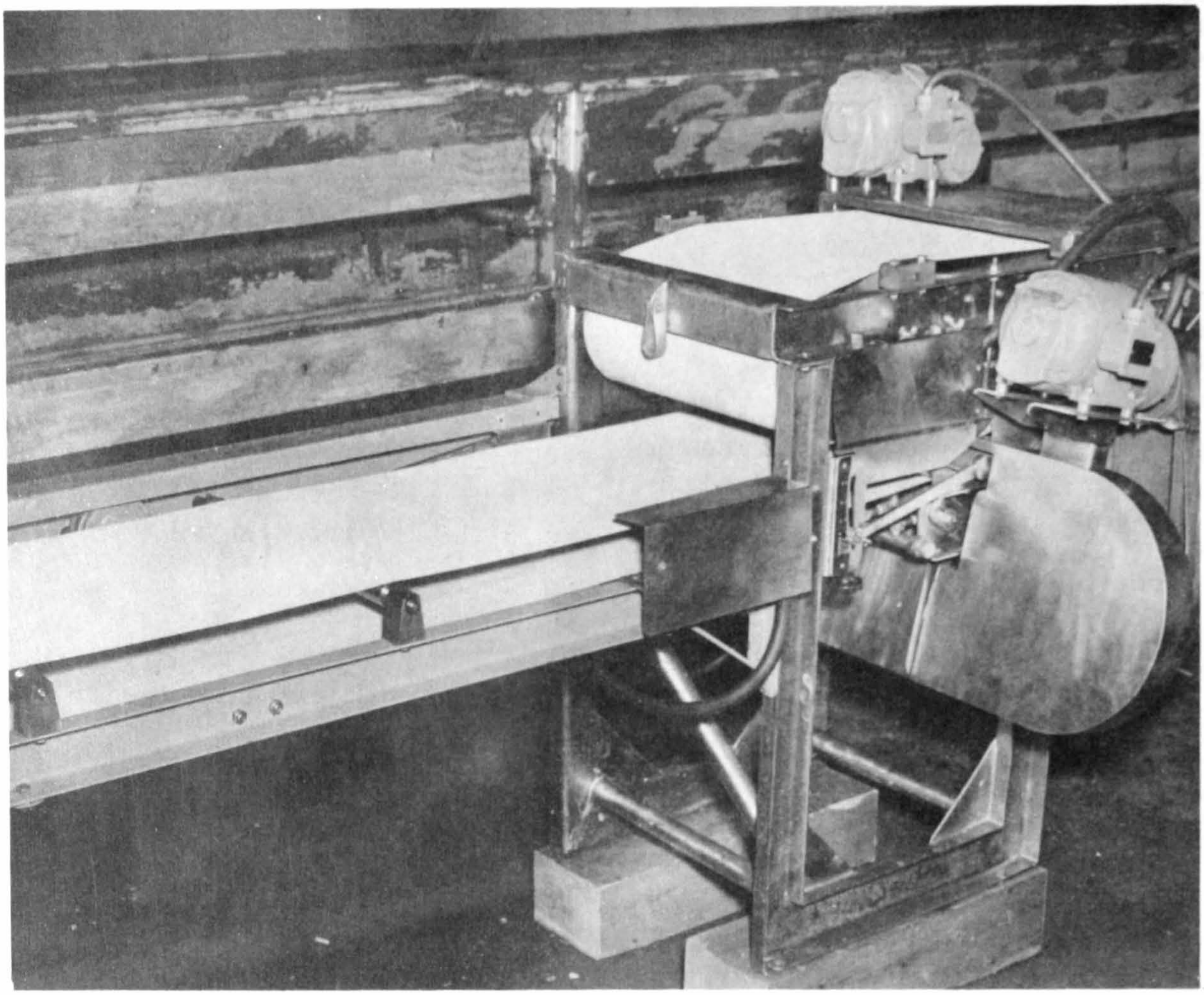


Figure 16.--Typical skinning machine. (Photo courtesy of Jensen Equipment Company.)

The fillets are inspected and brine dipped as was previously described. They are drained on a mesh belt and are dropped into cartons or corrosion-resistant pans set on scales to obtain an approximate weight. The containers then are sent to a packing table, where their weight is adjusted. The containers used are the same as was described in the previous section on hand cutting of fillets.

PREPARATION OF FROZEN STEAKS--HANDLING OF HALIBUT, SALMON, AND SABLEFISH AS EXAMPLES

Why Certain Species of Fish are Frozen for Steaking or Filleting

Most species of fish are landed in the unfrozen state from the fishing vessel, are processed into fillets or other desired cuts, are packaged, and then are frozen. Halibut, salmon, and sablefish, which are caught mainly in the Pacific Northwest and in Alaska, are trimmed and washed thoroughly after being landed, and then are frozen and are stored as whole glazed fish. These whole fish are withdrawn at intervals as orders are received. Steaks or fillets are cut from either the hard-frozen fish or the partially thawed fish, and the cut product is packaged, refrozen if necessary, and returned to cold storage.

There are two considerations that have led to this practice:

First, halibut and salmon are caught during a relatively short season, usually in areas remote from locations that have complete processing plants. In Alaska, for example, it is easier to ship whole frozen fish to centrally located plants for cutting and packaging than it is to carry out these latter operations at widely scattered locations.

Second, halibut and salmon, like other kinds of fish, have a much longer cold-storage life when stored as glazed whole fish than as steaks. Steaks cut from frozen fish cannot be packaged without leaving considerable air space inside of the package. This method of packaging thus does not provide adequate protection for prolonged storage. The better practice therefore is to store the fish for as large a part of the total storage period as is possible in the form of glazed whole fish.

A few processors have developed equipment for cutting unfrozen or partially thawed fish into steaks. When such steaks are packaged and are frozen under pressure, the pieces fill the space inside the package. Such fish then have increased storage life, and it is not so important to hold them in the whole dressed and glazed state initially.

Steaking and Packaging Frozen Fish

Halibut steaking.--A processing line similar to the one shown in figures 17 and 18 is usually employed in the steaking of frozen halibut.

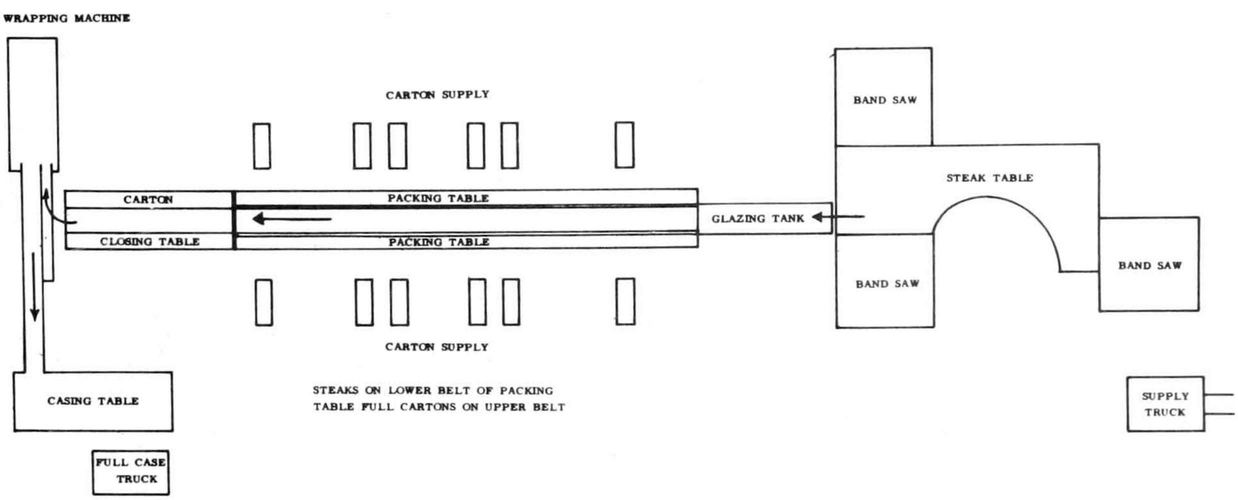


Figure 17.—Line for steaking and packaging frozen halibut.

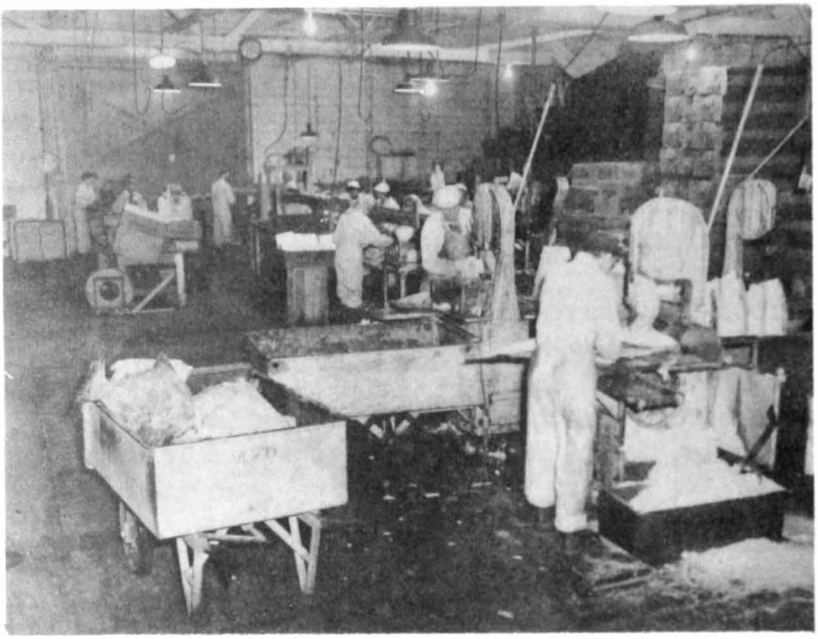


Figure 18.--Packing line for frozen halibut steaks. The man in the foreground is the first sawyer. (Photo courtesy of Seattle Seafoods, Inc.)

