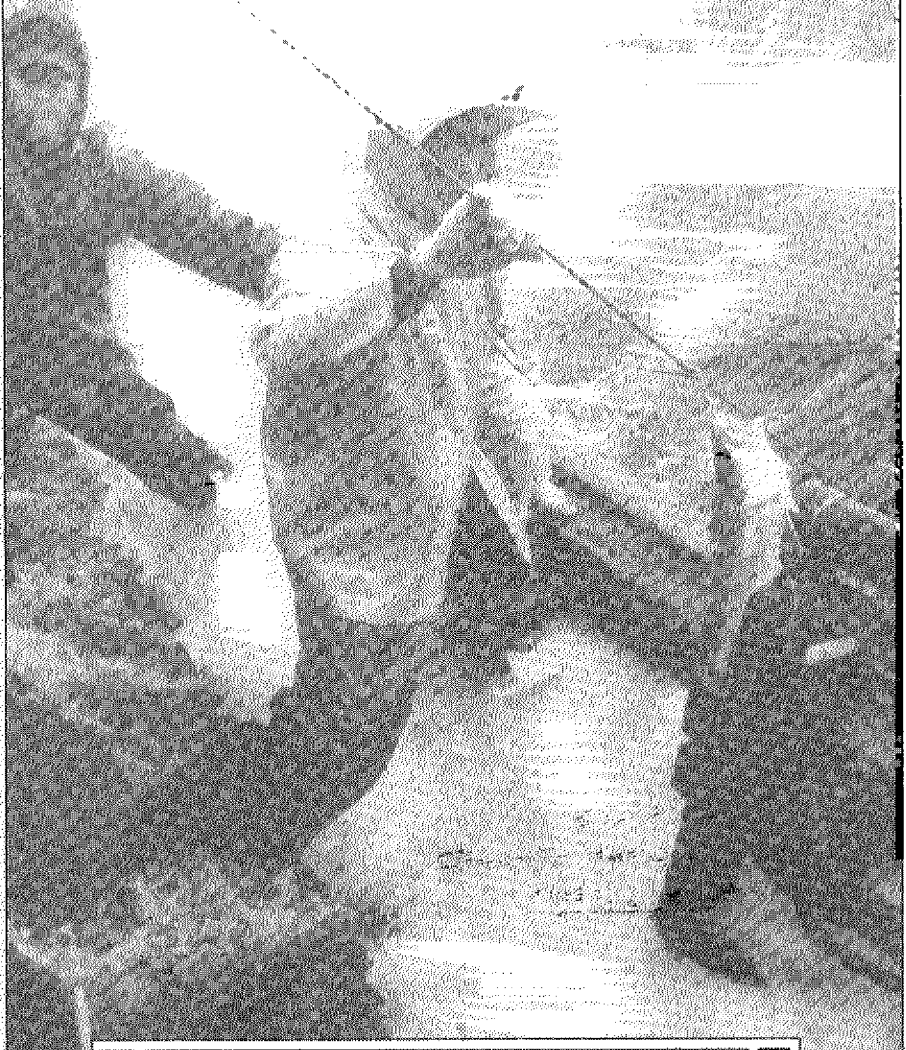
HANDBOOK ON WHITE FISH HANDLING ABOARD FISHING VESSELS

By John P. Doyle and Charles Jensen



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FOREWORD

This handbook is one of a series on handling and processing of ocean white fish. It is a companion to Marine Advisory Program bulletins No. 8, Teaching Manual for Extension Course in White Fish Processing Technology by Per O. Heggelund; No. 18, Care of Halibut Aboard the Fishing Vessel, by Donald Kramer and Brian Paust; No. 20, Quality Handling of Hook-Caught Rockfish by Brian Paust and John Svensson and No. 28, White Fish Processing Manual by Chuck Jensen. Used together they provide the basis for a complete practical course in white fish handling and processing. They can be used individually as aids in teaching short courses or as information bulletins to the seafood industry. The material is designed for fisheries in cold to temperate regions and may be of less use in tropical areas. It deals specifically with those species found in the North Pacific Ocean and the Bering Sea. The principles of good handling and production of quality seafood cannot be ignored if the best results are to be achieved regardless of the geographic location.

This handbook was written for people who have considerable experience in fish handling. We expect its primary use will be by extension educators, fishing fleet and seafood production managers, and fishermen who have a strong interest in providing only the best. It is based on the best scientific evidence and practical experience available. We have not cited the references in the usual scientific manner in order to increase the readability of the manual for the nonscientist. All references used in the development of this handbook are listed in the last section. As is true of the entire field of food production, changes are rapid and new techniques are constantly being developed. As this handbook is being published we are undertaking investigations on the care and handling of several soft textured flatfish. The last word on fish handling is far in the future.

John Doyle
Marine Advisory Program
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I.
INTRODUCTION

Alaskan white fish products face severe competition from imports from Canada, Europe, Asia and more recently South America. In 1986 more than 425,000 tons of white fish products were imported into the U.S. If Alaskan products are to have a significant impact in the U.S. market, they must displace imports. This is no easy task in view of the fact that most of the imported fish is produced under strict governmental quality and handling regulations. The developing ocean white fish industry has the potential of becoming a major part of Alaska's fishery. Fishermen and processors are making a very large investment in vessels, gear, plants and equipment to produce white fish.

Two major factors influence the return on investment to the fisherman: QUALITY and SHELF LIFE. Quality is the desirability of fish in the marketplace. Shelf life is the length of time fish remains desirable to the consumer. Quality will influence shelf life and is directly influenced by the handling of that product on the fishing vessel, in the processing plant and in the retail outlet.

Initial high quality at landing is important to the processor who knows that his product commands the highest price possible in the marketplace for that species. Also the product will be marketable over a controlled period of time avoiding panic selling and the resulting low price, low to the point that the seller may and frequently does lose money.

The retailer will buy high quality products because he knows that his prices can be as high or possibly higher than his competition and he will be able to follow a controlled marketing

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method.This assures that he gets the highest possible return on his investment. Shelf life plays a very important part in the marketing scheme for both the processor and the retailer as they can plan on the length of time that any particular product can be held at the plant and the retail market and thereby "control the market." A few days or even one day of extra shelf life will allow all the participants to get top dollar and will ensure that repeat sales are the rule rather than the exception.

It is a fact that in the long-term, the price the fisherman will receive for his product will directly depend on the reputation that Alaskan white fish products eventually command in the retail marketplace. In order to maximize the return on investments, the quality of the product delivered must be well above the average being received today by the buyer/processor. This cannot be achieved by using traditional methods. Significant changes must be made in vessel operation and handling methods during catch and storage. The methods described will produce a high percentage of good quality product. However, part of the catch is usually of poorer quality and will not command as high a price. Better technology and good practices have resulted in the worldwide market expectations of quality fish. Only with proper handling can fishermen expect to receive maximum return on their investment of time and money. With current technology it is possible

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to harvest fish in the North Pacific and deliver an excellent quality seafood product anyplace in the world. The delivery of high quality seafood therefore becomes a matter of attitude on the part of the vessel owner, captain and crew. The desire to produce only the best will result in steps being taken which produce the best product.

Professional fishermen take pride in delivering high quality fish. This manual provides fish handling guidelines based on both scientific evidence and practical experience. It applies to fresh fish intended for human consumption. Following these guidelines will enable you, the primary producer, to produce the highest quality product which will in the long run produce the highest profit. Subjects discussed include deck and hold design, product handling, refrigeration and quality loss.

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II.
WHAT IS QUALITY? WHAT IS SPOILAGE?

What is quality? Quality is what the buyer or consumer considers desirable in a food product. In seafood it is a set of attributes or characteristics that make eating it an enjoyable experience. For seafood there are a number of characteristics which are related to quality. Quality involves the species or variety of fish, the size and condition at catching of individual fish and the characteristics of odor, flavor, texture and appearance which deteriorate during the holding of fish after catching. For the purposes of this manual, high quality is defined as providing the consumer a product which is attractive and wholesome with good odor, flavor, texture and appearance. It is free from defects, firm and moist. It is a product that will encourage the consumer to make repeated purchases. Once the fisherman has control of the fish on board, his efforts must be directed at maintaining the quality of his product.

