

especially with the high speed multi-cylinder compressors, to use liquid injection or other means for making sure the ammonia gas does not contain excessive superheat.

FRESH FISH

This section is confined to the discussion of fresh fishery products only, i.e., fresh fish, shellfish, and crustacea as opposed to frozen fish, shellfish, and crustacea.

The term fish as used here will refer to fish in the natural state, with added ice as the only means of preservation employed.

In former years, a large proportion of all fish landings was marketed as fresh fish. A smaller proportion was marketed as frozen, canned, or cured fish. A marketing transition from fresh, cured, and canned fishery products to frozen fishery products began shortly after World War I and has proceeded at an accelerated rate in recent years. At the present time the ratio of fresh, cured, and canned fishery products to frozen fishery products has been reversed so that now only about 20 percent of all fish landings are marketed in the fresh form. However, at some time during processing, all fishery products are fresh and must be handled accordingly if a quality product is expected.

This chapter will be concerned with the proper methods for the protection of these fresh fish and fishery products, and the sanitation methods essential for handling products.

TYPES AND SOURCES OF PRINCIPAL FRESH FISHERY PRODUCTS

The fisheries in North America differ in a number of important respects with geographical location. Catching, handling, icing, and processing techniques have, to a great extent, been determined by tradition, and modified to some degree by current marketing practices.

Much of the fish, crustacea, and shellfish harvested by the fishing industries of North America is preserved in a fresh, iced condition on the vessel, and then marketed as fresh fish. On the following pages the various refrigeration and handling techniques necessary to preserve fresh fish on the vessel, at the shore plant, and during marketing will be treated in regard to the major fisheries of the United States, Canada, and Mexico. These fisheries shall be treated in this chapter under the general classifications of groundfish, crustacea, shellfish, fresh-water fish, halibut and salmon fisheries.

CARE ABOARD VESSELS

After being brought aboard the vessel, fish must be promptly and properly cared for to insure maintenance of maximum quality. Trawl-caught fish on the New England and Canadian Maritime Provinces coasts such as haddock and cod, are usually eviscerated, washed, and then iced down in the pens of the vessel's hold. In the summer months, the gills are usually removed prior to icing to further retard spoilage. Other groundfish, such as ocean perch and whiting, because of their small size are not eviscerated and are not always washed. Instead, they are iced down directly in the hold of the vessel.

Crustacea such as lobsters, and many of the various species of crabs, are usually kept alive on the vessel without the use of refrigeration. Shrimp are harvested by a trawl and are beheaded, washed, and stored in ice in the hold of the vessel.

Fresh-water fish in the Great Lakes and Mississippi River areas are caught in trap nets, haul seines or gill nets and sorted according to species, into 50 or 100 lb boxes, which may be kept on the deck of the vessel. Generally ice is not used on board the vessel because, in most instances, the fish are landed the day they are caught.

Fresh-water fish in the fresh water lakes of Canada are iced down in the summer time and stored at collecting stations on the lakes. A collector boat with a refrigerated hold is then sent around to the various stations to pick up the fish. Winter caught Canadian fresh-water fish are usually weather frozen on the ice immediately after catching, and are marketed as frozen fish.

Fish of the Pacific Northwest, such as halibut and sable fish, are largely caught by bottom long line or trawl gear. They are then eviscerated, washed, and iced in the pens of the vessel. Pacific salmon caught by seines for use in canneries have recently been stored whole aboard the vessel in hold tanks containing sea water refrigerated to approximately 30 F. Reports from commercial operators employing this method of preservation indicate that the fish is preserved quite satisfactorily for canning purposes. Tuna caught offshore by the bait boats are usually frozen at sea. However, tuna caught inshore by the trolliers or purse seiners are often iced in the round on the vessel. Many of these smaller boats employ refrigerated holding coils to reduce ice losses during long trips.

