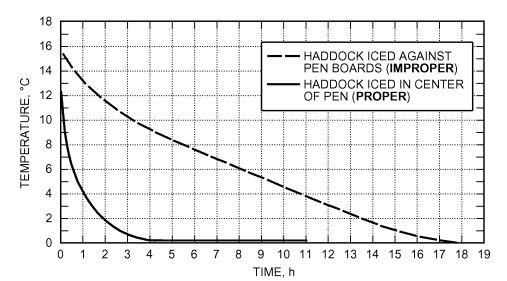
Icing

Fish lose quality because of bacterial or enzymatic activity or both. Reducing storage temperature retards these activities significantly, thus delaying spoilage and autolytic deterioration. Low temperatures are particularly effective in delaying growth of psychrophilic bacteria, which are primarily responsible for spoilage of nonfatty fish. The shelf life of species such as haddock and cod is doubled for each 4 to 5.5 K decrease in storage temperature within the range of 16 to –1°C. To be effective, ice must be clean when used. Bacteriological tests on ice in the hold of a fishing vessel showed bacterial counts as high as 5 billion per gram of ice. These results indicate that (1) chlorinated or potable water should be used to make the ice at the plant, (2) ice should be stored under sanitary conditions, and (3) unused ice should be discarded at the end of each trip. Both flake and crushed block ice are used aboard fishing vessels, although flake ice is more common because it is cheaper to produce and easier to handle mechanically. The amount of ice used aboard vessels varies with the particular fishery and vessel; however, it is essential to provide enough ice around the fish to obtain a proper cooling rate (Figure 1). A common ratio of ice to fish used in bulk icing on New England trawlers is one part ice to three parts fish. Experiments on British trawlers in boxing fish at sea with one part ice to two parts fish demonstrated improved quality in the landed fish, and, as ice has become more plentiful and less costly relative to the value of fish, the ratio of ice to fish continues to increase. Some vessels use mechanical refrigeration to retard ice melting en route to the fishing grounds; however, the hold temperature must be controlled after fish are taken to allow the ice to melt for effective cooling of the fish.



**Saltwater Icing**

Iced fish storage temperatures must be maintained close to the freezing point of fish. To obtain lower ice temperatures, the freezing point may be depressed by adding salt to the water from which ice is made. Adequate amounts of ice made from a 3% solution of sodium chloride brine maintain a storage environment of about –1°C. Tests conducted on haddock storage in saltwater ice aboard a fishing vessel showed that, under parallel conditions, fish iced with saltwater ice cooled more quickly and to a lower temperature than fish iced with plain ice. However, the saltwater ice melted more quickly because of its lower latent heat and greater temperature differential. Therefore, once the saltwater ice melted, fish stored in this ice rose to a higher temperature than those in plain ice. Because it is not always possible to replenish ice on fish at sea, sufficient quantities of saltwater ice must be used initially to make up for its faster melting rate. In making ice from water containing a preservative, rapid freezing and/or using a stabilizing dispersant 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 freeze water rapidly into thin layers of ice, thus fixing additives within the flakes. Chapter 43 describes the manufacture of flake ice in more detail.

**Use of Preservatives**

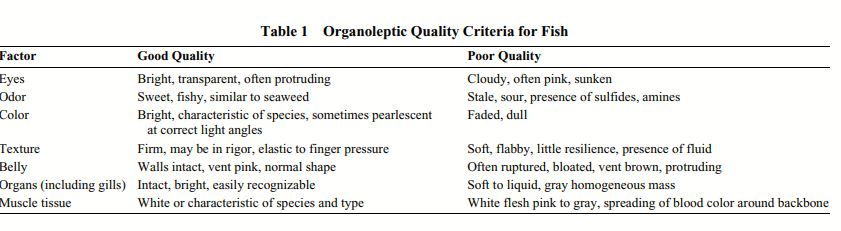
In the United States and Canada, the use of antibiotics in ice or in dips for treatment of whole or gutted fish, shucked scallops, and unpeeled shrimp is prohibited by regulation.