These facilities may be more highly mechanized or less highly mechanized than is the one shown, depending upon the cost of equipment, the cost of labor, the desired throughput, and the maximum unit packaging cost that can be borne by the product.

The usual starting material in cutting steaks is frozen halibut, dressed head-off and weighing from 10 to 60 pounds. Immediately after the halibut are removed from frozen storage, the dorsal and the ventral fins are shaved away with a large sharp knife. The halibut then are hauled to the first bandsaw in a buggy or a cart. A man known as the first sawyer carries the halibut, one at a time, to the first saw and begins the steaking operation. With his initial cut, he removes 2 or 3 inches of gristle at the nape of the neck. With his second cut he removes the belly and the nape as one unit. With his third cut, he separates this unit into two pieces. He then throws the belly piece into the scrap box and proceeds to cut 3/4- or 7/8-inch-thick steaks from the nape piece and from the loin piece. The steaks get smaller in diameter as the tail is approached. He therefore discards the tail piece when the steaks are no longer large enough for a single small serving.

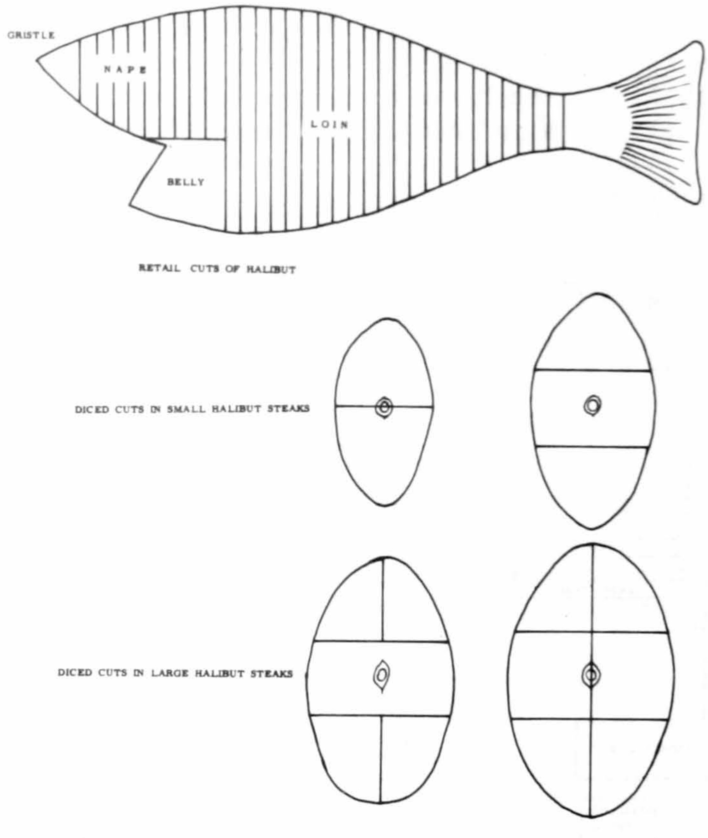


Figure 19.--Cuts of halibut steaks.

If there are three sawyers working together, a second sawyer receives the belly piece, trims away the fins and the thin belly wall that is less than 1 inch thick, and cuts steaks from the remainder. Steaks from the first and second sawyer are passed along to a third sawyer, who dices or cuts them into serving-size pieces suitable for packaging. If there are only two sawyers, the second sawyer trims and steaks the belly piece and dices all of the steaks. Sometimes a number of belly pieces are accumulated, trimmed, and steaked by the first sawyer. Trimmings and sawdust from the steaking operation are used for pet food or for mink food. The yield of salable halibut steaks from dressed frozen halibut is about 70 percent of the weight of the dressed halibut.

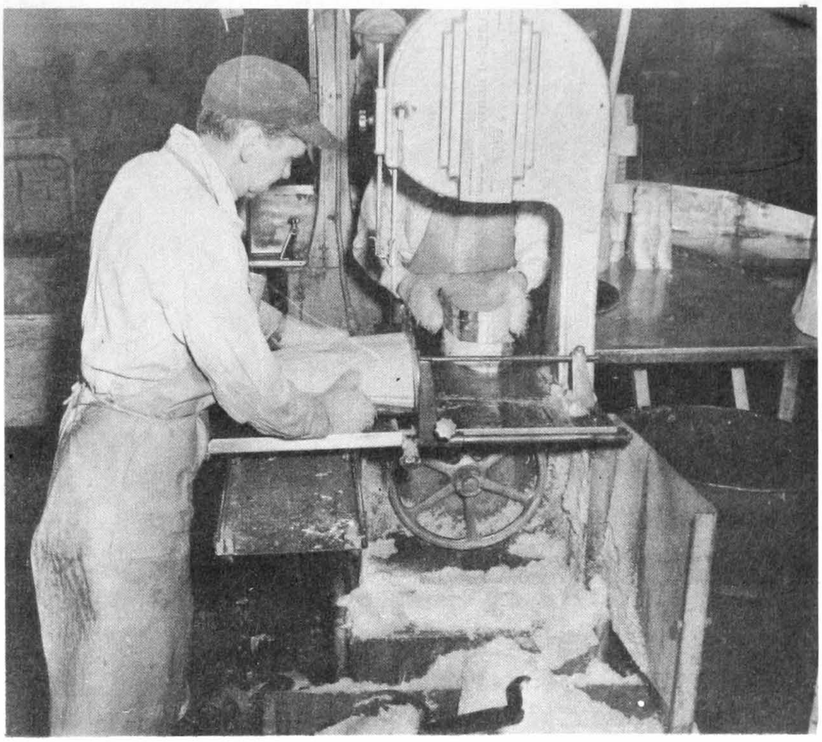


Figure 20.--Steaking a frozen halibut loin. (Photo courtesy of Seattle Seafoods, Inc.)

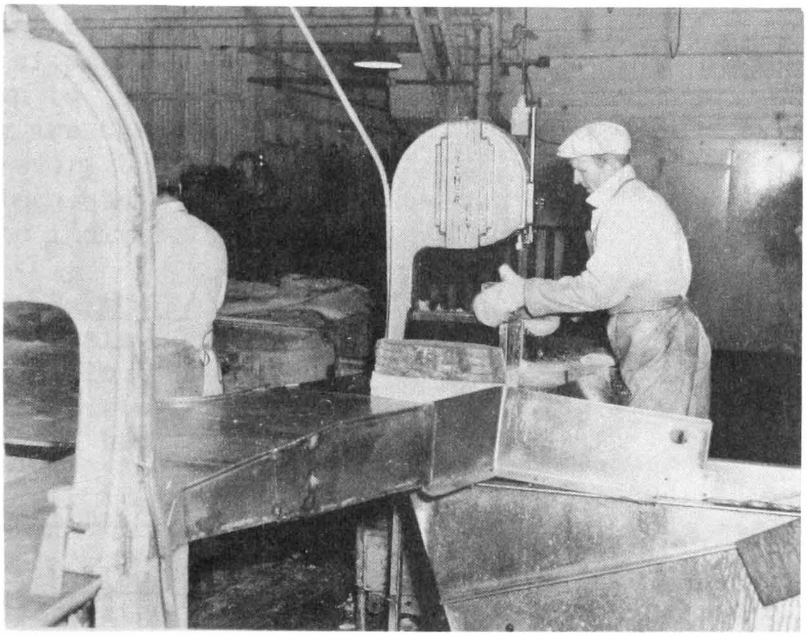


Figure 21.--Dicing frozen halibut steaks. (Photo courtesy of Seattle Seafoods, Inc.)