Icing of Fish

The functions of ice are (1) to reduce the fish flesh temperature to about 32 F, (2) to thereafter keep the fish cool, (3) to provide melt-water to wash the slime and bacteria off the surface of the fish, and (4) to maintain aerobic conditions in the fish stored in the vessel's hold.

Ice, to be effective, must be clean when used aboard the vessel. Bacteriological tests on ice in the hold of a fishing vessel showed bacterial counts as high as five billion bacteria per gram of ice. These results indicate that chlorinated or potable water should be used in making the ice at the ice plant; ice should be stored under sanitary conditions; and unused ice should be discarded from the vessel at the end of each trip.

The fishing boats operating out of New England use crushed block ice almost exclusively. In recent years, Canadian boats operating out of the Maritime Provinces have been using flake ice almost to the exclusion of crushed block ice. Flake ice is of smaller, more uniform particle size, is usually loaded at a lower temperature and is lower in production cost than crushed block ice. Because of the increased surface area per pound of ice by virtue of the smaller particle size, the melting rate of flake ice is higher than block ice. Other factors being equal, the increased rate of melting has not been enough to appreciably shorten the trips of the boats. The increased rate of melting protects the quality of the fish by maintaining the catch at a lower temperature. When flake ice was first introduced on Canadian vessels there was considerable resistance and prejudice against its use. Now, the fishing vessel operators prefer flake ice over crushed block ice. Principal objections to flake ice were that the ice melted too fast and the particles fused together in the boat hold.

These problems have been minimized by the development of flake ice machines which chip off a sub-cooled ice flake from the ice machine drums, and store the ice in storage bins refrigerated to 0 F. Flake ice so prepared and stored, flows easily in a stream of small, uniform, dry ice flakes, and packs well around the exterior and in the abdominal cavity.

The melting rate of ice must not be retarded because melt water must constantly wash the surface of the fish to reduce bacterial count. Some operators have attempted to extend the length of trips by the addition of mechanical refrigeration to supplement ice. The attempts have resulted in spoilage of the entire catch of fish due to lack of sufficient melt water for fish surface washing. The ice melting rate must be sufficiently high to afford adequate flow of melt water over the fish. This rate is accomplished by use of proper size of ice particles and

Meat and Fresh Fish

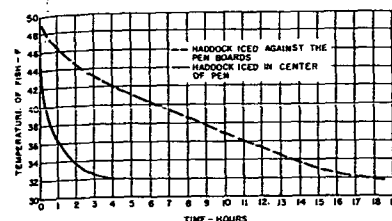


Fig. 11 Cooling Rate of Haddock Properly and Improperly Iced

by elimination of supplemental mechanical refrigeration within the fish holds.

Salt Water Icing

The importance of iced fish storage temperatures close to the freezing point of fish has been stressed by several workers. One method of obtaining lower ice temperatures is to depress the freezing point by adding salt to the water from which the ice is made. Adequate amounts of ice made from a three percent solution of sodium chloride brine will maintain a storage environment of about 30 F for the fish. Tests conducted on the storage of haddock in salt-water ice aboard a fishing vessel showed that under parallel conditions, fish iced with salt-water ice were cooled faster and to a lower temperature than were fish iced in plain ice. But, the salt-water ice melted faster than the plain ice by virtue of the lower latent heat and greater temperature differential of the salt-water ice. Therefore, once the salt-water ice melted, the fish stored in this ice rose to a higher temperature than those stored in the plain ice. Since it is not always practicable to renew ice on the fish at sea, sufficient quantities of salt-water ice must be employed initially to make up for the faster melting rate if the fish is to be initially cooled and subsequently held at temperatures low enough to result in maintenance of maximum product quality.

In making ice from water containing a preservative, rapid freezing or the use of a stabilizing dispersant, or both, is essential to prevent migration of the additive to the center of the ice block. This problem is not encountered in flake ice, because flake ice machines are designed to freeze water rapidly into thin layers of ice, thus fixing additives within the ice flakes. Additional information on ice manufacturing equipment is given in Chapter 55, 1961 GUIDE AND DATA BOOK.