**Storage of Fish in Refrigerated Seawater**

Refrigerated seawater (RSW) is used commercially for preserving fish. On the Pacific Coast, substantial quantities of net-caught salmon are stored in RSW aboard barges and cannery tenders for delivery to the canneries. Most salmon seiners now use RSW systems. It is often a condition of sale. On the East and Gulf coasts, RSW installations on fishing vessels are used for chilling and holding menhaden and industrial species needed for production of meal, oil, and pet food. On the east and west coasts of Canada, RSW installations are used for chilling and holding herring and capelin, which are processed on shore for their roe. Other, more limited applications of RSW include holding Pacific halibut and Gulf shrimp aboard a vessel; chilling and holding Maine sardines in shore tanks for canning; and short-term holding of Pacific groundfish in shore tanks for later filleting. With groundfish and shrimp, RSW works well for short-term storage (2 to 4 days), but is not suitable for longer periods because excessive salt uptake, accelerated rancidity, poorer texture, and increased bacterial spoilage may result. These problems can be partially overcome by introducing carbon dioxide (CO2) gas into the RSW; holding in RSW saturated with CO2 can increase the storage life of some species of fish by about 1 week. Additionally, RSW reduces (1) handling that results from bulk storage of the fish and (2) pressure on the fish as a result of buoyancy, faster cooling, and lower storage temperature. In many RSW systems, refrigeration is provided by ammonia flowing through external chillers (which gives the best results) or pipe coils in the tanks

**Boxing at Sea**

There are many advantages to using containers or boxes instead of bulk storage aboard fishing vessels. Using containers reduces pressure on fish stowed in a vessel’s hold. Because significant reductions in handling during and after unloading are possible, mechanical damage and product temperature rise may be virtually eliminated, and handling costs may be reduced. Fish can be sorted into boxes by size and species as soon as they are caught. Boxed fish lend themselves more readily to mechanized handling, such as machine filleting, because they are generally firmer and of more uniform shape; fillet yields are generally better than with bulkstored fish. Boxing at sea is not generally practiced in the United States, except by some inshore vessels. The principal problems with converting a fishing vessel from bulk to boxed storage are increased labor required by the crew for handling the boxes, reduced hold capacity, and relatively large investment for boxes. Many fisheries have difficulties working out the logistics for ensuring prompt return of properly cleaned boxes to the vessel. Most of these problems have been solved in European, Canadian (offshore), and South American (hake) fleets. Using nonreturnable containers for boxing at sea simplifies logistics and reduces initial capital outlay; it has proved justifiable in some U.S. fisheries. Reusable containers for boxing at sea are usually made of plastic. Careful icing is necessary to minimize the surface area of fish in contact with the box. Plastic provides more heat transfer resistance than aluminum in vessels with uninsulated fish holds and for inplant storage prior to processing. All fish boxes must be equipped with drains, preferably directed outside the boxes on the bottom of a stack.



**FRESH FISH STORAGE**

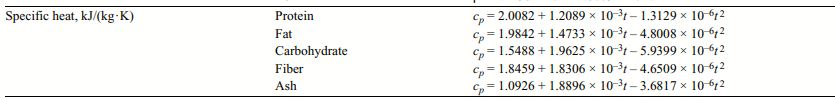
The maximum storage life of fish varies with the species. In general, the storage life of East and West Coast fish, properly iced and stored in refrigerated rooms at 2°C, is 10 to 15 days, depending on its condition when unloaded from the boat. Generally, freshwater fish properly iced in boxes and stored in refrigerated rooms may be held for only 7 days. Both of these time limitations refer to the period between landing/processing and consumption. Cold storage facilities for fresh fish should be maintained at about 2°C with over 90% rh. Air velocity should be limited to control ice loss. Temperatures less than 0°C retard ice melting and can result in excessive fish temperatures. This is particularly important when storing round fish such as herring, which generate heat from autolytic processes. Floors should have adequate drainage with ample slopes toward drains. All inside surfaces of a cold storage room should be easy to clean and able to withstand corrosive effects of frequent washings with antimicrobial compounds.