Halibut packaging.--After the steaks have been cut into serving-size pieces, they are dropped into a glazing tank containing cold water, from which they are lifted by an inclined mesh-belt and delivered to the packing table. Some glazing operations employ a spray of water above and below the mesh-belt to

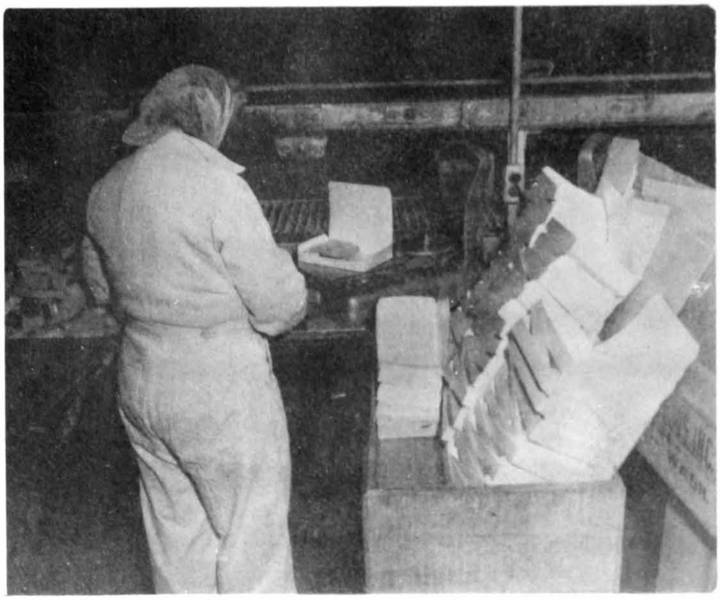


Figure 22.—Weighing frozen halibut steaks into a carton. (Photo courtesy of Seattle Seafoods, Inc.)

obtain a thicker glaze.

Waxed cartons for packaging the steaks come in flat cut blanks and are formed by hand, by hand-operated machine, or by automatic machine. They then are either carried in large boxes to the packers or are conveyed along the packing table on a supply belt. The packer takes cartons from the supply belt, places them on the scale pan, fills them with pieces of halibut steaks to a weight of 1 pound, and then places them on a conveyor belt running to the lid-closing table, where they are closed by hand. (These cartons of necessity must be large enough to hold odd-shaped frozen pieces without crowding, consequently they contain considerable air space.) The closed cartons then are fed either automatically or by hand to the machine that overwraps

Figure 23.--Closing cartons filled with frozen halibut steaks and feeding the closed cartons to a wrapping machine. (Photo courtesy of Seattle Seafoods, Inc.)

them with printed waxed paper and heat seals the paper. Wrapped cartons are packed in fiberboard shipping cases and are returned to storage at 0° F. or lower. Institutional size packs of steaks are packed in fiberboard boxes that have a capacity of 15 pounds. These boxes or cases are lined with heavy waxed paper, and a sheet of this paper is placed on top of each layer of steaks. When the box is full, the lining paper is folded over the top layer of steaks, and the box is glued shut. If the box is of two-piece construction, it is strapped shut.

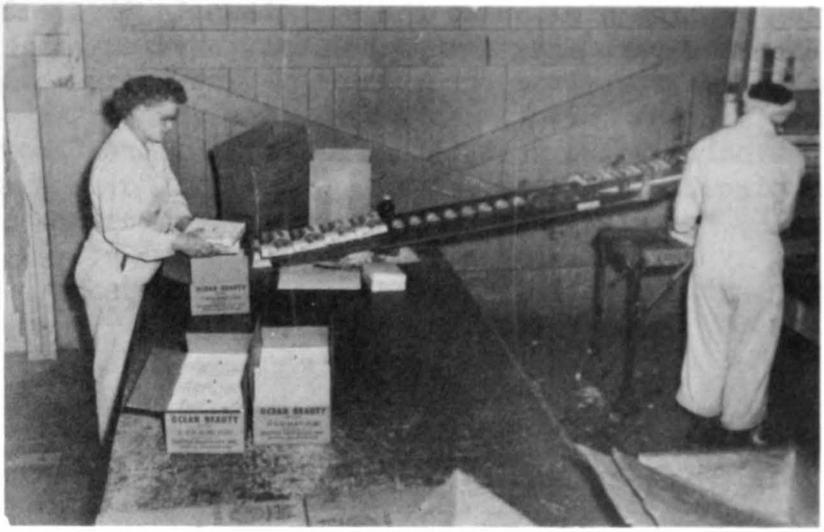


Figure 24.—Packing wrapped cartons of frozen halibut steaks into shipping cases. (Photo courtesy of Seattle Seafoods, Inc.)

<u>Salmon and sablefish steaking</u>.--Salmon and sablefish are steaked with the same type of equipment that is used for steaking halibut and are handled in much the same manner except that only two saws are required. In steaking salmon, the first sawyer trims away the fins, saws off the head behind the gills, and saws off the collar or nape piece, which contains the tips. (Frequently, these tips are saved and smoked for sale as kippered salmon tips.) The second sawyer simply cuts steaks right down to the tail piece. Tail steaks too small for a single small serving are thrown aside for use in animal food. For institutional packs, however, the tail piece is filleted and is packed with the steaks. Salmon steaks ordinarily are not large enough to require dicing or cutting into individual portions.

<u>Salmon and sablefish packaging</u>.--Salmon and sablefish are packed in retail-size cartons and in institutional-size cartons in the same way as are halibut steaks and then are returned to 0° F. storage. The yield of salable steaks ordinarily is about 70 percent of the weight of the dressed heads-on frozen salmon, but it may exceed this value.

Steaking, Filleting, and Packaging Partially Thawed Fish

<u>Halibut steaking and packaging</u>.--When the supply of freshly frozen halibut steaks packed in May and June has been sold, it is the practice in some plants to pack new supplies of steaks by partially thawing frozen dressed halibut that have been held in storage at 0° F. or colder. A

processing line similar to the one shown in figure 25 is usually employed for steaking partially thawed halibut. Medium halibut from 10 to 60 pounds are best suited for steaking. The frozen halibut are brought out of storage; the dorsal and ventral fins are shaved off with a sharp knife; and the halibut are put to thaw in air, on the floor of the fish house, or in circulating water. Thawing time will depend on the temperature of the fish, the size of the fish, the temperature of the thawing medium, and the type of thawing medium used (air or water). The temperature of thawing water should not exceed 60° F. (Magnusson and Hartshorne 1952).

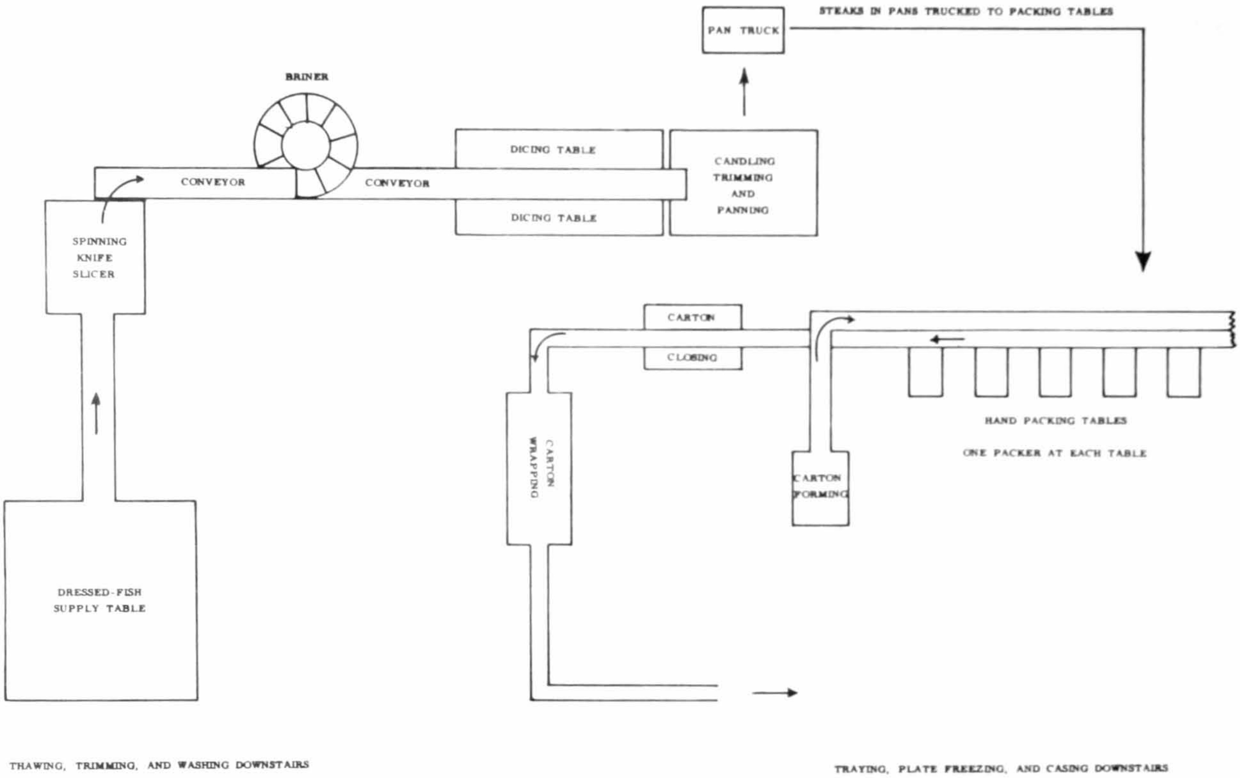


Figure 25.--Line for steaking and packaging fresh or partially thawed halibut.