Intrinsic vs. Extrinsic Quality

Intrinsic quality is the set of characteristics peculiar to a species of fish while it is still alive. These cannot be controlled by man. Intrinsic quality varies from species to species, with season and with locality. An example of an intrinsic quality characteristic is the amount of oil or fat. Cod is a lean fish compared with sablefish which is fatty. Some species like pollock or arrowtooth flounder are relatively soft textured while cod and halibut are firm. As a general rule soft fish deteriorate faster than firm fish. Within a species seasonal variations are important. Most species are soft and lower in oil content during and for several months after spawning. At that time meat recovery during processing will be lower and the product will deteriorate faster. For most species, all harvest should be discontinued during spawning and for one to three months thereafter. Smaller fish of a given species are generally softer and spoil faster than larger fish. This is especially true of pollock.

Extrinsic quality refers to changes in fish flesh that take place after death. It includes such preventable factors as bruising and contamination from oil, dirt and viscera, as well as those factors which cannot be stopped but can be slowed, such as bacterial and enzymatic activity. Control of extrinsic quality is where fishermen can have the greatest influence. Prevention of contamination and rough handling are easily controlled. Prevention of spoilage is more difficult.

Rigor Mortis

When fish are removed from the water alive or shortly after death, they are limber, the flesh and skin are elastic and bright. The immediate post-death condition is referred to as pre-rigor mortis or more commonly pre-rigor. After a period of time chemical changes take place within the flesh causing it to become stiff and rigid, a condition called rigor mortis or rigor. The time between death and rigor is pre-rigor. The time lapse between death and rigor varies with species, the physical environment, method of catch and handling. Rigor is brought on by the same chemical reactions which take place when an animal exercises. The stiffening of the body which takes place at the onset of rigor is due mainly to a contraction of the skeletal muscles. Rigor is similar to a muscle cramp. After a period of time, again depending on species and physical environment, the fish will become flaccid and limber. This is referred to as post-rigor (Figure 1). A post-rigor fish should retain its bright elastic condition.

Very few damaging changes take place in fish flesh prior to and during rigor. The longer the fish is in rigor, the longer the shelf life. This is due to specific chemical and physical changes which take place in the flesh shortly after death. Flesh of newly killed fish is neutral or slightly alkaline. After death, lactic acid is formed in the muscle from the breakdown of glycogen and it becomes more acidic. Fish species which become more acidic have a longer shelf life. In most species of fresh water and marine fish, the more acid the flesh becomes after death, the longer the fish will be in pre-rigor and rigor. Fish that struggle before death build up high levels of lactic acid in the muscle which rapidly dissipates when the fish dies. This greatly reduces the time the fish is in pre-rigor and rigor.

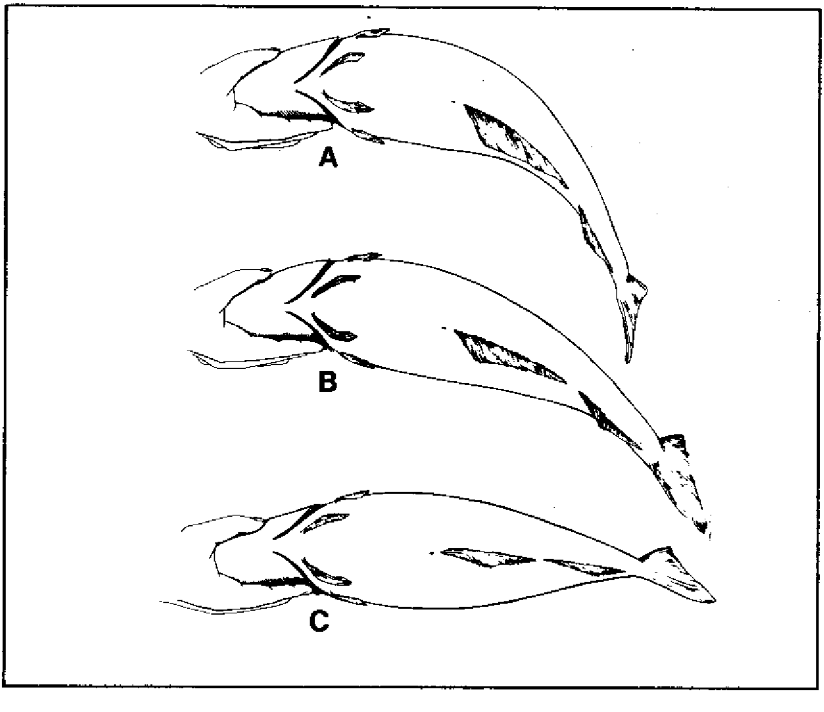

Figure 1. Diagram of fish flexibility in pre-rigor (A), rigor (B), and post-rigor (C).

Biological and Chemical Loss of Quality

There are two types of fish flesh degradation which need to be understood. They are bacteriological and enzymatic. Bacterial spoilage leads to putrification. Enzyme activity in dead fish is the main cause of chemical degradation of fresh fish flesh.

Bacteria are always present in sea water and on the fish. When the fish is alive it will have bacteria on its skin, gills and in the gut. The body's protective mechanisms keep the number of bacteria at a constant level. The flesh is essentially free of bacteria. As long as fish is pre-rigor or in rigor, these same forces prevent the number of bacteria from increasing. It is therefore desirable to maintain fish in rigor as long as possible. The colder the fish the longer it remains in rigor.

Once the fish comes out of rigor, the number of bacteria increases. The rate of increase depends on temperature. The higher the temperature, the faster the growth rate will be. The rate of bacterial multiplication will about double with every 10°C (18°F) increase in temperature (Figure 2). The rate of spoilage is directly proportional to the number of bacteria present. Therefore, temperature is a major factor in the rate of fish spoilage. The temperature of the product will directly control the rate of both bacterial and enzymatic deterioration. This can be expressed by the formula $R = 1 + 0.1T$ where R is the relative rate of spoilage and T is the temperature in degrees Celsius. This relationship holds true for temperatures between -1°C to 20°C (30.5°F to 60°F). Taking 0°C (32°F) as a rate of 1 then the relative rate of spoilage of seafood would be twice as fast at 4°C (39.2°F) and 4 times as fast at 10°C (50°F). If Pacific cod have a total shelf life of 12 days when held at 0°C (32°F) in ice then the same fish held at 10°C (50°F) for 24 hr would lose the equivalent of 4 days shelf life during this time or one-third of its total shelf life.

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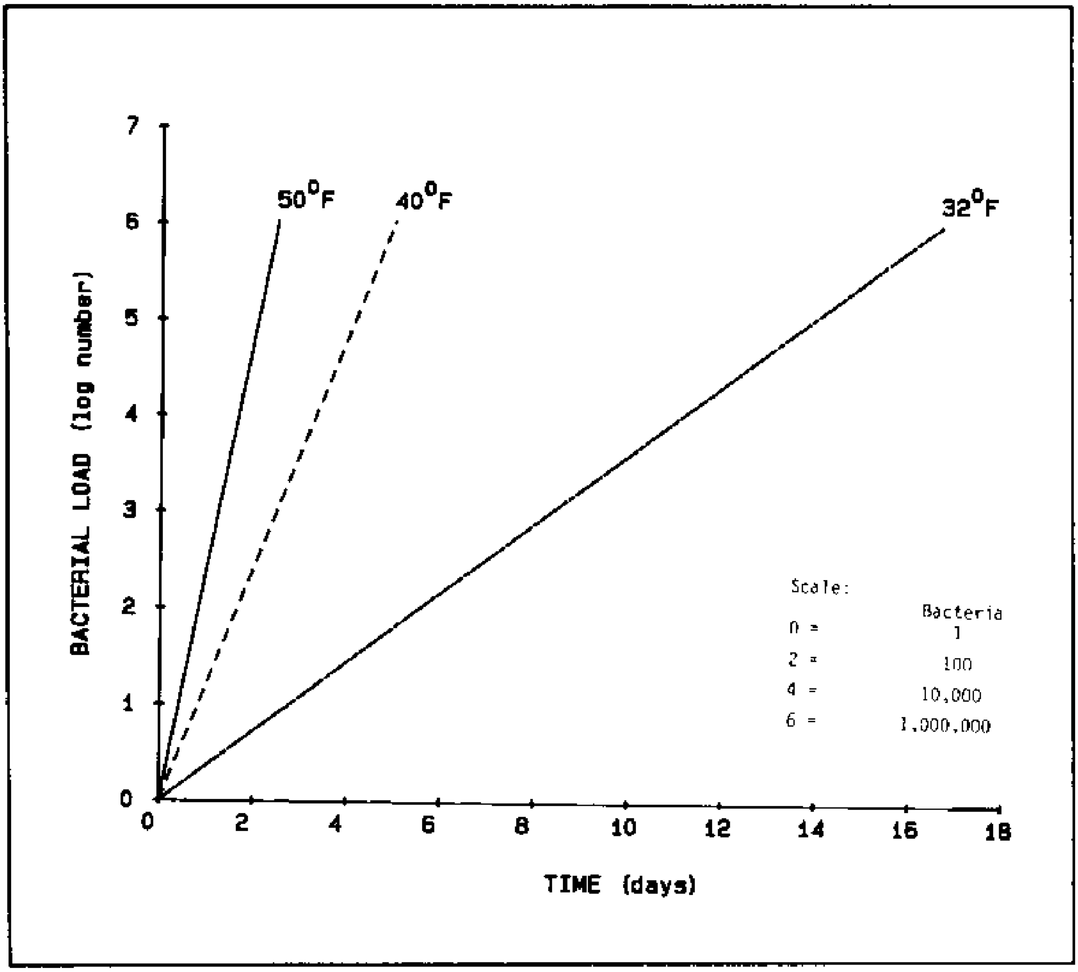


Figure 2. Comparative growth rates of some spoilage bacteria at different temperatures.