Application of Ice

Correct icing of fish in the holds of the vessel is necessary to maintain the product at the highest possible level of quality. Ice is not a cure-all; it merely lowers the temperature of the fish and thereby retards the growth of bacteria. Therefore, even fish properly iced may spoil after about 12 to 16 days of storage, depending on the species. Some species may be stored in ice for only two days; others may be stored for as long as 28 days. Improper use of ice will result in an accelerated growth of bacteria to such a degree that the fish may already be spoiled prior to being unloaded from the vessel. Experiments conducted by several investigators clearly show that improper and insufficient use of ice is one of the major causes for the loss of quality at sea.

To correctly ice the fish, a sufficient quantity of ice must

be used. The quantity of ice necessary varies with the species of fish being harvested, the ambient environment and the length of time the fish is to be stored aboard the vessel. A ratio of one lb of ice to two lb of fish is usually satisfactory. In addition, the ice must be layered against the walls of the pens in the hold and mixed in well with the fish, so that each fish is surrounded by an adequate layer of ice at all times. The cooling rates of fish properly and improperly iced (Fig. 11) clearly show the importance of applying ice properly.

The exact method of icing varies with the construction of the hold and the pen layout for the particular vessel. On most vessels employing bulk storage, the following method of icing, if adhered to, will result in maximum maintenance of quality:

The floor of each pen should be covered with a layer of ice 8 to 12 in. deep. A similar quantity should be placed along the sides of the pen. A layer of fish not over four to six inches deep should then be placed on the bed of ice, and covered by an eight inch layer of ice. The ice and fish should then be mixed together with a shovel. Each layer of ice and fish should be built up in the same manner, until the layers reach a height of four feet. At this point, arrangements should be made for the installation of a shelf consisting of wooden pen boards. The use of a shelf will prevent undue crushing of the bottom layers of fish. The layers of ice and fish should then be built up on the shelf as previously described.

Storage of Fish in Refrigerated Sea Water

The storage of fish aboard the vessel in tanks containing chilled sea water kept at 30 F by means of mechanical refrigeration offers promise in extending storage life of certain species of fish. Ease of handling, reduction of weight losses and elimination of crushing and bruising of the fish are some of the additional advantages of this particular method of storage over and above the minimization of bacterial spoilage.

Investigations have been conducted on the storage of shrimp and salmon in refrigerated sea water aboard a fishing vessel. Studies on shrimp showed that the flavor and appearance of samples stored in 29 F to 32 F sea water were superior to those held in crushed ice. However, in commercial practice, inadequate maintenance of temperature, use of improper materials in the construction of tanks, difficulty in keeping tanks clean, and holding fish for too long period of time resulted in the abandonment of this method of keeping fresh shrimp. Chilled sea water seems to offer more promise in the preservation of salmon and, more recently, halibut. In some experiments on salmon, fish stored for eight to nineteen days aboard the vessel were preferred over iced fish. Other studies show loss of less protein and no loss in weight due to storage in chilled sea water. Commercial use of refrigerated sea water is gaining impetus in the Pacific Northwest for transport of salmon and halibut aboard the vessel to port. Reports from vessel owners and operators indicate this method of preservation has proven satisfactory on cannery scows, and on trolliers and seiners. However, further industry experience would be desirable before making a final evaluation of this technique for maintenance of fish quality.

SHORE PLANT PROCEDURE AND MARKETING

The proper use of ice, and adherence to good sanitary practices, again are necessary to insure maintenance of iced fish freshness during unloading from the vessel, at the shore plant, during processing, and throughout the distribution chain. Fish landed in good quality will spoil rapidly if these practices are not carried out.

Fish unloaded from the vessel are usually graded by the buyer, then a price is established based in part on the quality of the particular grade involved. These fish may also be subject to inspection by local and federal regulatory agencies who have the right to seize the entire lot if the fish is judged