Partially thawed, or slacked, halibut are more desirable for steaking than are completely thawed halibut. Furthermore, one fourth to one fifth less thawing time is required to obtain a slacked halibut, which still retains a large quantity of ice crystals, than is required to obtain a fully thawed halibut. The time required for thawing halibut to the slacked stage can best be determined by practice under actual conditions.

The first steps in preparing slacked halibut for steaking are washing and trimming. The halibut is scraped inside and then is scrubbed inside and out with water. The thin belly flaps are cut away, and the nape is cut off back to where a good slice can be obtained. The washed and trimmed halibut then are transported to the steaking plant or room.

Figure 26.--Slicing partially thawed halibut. (Photo courtesy of Pacific Fisherman.)

Slices 7/8-inch thick are cut one at a time on a specially constructed slicing machine (Beard 1953). The tail portion of the halibut is collected along with the nape pieces, from the smaller halibut, filleted, and packed in fillet cartons for freezing.

As the steaks leave the slicing machine, they fall on a conveyor and are washed under a heavy spray of water. Continuing on the conveyor, they are allowed to drain before they fall from the end of the conveyor into a stainless-steel rotary briner. Here they are brined, like fillets, as they travel around a complete circle. After the steaks leave the briner, they are conveyed to the dicing table, where they are cut into pieces for packing into cartons of 1-pound capacity. Only steaks from large halibut require extensive cutting to obtain pieces of proper size.

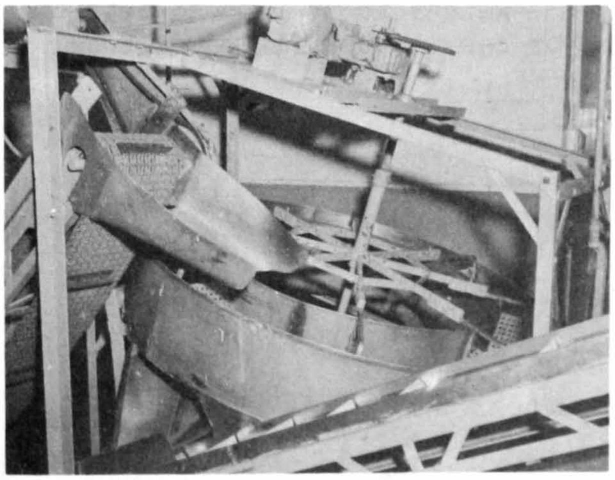


Figure 27.--Stainless-steel briner for halibut steaks. (Photo courtesy of New England Fish Company.)

Figure 28.--Trimming and dicing halibut steaks to size. (Photo courtesy of New England Fish Company.)

The cut steaks then are conveyed to the inspection table, where each steak is candled over a frosted glass plate illuminated from below by

Figure 29.—Trimming, candling, and grading halibut steaks at inspection table. (Photo courtesy of New England Fish Company.)

strong lights, which help to disclose any imperfections or parasites present in the flesh. The imperfections are trimmed away with a pair of shears, and the inspected steaks are put into pans and are trucked to the packing tables.

Waxed cartons into which the steaks are packed come in flat ready-cut pieces in bundles. These flat-cut pieces are formed into cartons automatically by machine and then are conveyed by belt along the line of fillet packers. Each packer stands in front of her own table, selects a carton from the belt, places it on a scale pan, fills it with pieces of steak that fit into the space in the carton, weighs it to 1 pound net, and places it on a conveyor. This conveyor carries the filled cartons to a machine that closes the lid. After the cartons have been closed, they travel by conveyor to the wrapping machine, where a printed waxed-paper overwrap is applied. The wrapped cartons are placed on trays, plate frozen under pressure, packed in shipping cases, and stored at 0° F. or lower until shipped to market.

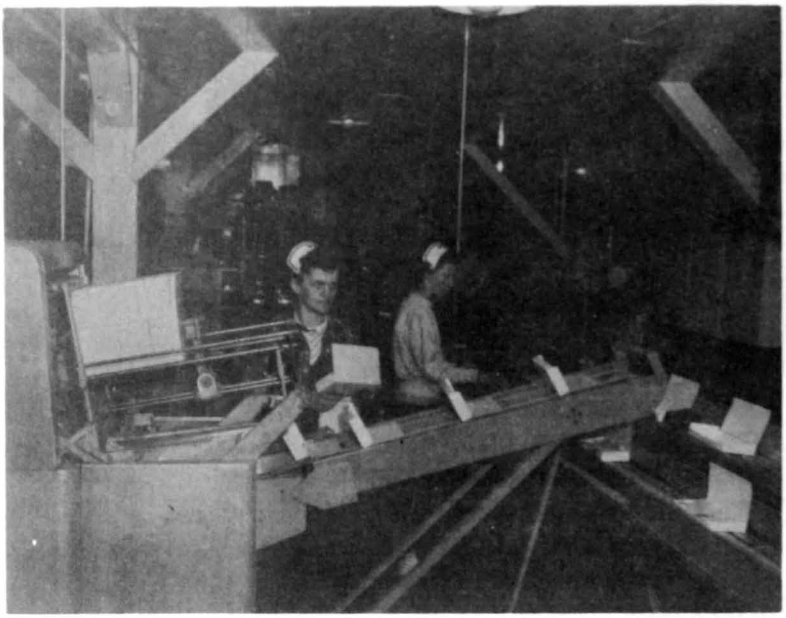


Figure 30.--Machine for making cartons. (Photo courtesy of New England Fish Co.)

Freezing under pressure causes the tightly packed halibut steaks to fill the voids in the carton, thus eliminating air pockets. The resulting product is a completely filled carton having flat surfaces.

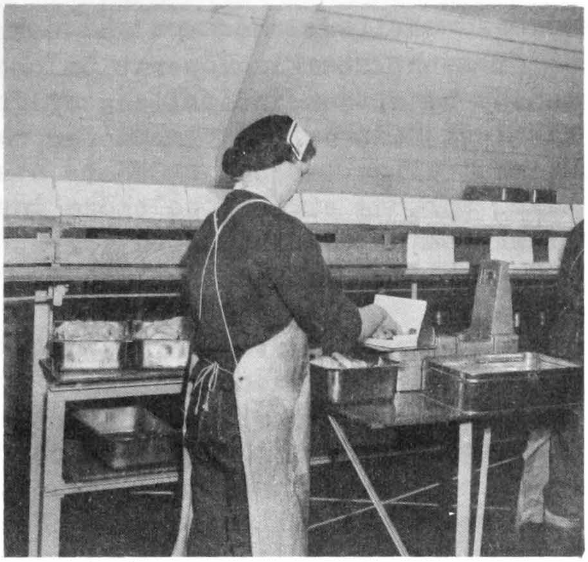


Figure 31.--Packing and weighing halibut steaks into 1-pound cartons. (Photo courtesy of New England Fish Company.)

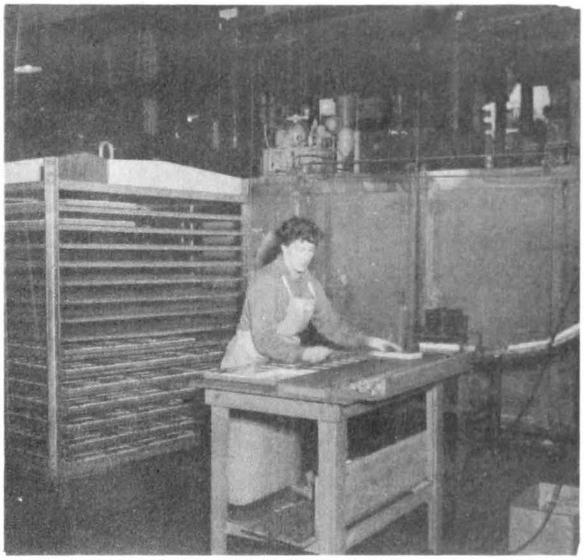


Figure 32.--Placing wrapped cartons on trays. (Photo courtesy of New England Fish Co.)

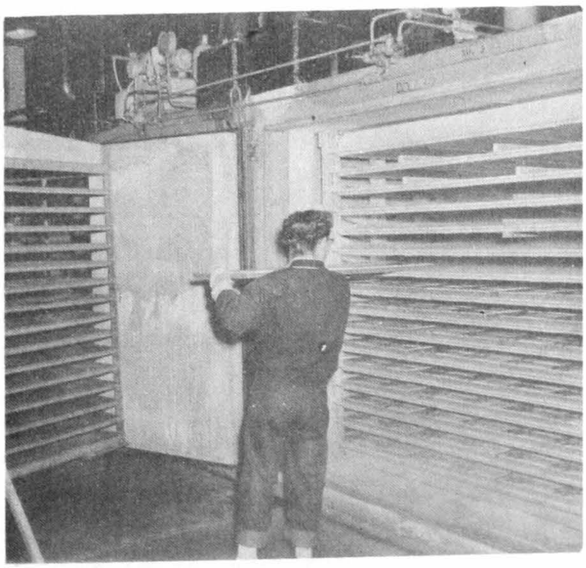


Figure 33.--Loading trays of cartons into a plate freezer. (Photo courtesy of New England Fish Company.)