"Table 1 shows the relative rates of spoilage at different temperatures compared to the rate of spoilage at 0°C (32°F), or the equivalent days in ice. It is readily seen that temperature abuse at any stage of handling reduces shelf life and therefore costs the industry."

Table 1 shows the relative rates of spoilage at different temperatures compared to the rate of spoilage at 0°C (32°F), or the equivalent days in ice. It is readily seen that temperature abuse at any stage of handling reduces shelf life and therefore costs the industry. Rapid cooling and prevention of contamination from dirty surfaces are imperative in maintaining high quality.

Enzymes are organic catalysts which are present in all biological organisms. They are needed for the digestion of food and most biological functions. They are absolutely necessary for the breakdown of food in the digestive system and the breakdown of waste in the muscle tissue. Although enzymes are a necessary part of life, they continue to be active after an animal dies. Some of the most active protein digesting enzymes are in the viscera. After a fish dies, enzymes in the gut and in the flesh continue to cause the breakdown of protein including the stomach and intestine walls. When the digestive tract is pierced, these enzymes get into the tissue and work on the flesh causing "belly burn," the most common deteriorative effect of enzyme activity in fish. Enzymes are also present in muscle cells. Crushing of the cells releases the enzymes allowing them to attack adjacent protein structures.

Table 1. Loss of equivalent days of shelf life at temperatures above 0°C (32°F), also referred to as "equivalent days on ice."

Temperatures °C	°F	2 hr.	4 hr.	24 hr.	2 days	4 days	6 days
0.0	32.0	0.1	0.2	1.0	2.0	4.0	6.0
2.0	35.6	0.1	0.2	1.4	2.8	5.6	8.4
4.0	39.2	0.2	0.3	1.9	3.8	7.6	11.4
6.0	42.8	0.2	0.4	2.5	5.0	10.0	15.0
8.0	46.4	0.3	0.5	3.2	6.4	12.8	19.2
10.0	50.0	0.3	0.7	4.0	8.0	16.0	24.0
15.6	60.0	0.5	1.1	6.5	13.1	26.1	39.2

Adapted from Bremner 1984.
Bremner et al. 1987.

Bacteria attack fish by releasing digestive enzymes which penetrate the skin and enter the flesh. Therefore all spoilage can be considered to be enzymatic. Rapid softening of fish flesh is most often the result of active enzymes in the fish or from enzymes produced by parasites in the flesh of fish (such as those found in hake). At temperatures between 0°C (32°F) and 38°C (100°F), the rate of enzyme induced spoilage is directly proportional and can be predicted by the formula given above. The higher the temperature the more rapid the chemical changes. At about 60°C (140°F) most enzymes are deactivated. Some fish enzymes increase in activity below 0°C (32°F). It has been shown that some enzymatic reactions in the flesh of Pacific cod and some other species increase below 0°C (32°F) and are fastest at -3.9°C (25°F). This is caused by the partial freezing of the flesh and the concentration of enzymes which increases the amount of activity (Figure 3). To minimize enzymatic activity ideal storage temperature for fish is between 30° and 32°F. Any temperature higher or lower (at least until the fish is well frozen) will speed up enzymatic decomposition. Again rapid chilling is essential to the preservation of quality.

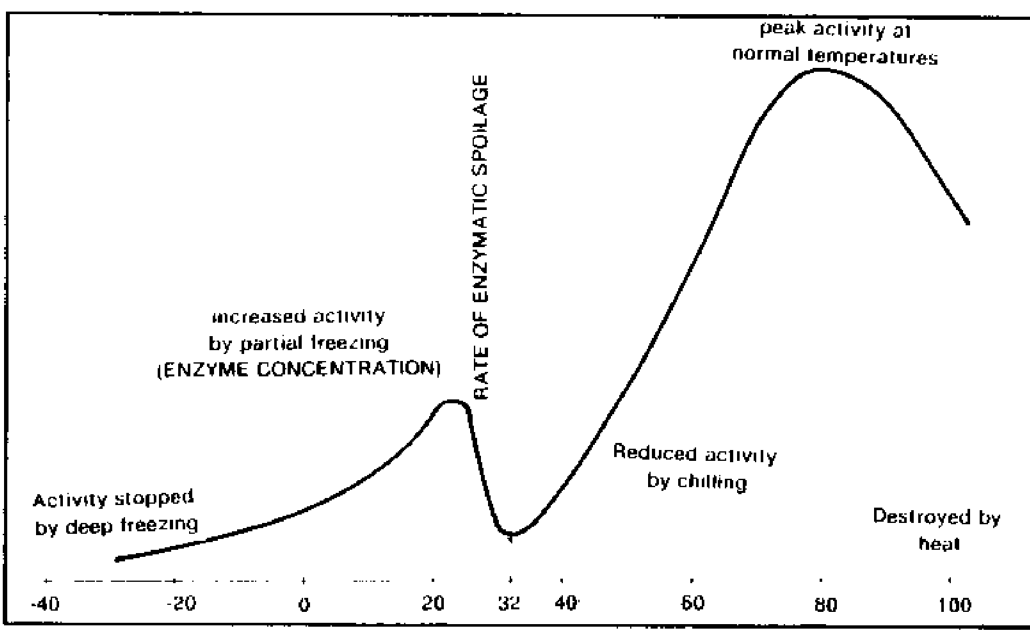


Figure 3. The effect of partial freezing on fish flesh for a hypothetical fish. Enzyme activity curves will be different for each species.

Physical Damage

At every step of catching, landing, storage and unloading care must be taken not to damage the fish. Most white fish are soft by nature and very susceptible to physical damage by crushing and bruising. Each handling of the product increases the physical damage.

External damage such as seal bites, lamprey scars, puncture wounds, etc. are obvious. Fish damaged this badly should be discarded as breaks in the skin will allow bacteria to enter the flesh promoting rapid spoilage.

Internal damage is more insidious than external damage in that it cannot be recognized until some later point in the processing stage; i.e., filleting, trimming, etc. For example, experiments have shown that 20 percent of chum salmon taken by gillnet can be bruised internally even though there is no external evidence of damage. Figure 4 shows a bruised cod fillet.

In addition to bruising, internal damage ruptures muscle cells releasing enzymes which accelerate the breakdown of protein. This causes rapid softening of the flesh resulting in ragged, poor quality fillets. Crushing or rough handling also damages the viscera, which if ruptured, releases very active enzymes into the body cavity. This can result in digestion of the surrounding flesh.

Bruises are caused by ruptured blood vessels and result in poorly appearing fillets or steaks. Bruises must be removed which increases trim loss.

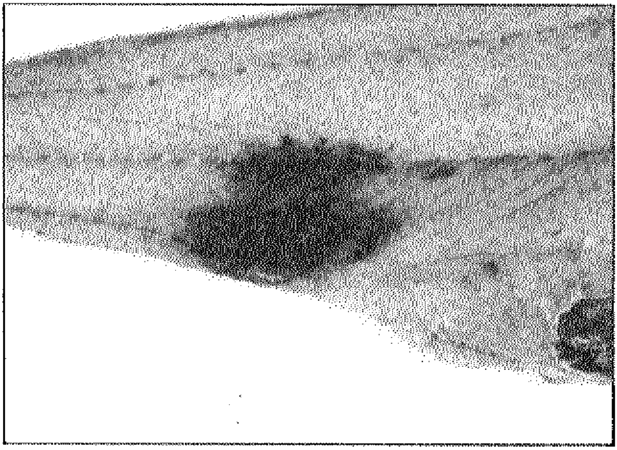


Figure 4. Severe bruising of a cod fillet caused by rough handling.