**The thermal properties of foods**

The thermal properties of foods and beverages strongly depend on chemical composition and temperature, and because many types of food are available, it is nearly impossible to experimentally determine and tabulate the thermal properties of foods and beverages for all possible conditions and compositions. How ever, composition data for foods and beverages are readily available from sources such as Holland et al. (1991) and USDA (1975). These data consist of the mass fractions of the major components found in foods. Thermal properties of foods can be predicted by using these composition data in conjunction with temperature-dependent mathematical models of thermal properties of the individual food constituents. Thermophysical properties often required for heat transfer calculations include density, specific heat, enthalpy, thermal conductivity, and thermal diffusivity. In addition, if the food is a living organism, such as a fresh fruit or vegetable, it generates heat through respiration and loses moisture through transpiration. Both of these processes should be included in heat transfer calculations. This chapter summarizes prediction methods for estimating these thermophysical properties and includes examples on the use of these prediction methods. Tables of measured thermophysical property data for various foods and beverages are also provided.

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|  |  |  |
| --- | --- | --- |
|  | Initial | Final |
| T/c | 25 | 0 |

t = (25-0) / 2 = 12.5

**Cp values calculations**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Whole Fish | T | Moisture Content, % xwo | Protein, % xp | Fat, % xf | Ash, % xa | MoistureCwp | Protein(Cpp) | Fat(Cfp) | Ash(Cap) | Cp |
| Cod | 12.5 | 81.22 | 17.81 | 0.67 | 1.16 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.778351 |
| Haddock | 12.5 | 79.92 | 18.91 | 0.72 | 1.21 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.747877 |
| Halibut | 12.5 | 77.92 | 20.81 | 2.29 | 1.36 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.7359 |
| Herring, kippered | 12.5 | 59.7 | 24.58 | 12.37 | 1.94 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.259578 |
| Mackerel, Atlantic | 12.5 | 63.55 | 18.6 | 13.89 | 1.35 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.323215 |
| Perch | 12.5 | 78.7 | 18.62 | 1.63 | 1.2 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.709169 |
| Pollock, Atlantic | 12.5 | 78.18 | 19.44 | 0.98 | 1.41 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.693374 |
| Salmon, pink | 12.5 | 76.35 | 19.94 | 3.45 | 1.22 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.674397 |
| Tuna, bluefin | 12.5 | 68.09 | 23.33 | 4.9 | 1.18 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.42663 |
| Whiting | 12.5 | 80.27 | 18.31 | 1.31 | 1.3 | 4.175919372 | 2.023106109 | 2.001866 | 1.115645 | 3.763169 |

**FISH BOX CALCULATION**

Product Heat Load

Fish Mass = 30 kg

Cp of Fish = 3.7 kJ/kg.K

Take Cooling time = 3 hr

Q = mcθ

Q = (30 kg) x (3.7 kJ/kg.K) x (25-0)K

Q = 2775 kJ

Cooling load =

= 0.2569444 kW

= 257 W

Cooling load through wall

Polycarbonate

K = 0.2 W/(m.K)

Polyisocyanurate cellular (R-141b expand)

K = 0.027 W/(m.K)

Air at 25 0C h = 37.91 W.m2.K

Ice at 0 0C k = 2.22 W/(m.K)

U =

U = 0.83577 W/(m2.K)

Area of the Cooling box = ( (0.7x0.4) x 4 ) + ( (0.4x0.4) x 2 )

A = 1.44 m2

Q = U.A.(T1 – T2)

= 0.83577 x 1.44 x 25

= 30.08772 W

**The temperature difference Δt can be adjusted to compensate for solar effect on heat load.**

Q = U.A.(T1 – T2)

= 0.83577 x 1.44 x 5

= 6.0175 W

**INFILTRATION LOAD**

Heat gain from infiltration air can amount to 20 % of total refrigeration load.

Infiltration load =

= 58.62 W

Total Load =

= 351.73 W

The calculated load is typically increased by a safety factor 20 %

Total Load =

**Total Load = 422.076 W**

PCM

Ice, gel

Gel is type of salt(Sodium Polyacrylate)

Need Ice Gel =

= 13677.85 g

= 13.68 kg

Ice Gel Volume =

= 0.01336 m3

Desing box volume = (0.7 x 0.4 x 0.4) m3 = 0.112 m3

Inner box volume = (0.66 x 0.345 x 0.38 ) m3 = 0.086526 m3

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