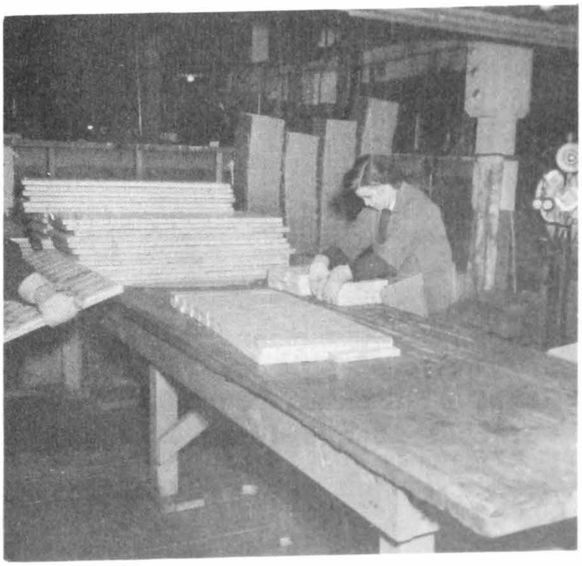


Figure 34.--Packing cartons of frozen halibut steaks into a shipping case. (Photo courtesy of New England Fish Company.)

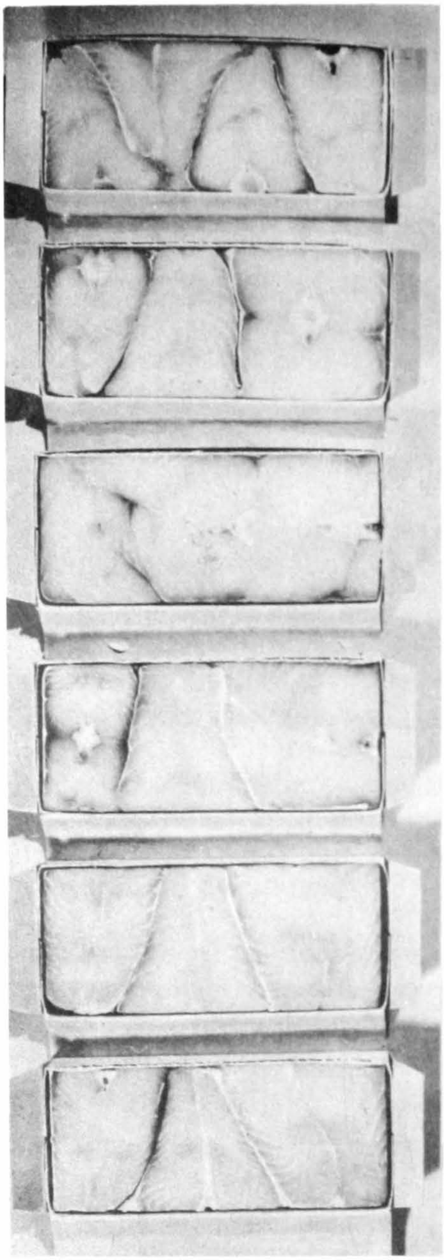


Figure 35.—One-pound packages of halibut steaks. (Photo courtesy of Pacific Fisherman.)

Halibut filleting and packaging.—As was mentioned earlier, the nape and tail pieces from the steaking operation are filleted by hand, cut into slices of suitable size, washed, brined, inspected, and packed into fillet cartons. Other types of waxed cartons similar to those in which partially thawed halibut steaks are packed may be used for halibut fillets. The packer, before filling the collapsed snap-open type of waxed carton, lines a metal mold or box with a sheet of transparent packaging film, packs the fillets into the mold, and folds the film to cover the fillets. The packer then snaps the carton open, covers the full mold with the carton, turns over the carton and mold together, withdraws the mold, and snaps shut the carton lid. The filled carton is then wrapped by machine, frozen, cased, and stored at 0° F. or lower, in much the same manner as are the halibut steaks. In this respect, halibut fillets are a by-product of the halibut-steak operation.

Figure 36.—Packaged fillets in carton after metal mold has been withdrawn. (Photo courtesy of Booth Fisheries Corporation.)

Salmon and sablefish steaking and packaging.—Steaks are cut by machine from partially thawed, dressed, washed, and trimmed salmon or sablefish. (This machine is the same one that is used to prepare halibut steaks.) The tail piece is discarded when the steaks are no longer large enough to provide a small individual serving. Very few of these steaks are so large as to require dicing or cutting in half for packing. Salmon and sablefish steaks, unlike halibut steaks, are not brined, but they are packed in cartons in the same manner as are the halibut steaks.

Salmon and sablefish filleting and packaging.—Fillets are cut by hand with a fillet knife from partially thawed, dressed, and washed salmon or sablefish. The fillets then are skinned, are cut crosswise into pieces as wide as the width of a fillet carton, and are packed, 1 pound net, into the cartons. The pieces are packed in such a manner that the thick part of one fillet overlaps the thin part of the adjacent fillet.

HANDLING OF FISH FROZEN AT SEA--PROCESSING OF TUNA AT THE CANNERY AS AN EXAMPLE

Some species of fish are frozen at sea and, after being landed, are thawed and then are processed. The most important fishery operating in this fashion is the one in which tuna are frozen in brine aboard the fishing vessel and are landed either frozen or partially thawed. After the thawing has been finished at the shore plant, the tuna are butchered, are precooked, and then are canned. A small part of the salmon catch is also frozen at sea and handled in much the same manner as are tuna except for the precook. Because the methods employed by the tuna industry are quite typical for this kind of operation, they will be described in detail.

Arrangement of Tuna Plant

Most tuna plants are located adjacent to a dock suitable for unloading fish from a vessel and are provided with rail facilities for the delivery and shipment of cans and other materials (sometimes including frozen tuna as well as the final canned product). The cannery usually faces the dock with the rail line at the rear. Ordinarily, a doorway opens from the dock side of the plant into a room where the tuna are thawed and butchered. If thawing tanks are employed, these may be in the butchering room or in an adjoining one. If there is a cold storage, it is generally adjacent to and entered from this room. The fish are usually delivered to an open space near the door and, if frozen, are merely laid on the floor for defrosting with or without sprays. The butchering table, sometimes permanently installed but in other cases equipped with casters for moving about, is usually nearby.

The butchered tuna are placed in baskets on racks, which are wheeled into the precookers. The tuna, after being precooked, are cooled, are cleaned, are packed in cans, and then are retorted. Figure 37 shows a typical layout of a tuna plant up to the point where the fish are precooked.

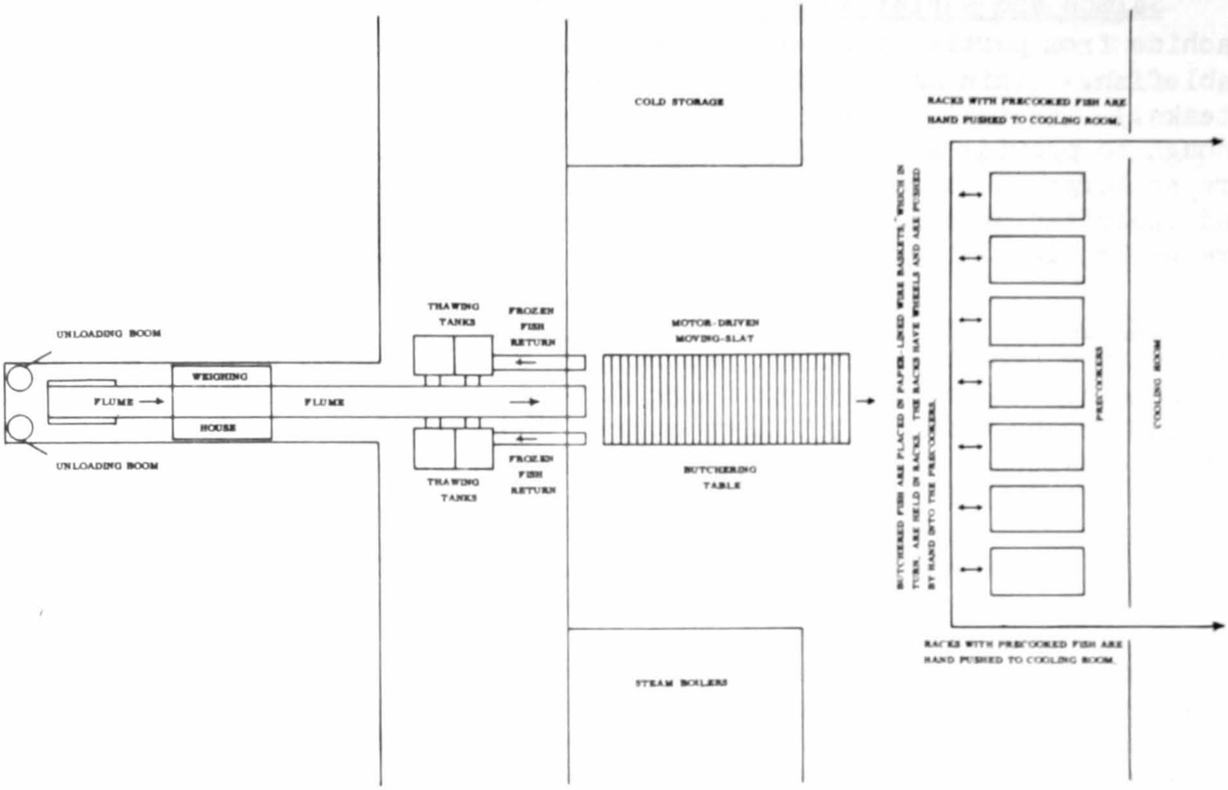


Figure 37.--A typical layout of a tuna plant.