Rough handling, overfull cod ends, contact with sharp objects, use of pughs, or allowing fish to roll around in checkers or the hold, must be avoided. Dehydration and sunburn are also evidence of physical damage. Direct sunlight causes dehydration and sunburn as well as heating the flesh. Dry skin loses elasticity and its capacity to produce slime. This results in a loss of its effectiveness as a barrier against bacteria. Weight loss will increase and the rate of spoilage will increase.

Contamination on the vessel is generally a result of allowing fish to come in contact with fuel oil, grease and/or hydraulic oil. Fish acquire undesirable flavor and odor from such contaminants and become inedible. Fish can also be contaminated through contact with dirt, gurry and fresh viscera. While they may not be rendered inedible, they pick up a heavy load of bacteria which causes rapid spoilage.

Review of Quality Factors

Cause of Loss	Remedy
• *Bacterial growth*	• Cold temperatures • Clean vessel and tools
• *Enzyme activity*	• Cold temperatures • Rapid dressing • Careful handling
• *Physical damage:*	
Crushing & bruising	• Care in handling • Short trawl hauls • Care in stowing
Breaks in skin & belly wall	• Gaff in head • Do not use pughs • Care in dressing
Dehydration & sunburn	• Protect from sun and wind
• *Contamination*	• Clean vessel • Shield oil lines and grease fittings • Prevent contact with guts and gurry

III. CATCHING AND LANDING

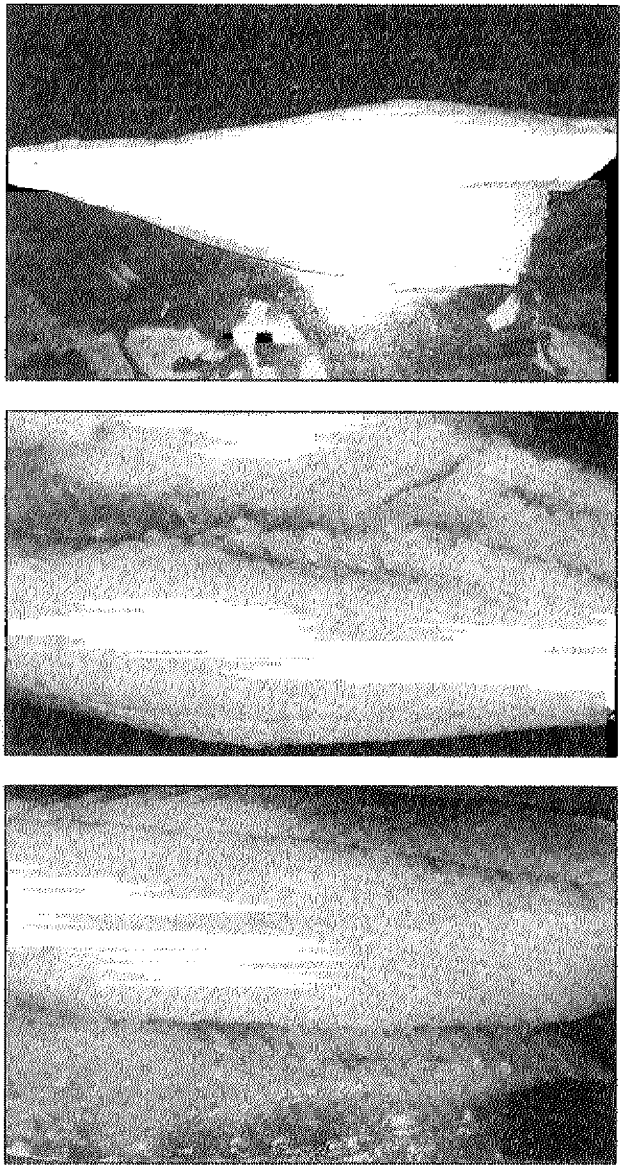
Methods of catching and landing influence product quality. The length of time the fish struggles and the amount of crushing that occurs as fish are caught and brought on board are important factors. The less a fish struggles, the longer the keeping time or shelf life. Fish caught and handled in a careful manner and immediately chilled will go into rigor later, stay in rigor longer and have a longer shelf life. Killing fish immediately will significantly delay the onset of rigor. When a fish goes into rigor very rapidly, gaping (i.e. separation of the muscle layers) takes place producing a soft, unattractive, low value product (Figure 5).

When a fish is crushed or squeezed, several damaging things happen. First, crushing damages the cell walls allowing enzymes to escape and attack the flesh. This causes rapid softening. Second, fecal material and digestive juices can be forced out and will contaminate the surface of the fish with bacteria and digestive enzymes. This hastens spoilage.

It is obvious that all struggling and crushing cannot be prevented when fish are harvested. The fisherman's job then is to minimize the damage.

Catching

As for the method of harvest, jigging produces the best quality fish. This method is useful and profitable for small boats fishing for high value species such as rockfish. When landing the fish, they should be stunned and gently sent to the checker. Snapping the fish off the hook so they slap on the deck must be avoided. Violently snapping the fish off by whipping the gangion will result in bruising, lower recovery, lower quality and shorter shelf life.



A.

B.

C.

Figure 5. Gaping in a cod fillet. Fillet (A) shows minor gaping; fillet (B) shows significant gaping, this fillet should be graded No. 2; and fillet (C) has no gaping.

Longlining can produce very high quality fish. Gear soaks should be short so the fish do not struggle to death. Dead fish will not bleed as efficiently as live fish. Also short soaks will lessen the chance of attack by sand fleas (amphipods) which can rapidly turn a fish into a number two. Again, care must be taken when landing the fish. If a gaff is needed care must be exercised not to puncture the skin of the body. Sink the gaff in the head.

Trawling, an often condemned and overly maligned method of fishing, is the only practical method for taking many low unit value, high volume fish species. This fishing method can catch fish which will produce an excellent product if a few basic rules are followed. The biggest quality problem facing the trawler is crushed and dead fish. The first can be prevented by making sure the cod end doesn't get overly full. A very full cod end will surely crush fish when it is brought on board. The weight in the cod end can be monitored by the use of tension meters on the trawl warp or by head rope sonar. With experience, the tension meters will show when the net is getting heavy. Long tows are also damaging. When the tows are long, a higher percent of the fish will be dead when brought on deck and these fish will be exposed to elevated temperatures for a longer period of time. It is natural that you, the fisherman, would like to see each tow produce a full cod end. In practice no tow should exceed 2 hr duration.

In many areas of the world gillnets are commonly used to catch all species of ocean white fish. The quality problem encountered with gillnet fish is prolonged struggling and dying in the gear. To achieve quality, the gear must be picked at least once a day. Longer soaks can lead to fish decomposing in the gear.

Danish seines are commonly used to harvest flatfish and cod. Because the tows are relatively short, excellent quality product can be landed using the same precautions applicable to trawl fish.

Landing

Much of the irreversible damage occurs during the landing of the catch. It is the tendency to want to clear the deck as quickly as possible to return the gear to the water. It is here that extreme care should be exercised in handling. Do not treat the product as if it were wood or coal. Rough handling will cause bruising and soft flesh. In the case of bulk deliveries, the fish should be landed on deck in such a manner as to leave room for the crew to easily work and sort the catch as necessary. If the fish arrive one at a time they should be moved quickly to the appropriate place for bleeding, gutting and grading. Fish with obvious defects such as tumors, abscesses and of generally poor condition should be discarded. Dehydration from sun and wind can and must be prevented by rapidly moving the fish below deck or covering them with a light-colored tarp. Pughs or pitchforks must not be used to move fish. Pughs can inject large numbers of bacteria into the flesh which hastens spoilage. It has been shown that a pugh wound cuts the shelf life of the fillets in half.

Remember, anytime the fish is bruised or struggles for a long time, it has a shorter shelf life and will be graded as number two or worse. This hurts the fisherman, the processor and the consumer. The key is rapid and gentle handling.

Points to Remember:

- Short gear soaks and tows reduce the time the fish struggles.
- Killing fish immediately prolongs rigor.
- Avoid crushing and bruising.
- Gaff only in the head.
- Do not use pughs or pitchforks to move fish.
- Rapid and gentle handling is necessary for high quality.