Conveyor Systems for Carrying Tuna to the Plant

The larger canneries that are located adjacent to wharves and that have no intervening roadway or other obstruction ordinarily employ the following system. A large tub is lowered through the hatch of the fishing vessel into the hold and is filled, by hand, with tuna. The tub then is lifted out of the hold by a boom hoist and is swung over an apron, where it is dumped automatically with a catch chain. In some installations, two hatches of a single vessel can be unloaded simultaneously in this way.

The tuna fall from the dumping apron into a flume containing running sea water, which sluices them onto a slat-type conveyor-belt elevator which, in turn, lifts them to a scale house, where they are weighed, usually in the presence of representatives of both the fishing vessel and the cannery. The weighing is done in batches, with a scale hopper of about 700-pound capacity ordinarily being employed. The tuna then are sluiced through flumes to the cannery. This method is highly efficient and involves a minimum of handling. In California, it is used by the large plants in San Diego and by one on Terminal Island. Such a system can handle about 15 tons of tuna per hour.

Most of the plants on Terminal Island are located across a roadway from the unloading docks, making the use of continuous sluiceways for conveying the fish to the plants inconvenient. A majority of these plants make use of three-wheel metal carts holding 1,000 to 1,400 pounds of tuna. These carts are lowered into the hold of the vessel, are filled with tuna, and then are lifted onto the dock by boom or, in some cases, by overhead trolley with chain lift. Otherwise, a large bucket, usually with a hinged bottom, is loaded with tuna in the hold and is dumped into the cart on the dock. The cart is wheeled over a floor-level weighing scale and then is wheeled into the cannery. This method, although requiring more labor than does the sluicing method, is reasonably efficient.

Some tuna are brought to the cannery by other means of transportation than by fishing vessel. In a few instances, the fishing vessel discharges tuna at some remote port, and the iced tuna are hauled to the cannery in large truck-trailers. The trucks then are unloaded, usually into the carts, which are wheeled into the cannery. Often, Japanese tuna are unloaded at points such as Portland or Seattle, where they are placed in cold storage. The tuna, when needed at a cannery, are packed into a truck or freight car for shipment. At the destination, they are unloaded from the freight car or truck into hand-pushed carts and are wheeled into the thawing or butchering room. The extensive handling and rehandling of such frozen tuna may result in quite serious bruising, abrasion of the skin, or other damage. Frequently, the workers, in unloading a car or truck of such fish, handle them with hooks. Although an effort usually is made to handle the tuna by the head or by the tail, occasionally they are hooked through the body, and if they are partially thawed, considerable damage may result. When the tuna are handled as many as four or five times in this way, as sometimes happens, an appreciable portion of them may show the effect of such rough treatment.

Methods of Thawing Frozen Tuna

Tuna frozen aboard clipper ships generally are thawed or are partially thawed before they are unloaded at the cannery. It is customary to turn off the refrigeration a day or two before the vessel docks. In some cases, sea water is circulated through the coils in the wells containing the frozen tuna, in order to hasten the thawing. Thawing or partial thawing of tuna aboard the vessel facilitates unloading the tuna without the danger of breaking them or otherwise damaging them when they are removed from the wells. It also reduces the thawing time required at the cannery. Frozen tuna are more easily damaged than are thawed ones because of the greater tendency for them to stick to the coils in the wells or to each other; thus, in being handled during unloading, the tuna may be damaged when they are pulled apart or pulled from the coils. It is generally inadvisable to thaw the tuna completely aboard the vessel, however, because this thawing would entail too much danger of spoilage should there be a delay between the time that they are unloaded and the time that they are canned.

Tuna unloaded by sluicing generally go directly to the butchering area. It is common to have an arrangement whereby the insufficiently thawed tuna can be diverted by opening a gate so that they are sluiced into a thawing tank. After the tuna have been thawed, they are released back into a sluiceway that carries them again into the butchering room.

The thawing of tuna in tanks is generally done only in the larger plants. More frequently, the tuna are placed in a single layer on the floor and are allowed to thaw either without other aid or, as is more usual, are sprayed with water from an overhead pipe-spray system. In a few plants, they are placed in piles and are thawed by being sprayed at intervals with water from a hose. Even some of the larger plants use spray thawing rather than tank thawing.

Because tuna, when they reach the plant, are in such a variety of stages of thawing--from hard frozen to completely thawed--the thawing time at the plant varies over a wide range. Very frequently, even though the tuna were originally frozen aboard the vessel, they are sufficiently thawed by the time they reach the butchering table that they can be butchered forthwith, for the relatively short wait from the time they reach the butchering room until actual butchering starts is sufficient to complete the thawing.

For hard-frozen tuna, thawing overnight with sprays is generally employed, which in most cases is sufficient to thaw them. In some canneries, a cold-storage room is available for holding any surplus tuna. Such tuna can be withdrawn at a suitable time so as to be thawed when the canning operation starts.

Subsequent Processing Steps

The thawed or nearly thawed tuna pass along a motor-driven moving-slat butchering table, where they are eviscerated. At the same time, they are inspected to eliminate any that may be of doubtful quality. The butchered tuna are placed in baskets, which are arranged on racks. The tuna then are ready for the various canning operations. [The canning procedures for tuna have been described by Jarvis (1943) and by Anderson, Stolting, and Associates (1953).]

HANDLING OF SHELLFISH PRELIMINARY TO PROCESSING

The most important commercial species of shellfish in the United States are shrimp, crabs, lobsters, clams, oysters, and scallops. The methods of processing these shellfish are described in detail in section 2, Fishery Leaflet 430. Methods of unloading and of preliminary handling at the shore plant that are not discussed in the above leaflet will be described here.

Shrimp

In the South Atlantic and Gulf areas, the following three methods are used to unload shrimp from boats to shore plants: (1) the basket method, (2) the modified conveyor method, and (3) the all-conveyor method.

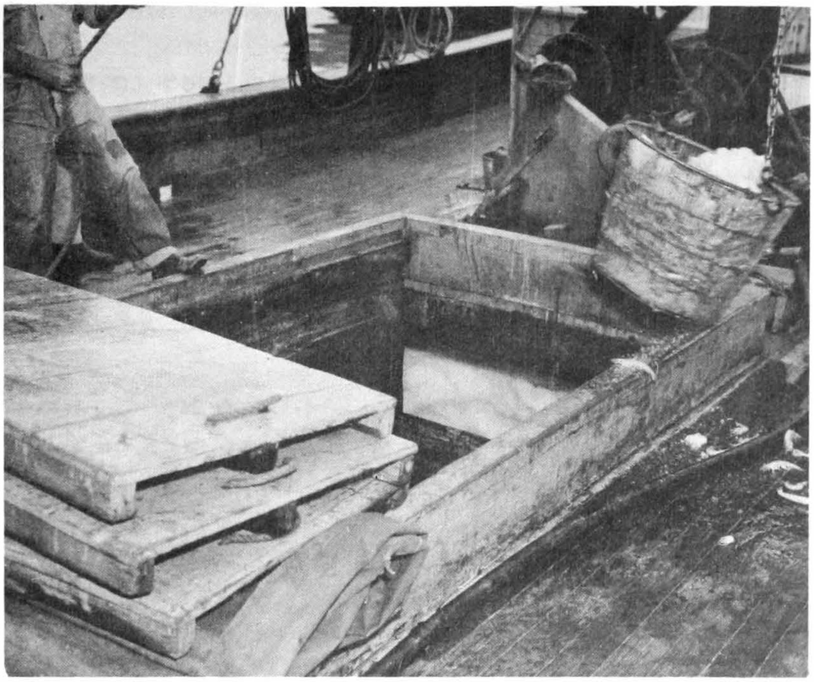


Figure 38.--Hoisting baskets from the hold of a shrimp trawler.

The basket method is used to unload shrimp from boats into trucks for subsequent transportation to the shore plant. A wire basket that will hold about 100 pounds of whole shrimp is lowered into the hold of the boat by hand. The shrimp and ice (some "day-boats" do not use ice) are shoveled into the basket, which is lifted to the deck of the boat by hand. The shrimp then are dumped into the truck. After the boat is unloaded, the truck delivers the shrimp to the plant for processing.