IV.
ON-DECK HANDLING

Deck Layout

The deck must be free from sharp objects which could damage or puncture the fish. Hatch combings, ribs, frames and other structures which fish come in contact with should be smoothed with fairing. Pen boards and stanchions should be in place to prevent fish from sliding into the trawl winch or other deck machinery. Checkers should be constructed in such a way as to prevent damage to fish. Stanchions and pen boards should be constructed of impervious noncorrosive materials which are easy to clean. The bottom of the checkers should be smooth so the fish are not scaled or scraped when they slide on the surface. The bottom should slope so fish will flow to the work area and allow the deck hands easy access to fish thus improving their efficiency. Corners should be faired. Checkers should be no deeper than 30 in. to minimize the pressure on those fish on the bottom. This will help maintain good quality and reduce weight loss. Checkers should all be of the same size so that the checker boards are interchangeable and installation requires only the stanchions need be permanently in place. There must be enough checkers to hold the fish coming on board during handling and dressing. The checkers should be narrow to prevent fish from sliding back and forth, and to prevent damage by scaling and bruising. Bleeding tanks must be located so all crew members have easy access to them. Figure 6 shows a deck layout design adequate for a longline vessel.

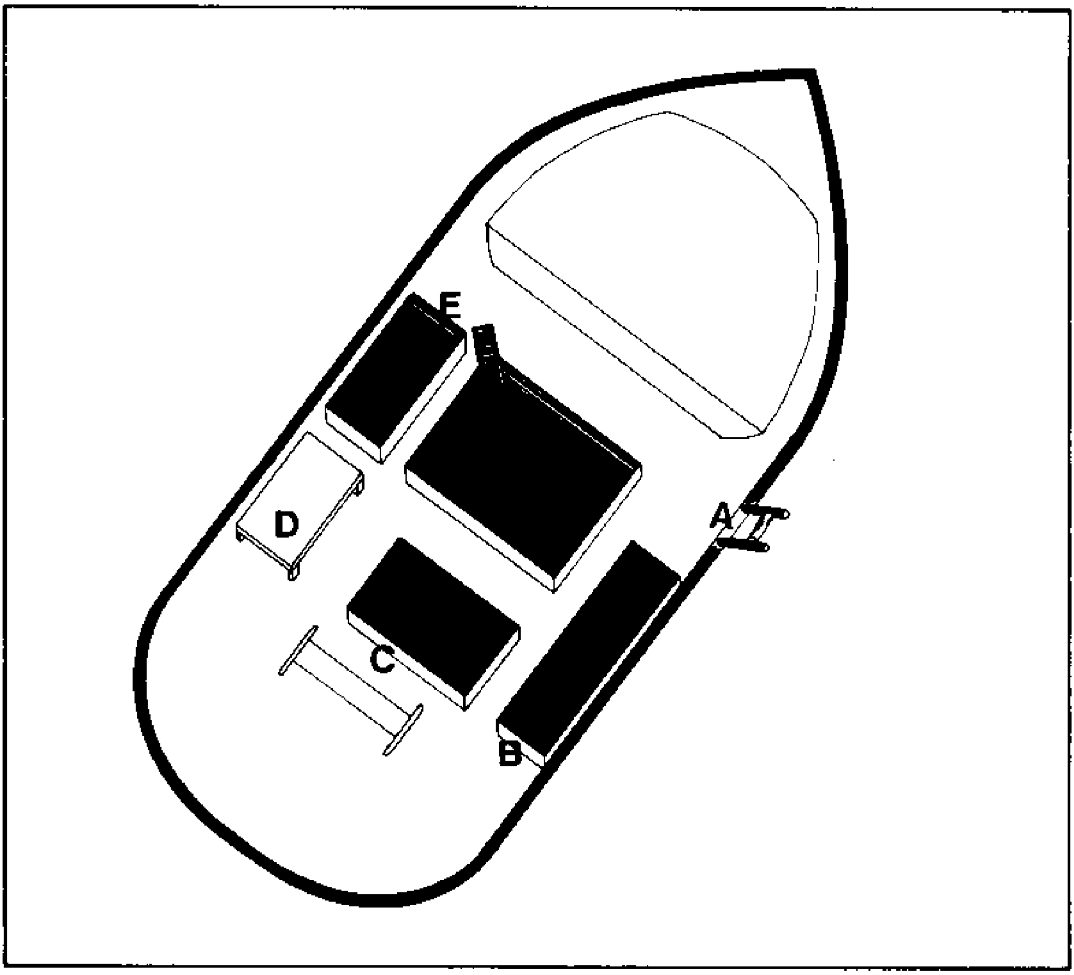


Figure 6. A suggested deck layout of a small to medium longline vessel. Roller (A), checkers (B), bleeding tanks (C), gutting area (D), and washing tank (E).

On-Deck Handling

When a fish is landed on deck, the first thought must be rapid handling and chilling. Gear repair should be put off until the fish are stowed.

If the fish is taken by otter trawl the first step is to thoroughly wash away mud and debris with the deck hose to reduce the bacteria load on the fish. Washing is especially important when chilled sea water (CSW) or refrigerated sea water (RSW) are used because dirt will quickly contaminate the entire system, load the system with bacteria and shorten the shelf life of the final product.

Bleeding and Gutting

Every study on the bleeding of fish shows that bled fish produce superior products. This is true regardless of the species studied. Bleeding is an essential step in producing high quality fish whether it is fresh, frozen or salted. Bleeding reduces reddening in the flesh, reduces browning in frozen fillets and reduces the development of rancidity. Bleeding also decreases the incidence of bruising. All cod, rockfish, large pollock and large flounder should be bled.

Bleeding

Experiments in Europe have shown that a two-step dressing procedure will give the best results. Live fish will bleed better than dead fish. Bleeding dead fish, however, will improve flesh color and quality. A deep throat cut starting behind the gills and in front of the heart continuing to the backbone and cutting the gullet is the best method for bleeding cod, flatfish and pollock (Figure 7). Rockfish intended for the fresh whole fish market should be bled by a deep throat cut. Insert the knife in back of the gills and cut through the throat into the backbone.

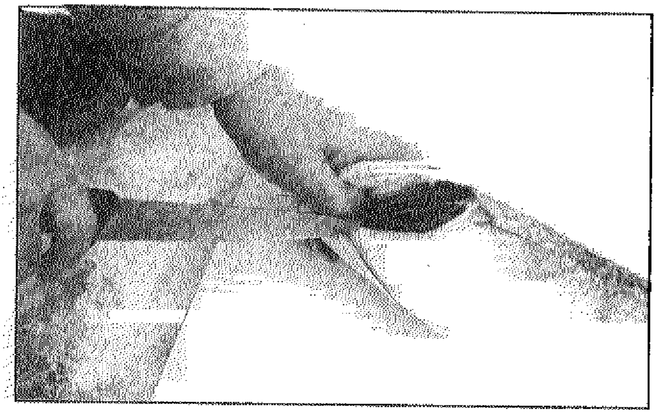
The tail cut (a ventral cut to the backbone in front of the tail) produces effective bleeding but exposes flesh to bacteria and reduces recovery. Tearing or cutting a gill is a less effective method.

Bleeding can be achieved by cutting the throat and immediately gutting. Research in Iceland has shown that this method results in poorer quality fillets than bleeding in running water followed by gutting.

Fish bleed more completely in cold sea water. The colder the water, the better the fish will bleed. Ten to 20 min from the time of throat cut is adequate for proper bleeding. Water in the bleeding tank should be continually replenished to prevent buildup of blood, slime and bacteria.

If there is not enough room on deck for a bleeding tank, fish may be bled in a checker. Air bleeding will only be about 70 percent as effective as sea water bleeding, but is still superior to not bleeding fish. Fish bled in air should be iced or chilled within 20 min of start of bleeding as a longer time at air temperature will cause increased discoloration of the flesh. If a choice is to be made between bleeding and gutting, it is most often better to bleed. In fact if fish are to be stored in RSW or CSW you should only bleed (see below).

a.) Shallow throat cut



b.) Deep throat cut

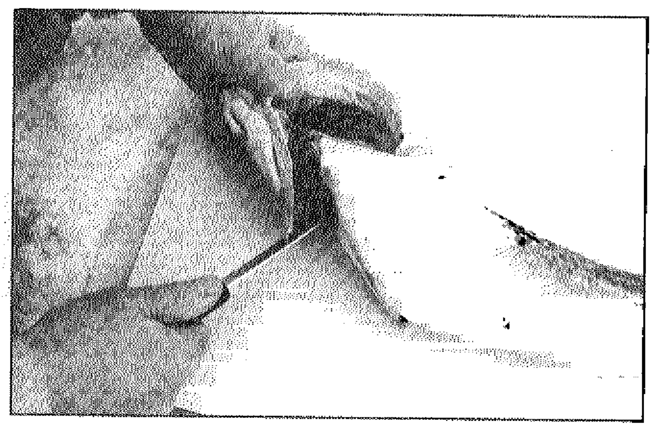


Figure 7. This cut starts at the base of the isthmus (throat) and continues in back of the gills ending at the backbone.