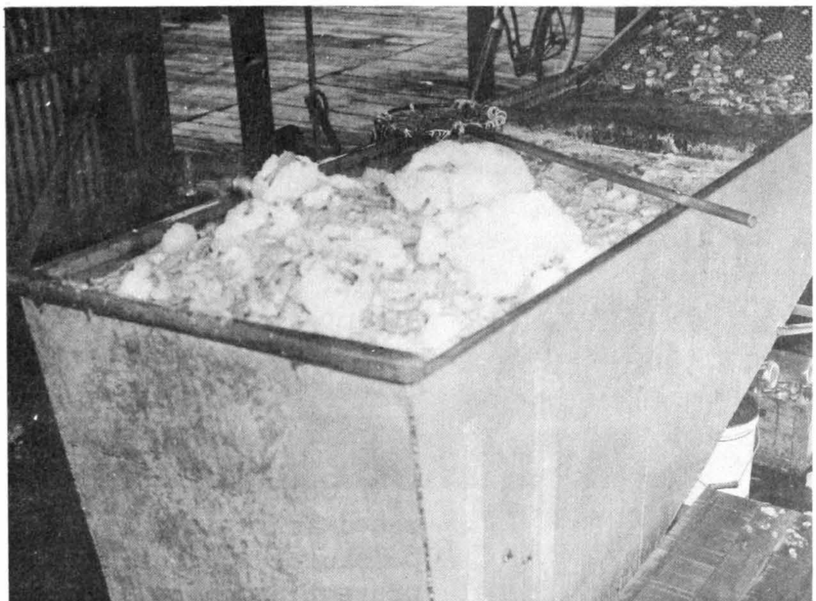


Figure 39.--Tank in which shrimp are de-iced and washed.

The modified conveyor method is used to unload shrimp at a dock adjacent to the processing plant. A wire basket is lowered by an electric winch into the hold of the fishing vessel. The shrimp and the accompanying ice are carefully shoveled into the basket, which then is hoisted to the wharf, where the contents of the basket are dumped into a de-icing and washing tank. This tank is a large rectangularly shaped metal container filled with a continuously changing supply of clean cold water. An inclined conveyor extends into the tank and carries the de-iced and washed shrimp into the plant for processing (Strasburger 1954).

The all-conveyor method also is used to unload shrimp at docks adjacent to the shore plant. This method differs from the modified conveyor method in that a conveyor is used in place of a basket to lift the shrimp and ice from the hold of the vessel. The conveyor is lowered to the level of the hold, and the shrimp and ice are shoveled, by hand, onto the conveyor. The shrimp then are elevated to the de-icing and washing tank, and the procedure that was described previously is continued.

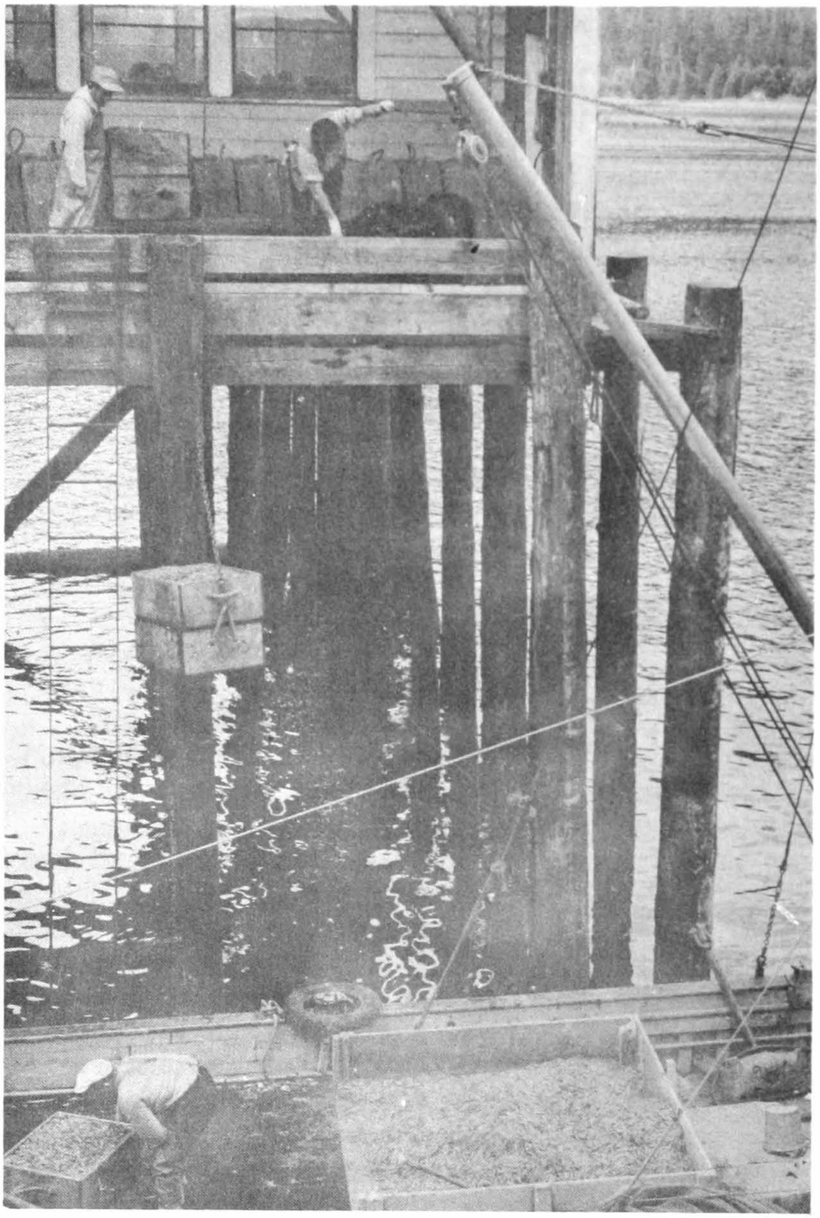


Figure 40.--Unloading boxes of whole shrimp.

In Alaska, the method of unloading shrimp is very simple. The shrimp, after being caught, may be placed in boxes, which hold 150 to 200 pounds, and are stored on the deck of the vessel. No ice is used because the air temperatures are low, and deliveries are made daily. At the shore plant, two or three boxes of shrimp are stacked, and two slings with hooks at the ends are threaded through rope handles on each box. The hooks are caught on the handles of the box at the bottom of the stack, and the boxes then are elevated to the dock with a boom-hoist. The boxes of shrimp are placed on a wheeled truck and are moved to the plant for processing.

Shrimp are processed as rapidly as is possible, in order to prevent spoilage. At times, however, it is necessary to store the shrimp for short periods.

As the shrimp are unloaded from the boats, they are de-iced and washed in tanks, inspected for spoilage, graded, and weighed. They then are re-iced and placed in cool rooms to await processing (Duggan 1954).

Lobsters and Crabs

Lobsters and crabs are delivered alive to the shore plant; dead lobsters and crabs are discarded. On the Atlantic coast, lobsters are covered with seaweed and are transported in wooden boxes aboard the vessel. After being landed at the processing plant, the lobsters are kept alive in sea water in specially constructed tanks until marketed. Crabs are marketed as delivered or are processed within a short time after being captured. On the Pacific coast, crabs are transported in sea water in live wells, aboard the larger vessels, or simply in boxes, aboard the smaller ones. After being landed, the crabs are held in boxes if they are to be processed within a few hours or, if they are to be held for a longer time, they are kept alive in holding pens through which sea water can circulate freely.

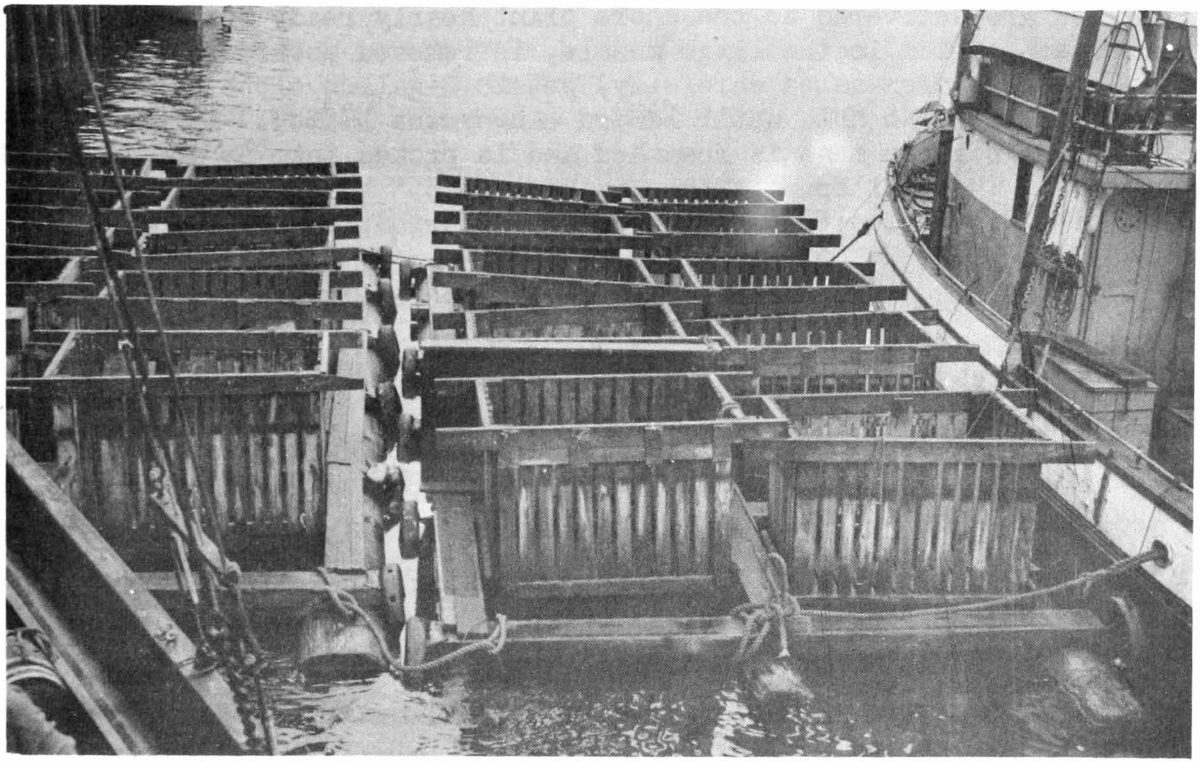


Figure 41.—Submersible live-boxes for holding Dungeness crabs.

Clams

All species of clams are delivered to the shore plant alive. They usually are delivered in sacks or in boxes, by boat or by truck depending on where the clams were dug. No refrigeration, such as holding in ice, is used during transportation; however, the clams are kept cool and moist. On arrival at the cannery, they are inspected, and dead or broken clams are discarded. Prior to being processed, the clams are stored in areas where it is cool or are held in chill rooms.

Oysters

Oysters are delivered alive in the shell to the shore plant. They are unloaded from the boats by means of a bucket and hoist and, in the larger plants, by means of conveyors. In some plants, the oysters are conveyed directly to the tables for shucking; dead oysters are discarded. In others, the mud is washed from the oysters, and they are held for 24 hours in running sea water to which free chlorine gas is added in a concentration sufficient to sterilize the shells (Tressler and Lemon 1951). Oysters, while awaiting processing or marketing in the shell, are held in cool areas to preserve quality.

Scallops

Scallops are delivered to the shore plant nearly ready for marketing. The edible meat, which is the large muscle, is removed aboard the fishing vessel. The meats are washed carefully, put in 2-gallon cloth bags, and held in ice in the fish hold until landed (Anonymous 1952c). At the shore plant,the scallop meat is rewashed and is packed into 5- and 10-pound waxed cartons. The scallop meat then is kept at 35° to 40° F. until marketed, or it is frozen for storage or for distribution to inland markets.

RECOMMENDATIONS FOR THE CONTROL OF QUALITY AT THE SHORE PLANT

Fish—Before Processing

1. The pewing of fish should be discouraged. If pews must be used, only those with a single tine should be employed. Pewed fish should be pierced only in the head.

2. When fish are stored for future processing, the pile of fish should not exceed 2½ feet in depth, in order to prevent crushing of the fish on the bottom of the pile. The use of shallow boxes or of bins helps to prevent crushing.

Flaked or finely crushed ice should be layered with the fish, and sufficient ice should be used to hold the fish at temperatures not higher than 35° F. Lump ice should not be used because it tends to bruise the flesh.

Adequate drainage is necessary to prevent blood and slime, washed down by the melting ice, from accumulating around the fish at the bottom of the pile.

3.—All equipment that comes into contact with the fish should be thoroughly cleaned by the use of a stiff brush and of running chlorinated water. Steam, if available, should be employed. This cleaning should be done daily because scales and slime, when allowed to become dry, are very difficult to remove.

4. All equipment should be painted periodically in order to facilitate cleaning and maintenance and to help to eliminate bacterial contamination. For inside surfaces of weighing boxes, storage boxes, and hand carts, a bakelite varnish is recommended. Sheet-metal inserts for these containers are also recommended in order to eliminate the damage done to wooden surfaces by pews.

5. If boxes of fish are exposed to the sun, the fish should be well covered with ice, and the whole box should be covered with a tarpaulin.

Fish--During Processing

1. All equipment that comes into contact with the fish flesh should be thoroughly cleaned at the end of each day's operation in order to eliminate sources of bacterial and off-odor contamination.

2. Before the fish are cut, they should be thoroughly washed to remove blood and slime. Such washing will greatly reduce bacterial contamination of the fillets and processing equipment by removing the bacteria-laden slime.

3. Removing the nape, or the belly flap, from fillets will result in higher-quality fillets. It is in the nape that a fish will show the first signs of deterioration.

4. Fillets should be washed, preferably with chlorinated water, as is done in a brine dip. The washing will reduce the bacteria on the surface of the fillet and will extend the storage life of the flesh.

5. If possible, packaged fresh-fish products should be prechilled to a temperature at which the flesh will almost start to freeze (about 30° F.). This prechilling is very important for fish that is to be shipped long distances.

6. If the fish are to be held in storage before being shipped, the iced boxes of fish should be stored in a chill room at 31° to 32° F.

Shellfish

1. Federal, state, and territorial regulations should be followed regarding sanitation in the shellfish industry.

2. Shellfish should be kept cool and moist at all times (in ice, in cool rooms, or in live-boxes) while being held for processing or use in the fresh trade.

3. The handling of shellfish should be kept to a minimum, and care should be taken not to damage them by rough handling.

4. Dead shellfish such as crabs, lobsters, oysters, and clams should be discarded.

LITERATURE CITED

ANDERSON, A. W.; STOLTING, W. H.; and ASSOCIATES

1953. Survey of the domestic tuna industry. Special Scientific Report: Fisheries No. 104, United States Department of the Interior, Fish and Wildlife Service, Washington, D. C.

ANONYMOUS

1946. Manual of recommended practice for sanitary control of the shellfish industry. U. S. Public Health Service, Public Health Bulletin No. 295.

ANONYMOUS

1947a. Proper fish plant sanitation. Fishing Gazette, vol. 64, No. 13, December, p. 46.

ANONYMOUS

1947b. The use of chlorine disinfectants in fish plants. Fisheries Research Board of Canada, Progress Report of the Atlantic Coast Stations, No. 40, November, pp. 9-11.

ANONYMOUS

1951. Longer-life cutting table. Food Engineering, vol. 23, No. 8, August, p. 11.

ANONYMOUS

1952a. Extermination of rodents. Food Manufacture, vol. 27, No. 9, September, p. 374.

ANONYMOUS

1952b. Insecticide incorporated in paint retains effectiveness for life of paint. Food Processing, vol. 13, No. 2, February, p. 73.

ANONYMOUS

1952c. Modern scallop production. Fishing Gazette, vol. 69, No. 8, August, p. 31.

ANONYMOUS

1954. British develop novel method of determining freshness of fish. U. S. Department of Interior, Fish and Wildlife Service Fishery Products Report No. S-42, March.

BEARD, HARRY R.

1953. NEFCO from sea to world markets. New England Fish Company 25th Anniversary Edition, p. 96.

DUGGAN, J. ROY

1954. Handling shrimp in the breading plant. Southern Fisherman Yearbook, March, pp. 62-64.

HOLSTON, J., and POTTINGER, S. R.

1955. Brine dipping of haddock fillets. Commercial Fisheries Review, vol. 17, No. 10, October, pp. 21-30.

HURLEY, STANLEY P.

1949. Sanitation problems in the fishing industry. Food Technology, vol. III, No. 12, December, pp. 416-418.

JARVIS, NORMAN D.

1943. Principles and methods in the canning of fishery products. Research Report No. 7, United States Department of the Interior, Fish and Wildlife Service, Washington, D. C.

KAYLOR, JOHN D.

1950. Plant sanitation. Techno-Logic, vol. 2, No. 2, Technological Section, National Fisheries Institute, Washington, D. C., February, pp. 1-4.

MAGNUSSON, HARRIS W., and HARTSHORNE, J. C.

1952. Freezing fish at sea--New England. Part 5 - Freezing and thawing studies and suggestions for commercial equipment. Commercial Fisheries Review, vol. 14, No. 12a, December, pp. 8-23.

SALTON, M. R. J.

1948. The use of surface active cations in detergency and sterilization. Food Preservation Quarterly, vol. 8, No. 1, March, pp. 10-15.

SOMERS, IRA I.

1949. How to select detergents for food plant cleaning. Food Industries, vol. 21, No. 3, March, p. 72.

STRASBURGER, L. W.

1954. Handling shrimp in the packing and freezing plant. Southern Fisherman Yearbook, March, pp. 58-61.

TRESSLER, DONALD K., and LEMON, JAMES McW.

1951. Marine Products of Commerce. Reinhold Publishing Corp., New York 18, New York, second edition.

WAIDELICH, A. T.

1951. Designing sanitation into food plants. Food Technology, vol. 5, No. 6, June, pp. 244-246.

INT.-DUP. SEC., WASH., D.C. 8080