Unbled fish result in:

1. Very light pink to deep red discoloration of the fillets.
2. A gray or dark appearance after freezing.
3. Flesh appearing to be slightly, if not much, softer in many cases.
4. Recovery drops due to the softness of the flesh.
5. Trimming and parasite removal become more difficult due to the discoloration and softness.
6. Lessened market acceptance due to lack of the expected creamy to bright white color.
7. An increased browning in rockfish fillets as product ages.

Based on the above, unbled fish should only command 75 to 80 percent of the price of bled fish. The lower price is justified from the processor's standpoint on the above seven points. Eye appeal alone would justify a lower price on the open market.

Gutting

Fish to be stored in ice should also be gutted after bleeding. Both bleeding and gutting can be done in a single step, but more blood will be removed if gutting is done after the bleeding step. To gut round fish, open from the vent to the throat, grasp the viscera with the other hand and jerk loose, and dispose of the viscera into a separate container or toss over the side to prevent gut contents from contaminating the flesh (Figure 8). The air bladder and kidney are left intact in cod and pollock as cutting them out and scraping will cause more damage than it will do good. Care must be taken not to cut the body wall in the gutting process. A cut in the body wall will allow bacteria into the flesh and also downgrade the fillet.

Fish which will be stored in RSW or CSW systems should be bled but NOT GUTTED. Gutting will expose more flesh which will increase the rate of salt uptake in the flesh. Increased salt uptake will result in surimi which has poorer elasticity and be of low grade. Dressed fish will also take up water, softening the flesh and reducing recovery.

The final step in the dressing process is thorough washing in clean sea water to remove blood, slime and any other debris. Many of the surface bacteria are removed by washing. This will slow down the rate of spoilage. Inspect to make sure all bits of liver, heart and intestines are removed.

a.) Start belly cut at vent

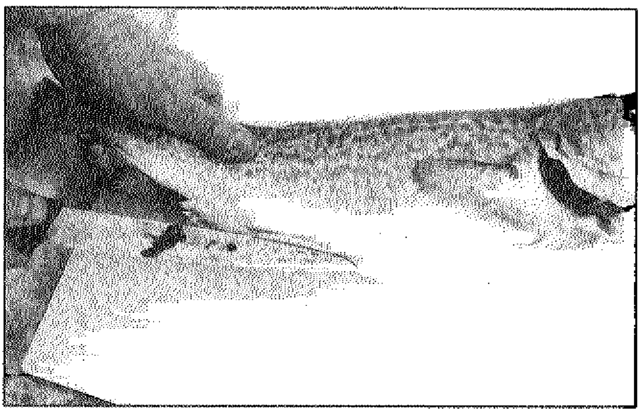
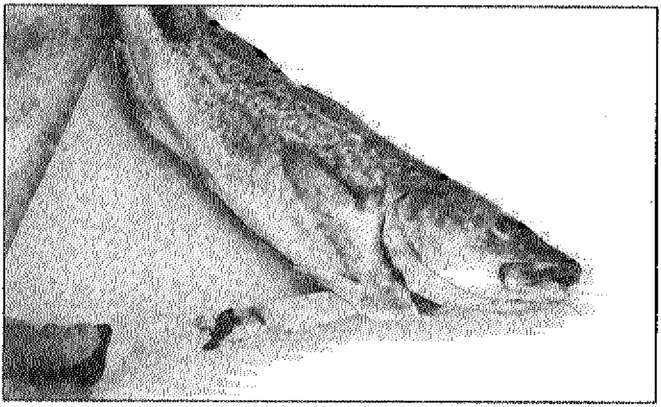
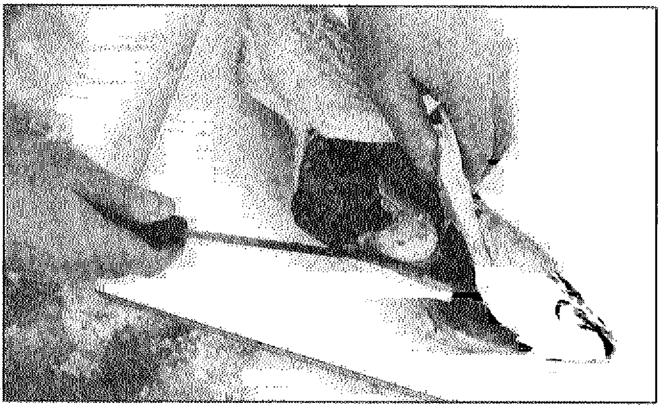


Figure 8. Gutting technique for cod and large pollock.

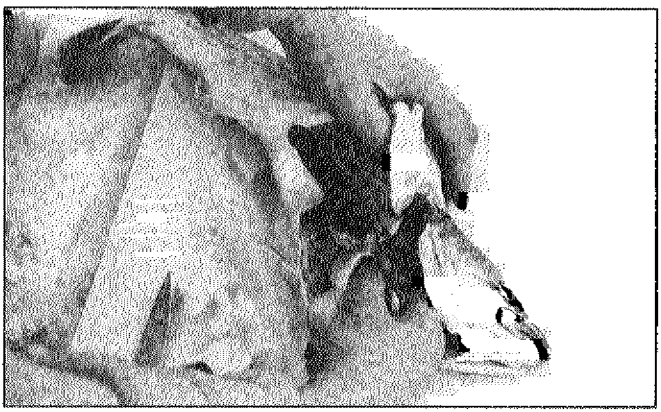
b.)
Split belly
through
the
isthmus



c.)
Grasp
viscera



d.)
Jerk
viscera
free and
discard



Points to Remember:

- The deck must be free of sharp objects which can damage fish.
- Fish must be shielded from deck machinery.
- Checkers should be designed to protect fish and allow deckhands easy access to the fish.
- Bleeding tanks are of great benefit.
- Once on deck fish should be handled gently and rapidly.
- Trawl hauls should be washed immediately to remove debris and reduce bacteria.
- Bleeding of fish will greatly improve quality by improving color, decreasing bruising and lessening oxidation.
- Bleeding is best accomplished in cold running water.
- Do not gut fish to be stowed in RSW or CSW.
- Bleeding is best accomplished with a deep throat cut.
- Gut round fish and large flatfish that are to be iced.
- Leave the air bladder and kidney intact.
- After dressing thoroughly wash fish to remove dirt, debris and reduce bacteria.

V.
STOWAGE

Rapid chilling is essential to produce a first class product. For chilling bled fish, the fisherman has a choice of three methods. Ice, RSW and CSW all produce good results when PROPERLY USED and PROPER TEMPERATURES ARE MAINTAINED.

Icing

Ice is the traditional method of preserving fish. Clean ice, in adequate quantities, properly applied, will go a long way toward ensuring a superior product will be delivered to the dock. The only accepted method of chilling gutted fish is with ice. The amount of ice used must be sufficient to cool the fish from their ambient temperature to 0°C (32°F). In theory, one pound of ice will cool 144 lb of fish 1°F. In other words, if the only heat source was from the fish, one pound of ice would lower the temperature of 5 lb of fish from 15° to 0°C (60° to 32°F). That's theory. The real facts are quite different. The major source of heat in a fish hold comes not from the fish, but is transmitted through the hull, engine room bulkhead, deckhead and shaft alley. Therefore, a well insulated fish hold is a must. Four inches of urethane foam on the engine room bulkhead (R=33) and 3 in. on other surfaces (R=25) are adequate for Alaskan waters.

Practical icing rates are 1 lb of ice for 2 lb of fish (1:2) for short winter trips or 1:1 for long trips and summer fishing. Wet fish weigh about 56 lb per ft^3. Flaked ice weighs about 30 lb per ft^3. Therefore, even minimally iced fish will always require a greater volume of ice than fish. Heavily iced fish will require approximately twice the volume of ice to fish.

A major step in landing quality fish is the training of the "iceman." Next to the skipper, he is the most important person on the boat. He is responsible for the handling of the fish in the hold and for making sure they are handled properly. He must decide the amount of ice for the trip, how heavy the first of the catch should be iced in order that the last fish caught has ice for cooling, and he must not run out prior to the end of the trip. The responsibility for delivering a good load of fish is directly upon his shoulders. A good iceman will make or break a vessel. Ice carrying capacity of small vessels may limit the trip length.

All fish must be iced as soon as possible. Deck loads are absolutely unacceptable. It has been proven that fillets from bled fish held at ambient winter temperatures for 4 hr were of significantly lower quality than those iced immediately after bleeding. Research in Iceland has shown that over 98 percent of fillets from fish bled and iced immediately after harvest were graded number one, while bled fish left on deck for 4 hr at an air temperature of 40°F produced only about 28 percent number one fillets.

Prevention of crushing of the fish is of upmost importance. Crushing softens the flesh by breaking down the muscle structure and releasing enzymes that attack muscle proteins. Relatively little weight can do considerable damage. For example, experiments with sockeye salmon have shown that fish bulk stowed 90 cm (36 in.) deep for 24 hr had 3 times the enzymatic activity of fish bulk stowed 30 cm (12 in.) deep for the same period of time. Weight loss (shrinkage) in fresh fish and drip loss in the frozen product both increase with the depth to which fish is stowed. It is obvious that fishermen who want to deliver a first class product will avoid stowing their iced fish in deep layers.

Boxing, shelving and bulk stowage are the three methods most commonly used in stowing bled and gutted fish. Of these, boxing will consistently give the best results.

Boxing

Boxing is practiced in Europe, Iceland and experimentally on the Atlantic coast of the United States. The boxes now in use hold 50 to 130 lb of fish with room for ice. Boxing has a number of advantages, the most important of which are:

- It prevents crushing of the fish and consequent weight loss. Properly boxed cod will gain about one percent of their weight in seven days.
- Fish are handled fewer times causing less damage.
- Species and different sizes of the same species can be segregated.
- The date of harvest is easily recorded, so that fish can be processed in order of harvest.
- Properly designed boxes which are interlocking, stackable and drain slime away from the product will prevent melt water from carrying bacteria to the fish below.
- Unloading is faster, easier and causes less damage to the product.
- Significant additional shelf life is obtained.

There are, as in all good things, drawbacks to the utilization of boxing at sea. First, hold capacity is reduced by approximately 40 percent from conventional shelving methods and second, good boxes are expensive. Traditional buyers are reluctant to purchase fish unseen and unweighed. They want to see, touch and smell the product prior to purchasing.This is not always possible when using boxes. Storage of boxes in a conventional hold on board ship is sometimes difficult due to sloping sides, round faired corners, sloping deck, bins, poor lighting and generally poor working conditions. Additional work is the biggest complaint heard from fishermen using this method and not being paid for the effort is a common complaint from the vessel owners.

For high-priced species such as cod and rockfish, however, increased quality would make the effort worthwhile. It has been estimated this type of handling on board the vessel results in as much as five days additional shelf life at the marketplace. The reduction in handling of the fish itself and the fact that they are packed very carefully in the boxes has a very definite enhancing effect on the marketability and shelf life of the product. Several fishing vessels working out of New England are having good success with a boxing program. One company is using one-way boxes that are taken directly from the fishing vessel to the primary consumer, in this case "white tablecloth" restaurants and high volume, high quality fish markets. The product is very well received by the consumer and generally the fishermen are paid more for their product. All species of fish are handled in the same manner with "round fish" being gutted and flatfish going ungutted. Fifty pounds of fish are put in each box and these boxes go from the vessel directly to the retailer with no additional handling of the product (personal communication, Mr. Charles Wicke, Blue Water Seafoods, Gloucester, Mass.).

Box size should be of suitable dimensions to accommodate large fish and hold 50 to 70 lb of fish plus an equal volume of ice. Large boxes holding up to 200 lb of fish and ice are not desirable. Too much weight will crush the bottom fish and make the boxes difficult to handle. Boxes should be of heavy duty plastic such as high density polyethylene. They must be stackable and interlocking. There are well designed boxes which drain the melt water away from the boxes underneath them. This is especially desirable because it helps prevent bacterial contamination from above. Boxes that nest take up less storage space. Wooden boxes should not be used as they cannot be properly cleaned and will add bacteria to the fish. The fish should be layered belly down on the bottom ice with sufficient ice between layers so that each fish is surrounded by ice. The fish should not touch each other or the box and must be separated by ice (Figure 9a). The boxes must not be overfilled or the pressure from boxes placed on top will crush the product.

Unless the hold is refrigerated and specially designed for boxing, as is now common in Europe, ice must be placed on the bottom, bulkheads and skin of the hold. This is necessary to absorb heat coming into the hold from outside sources (Figure 9b).

The date and time of stowage of each lot of boxes should be recorded. Processors want to process the fish in the order in which they are caught, that is by age. It is correctly assumed that the older fish will decompose first.

Shelving

This is a common method of stowing "wet fish" on trawlers in Europe and the northwest Atlantic. The recommended shelving method uses supports on the sides of the pen boards to hold horizontal boards about 24 in. apart forming shallow pens. A 24-in. shelf depth is a good compromise in that it prevents excess pressure on the iced fish while not significantly decreasing hold space (Figure 10). Eight to 12 in. of ice, depending upon sea water temperatures and hold insulation, is laid on the bottom and against bulkheads. Cod, pollock and other "roundfish" are laid belly down, not touching and head pointing to the vertical pen boards. No part of the fish should touch the pen boards, hold skin, or bulkheads. A layer of ice thick enough to prevent fish from touching by the end of the trip is then added, then the next layer of fish, etc. Do not overfill the pens, as the next shelf will crush the lower fish. The next shelf boards are added and then covered with 1 to 2 in. of ice. The sequence is repeated until the pen is full, ending with the top shelf at 30 in. below the deckhead. The fish on the top shelf are then covered with 6 to 8 in. of ice. Again the "iceman" should record the time and date for each lot of fish, so the oldest fish are identified for first processing.

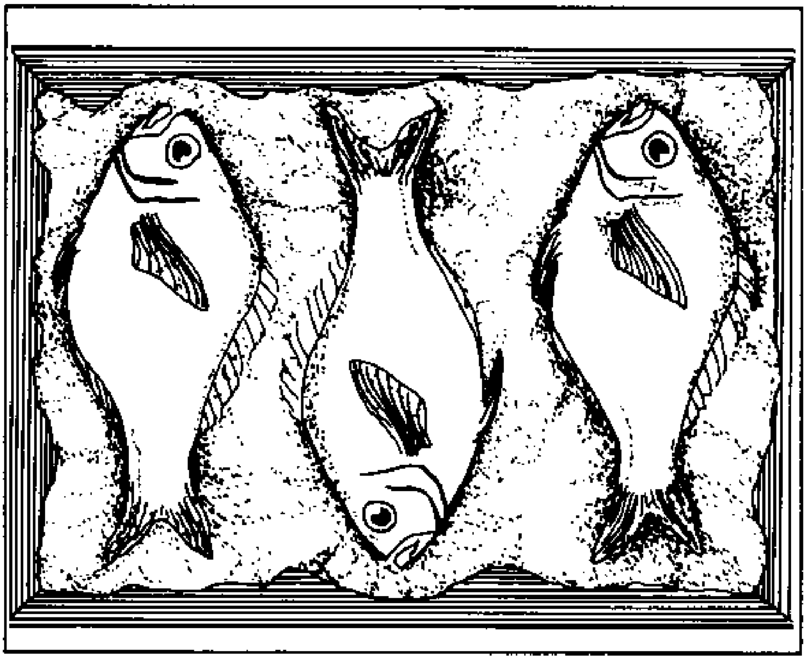


Figure 9a.) Typical "boxing" with fish laid on ice ready for storage.

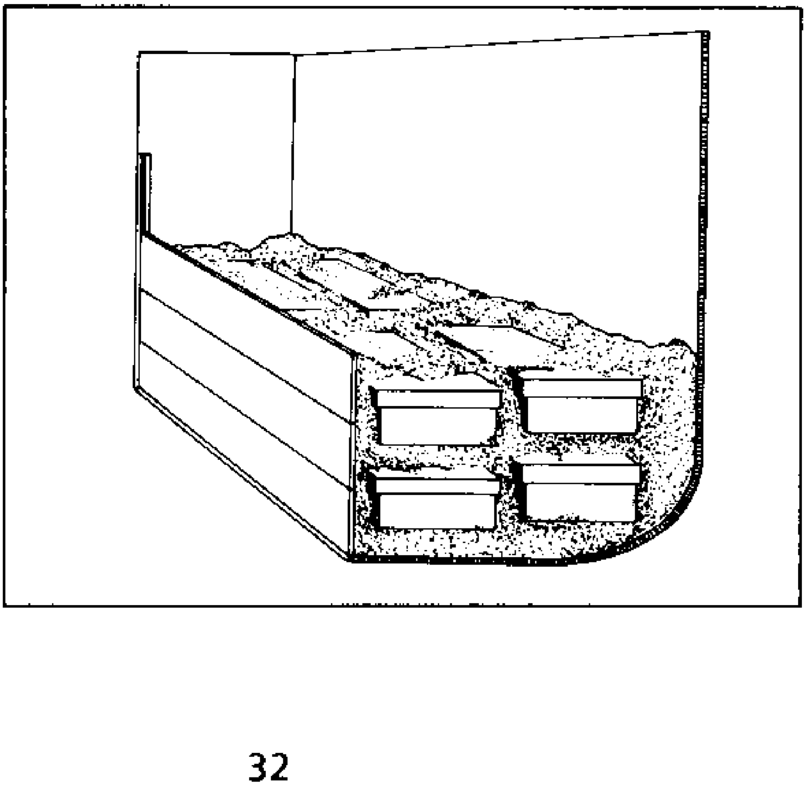


Figure 9b.) Stowage of boxed fish in the hold. Note that ice is placed under the bottom boxes and between the hold lining and the boxes.

Flatfish should be stowed in separate pens with white side up, especially if the processor leaves the skin on the white side. Rockfish must be stowed separately so the spines do not puncture other fish. Rockfish must be individually iced so the spines do not contact other fish.

The advantages of shelving over boxing or conventional bulk stowage are: storage space loss is minimized, fish are not exposed to the pressures found with large pens, shrinkage will be minimized, fish can be easily identified by age and can be unloaded in the proper order. Also the cost of converting is minimal, the work load of the iceman is little increased and a better product will be very evident.

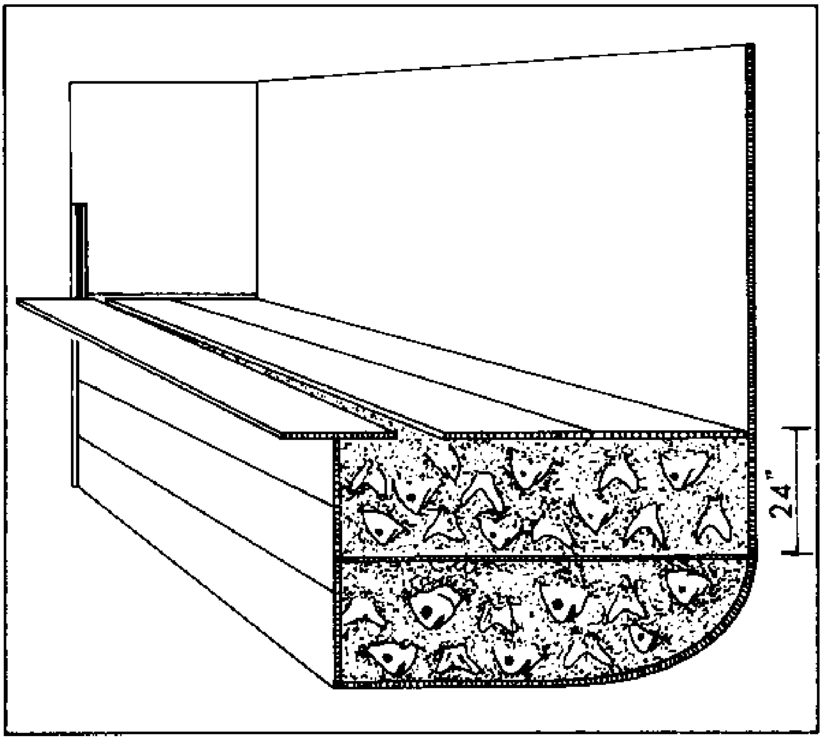


Figure 10. A typical shelving arrangement showing proper icing methods.

The disadvantage over boxing is that the fish will be handled more times and melt water will carry bacteria to the lower fish. The added bacteria will increase the rate of spoilage. Increased handling adds to the bruising problem and softens the flesh.

A second method of shelving is common in European ports. The shelves are spaced about 8 in. apart. This is sometimes referred to as short shelving. A 4-in. layer of ice is laid down on the shelf and one layer of fish is placed belly down on the ice. No top ice is used. The fish have a better appearance than those covered by ice, but it has been demonstrated that these fish will have a shorter shelf life than fish covered with ice. This method of shelving is NOT RECOMMENDED.

Bulk Stowage

Historically most white fish landed off the west coast of North America are bulk iced in pens. This unfortunate state of affairs dates back to a time when cod, flatfish and rockfish were considered cheap fish and not worth the extra effort. Poor handling has led to a poor reputation for west coast white fish. Only recently has this situation started to improve. BULK STOWAGE OF OCEAN WHITE FISH IS NOT RECOMMENDED IF THE OBJECTIVE IS TO PRODUCE A FIRST GRADE PRODUCT. Even under the best conditions, a bulk stowed product will not be as good as a boxed or shelved product if all other factors are equal.

Because bulk stowage is likely to continue until processors refuse to accept fish handled in bulk, we suggest the following recommendations be strictly adhered to. In order to roughly separate fish by date of harvest, the hold should be divided into pens as shown in Figure 11a. Enough ice must be used to cool the fish and absorb incoming heat. First, ice is spread on the bottom of the pen to a depth of eight to 12 in. and then piled up the hold skin to a minimum thickness of 4 in. and as high as possible. Eight inches of ice should be used on the engine room bulkhead. Fish are then laid on the ice, bellies down, one layer thick. Then another layer of ice 2 to 3 in. thick is added to the fish, heavier if it is the start of the trip and lighter as the trip nears the end (Figure 11b). When the pen is about full it should be topped off with 6 to 8 in. of ice to absorb heat coming through the deckhead and hatch covers. The fish is cooled by the melting ice. The fish are laid on their bellies so that melt water will not accumulate in the cavity and sour the flesh. Any overflow from the cavity would transfer souring bacteria onto and into the rest of the fish beneath it. Except for small flatfish, only gutted fish should be bulk stowed because the weight of the top load squeezes out the gut contents contaminating fish below.

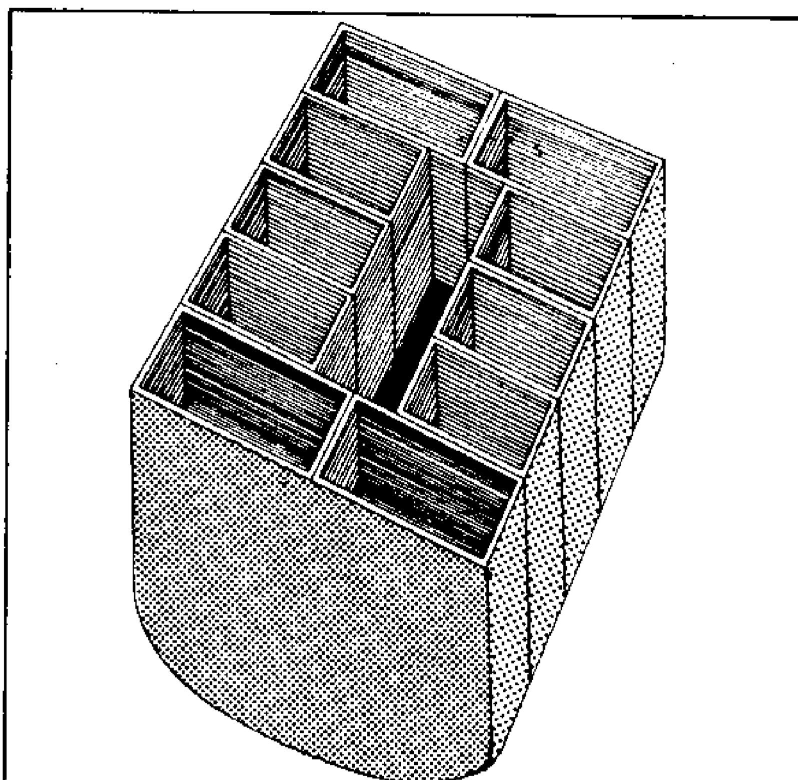


Figure 11a. Typical "hold" layout. Individual pens can be labeled with date of harvest, species, etc.

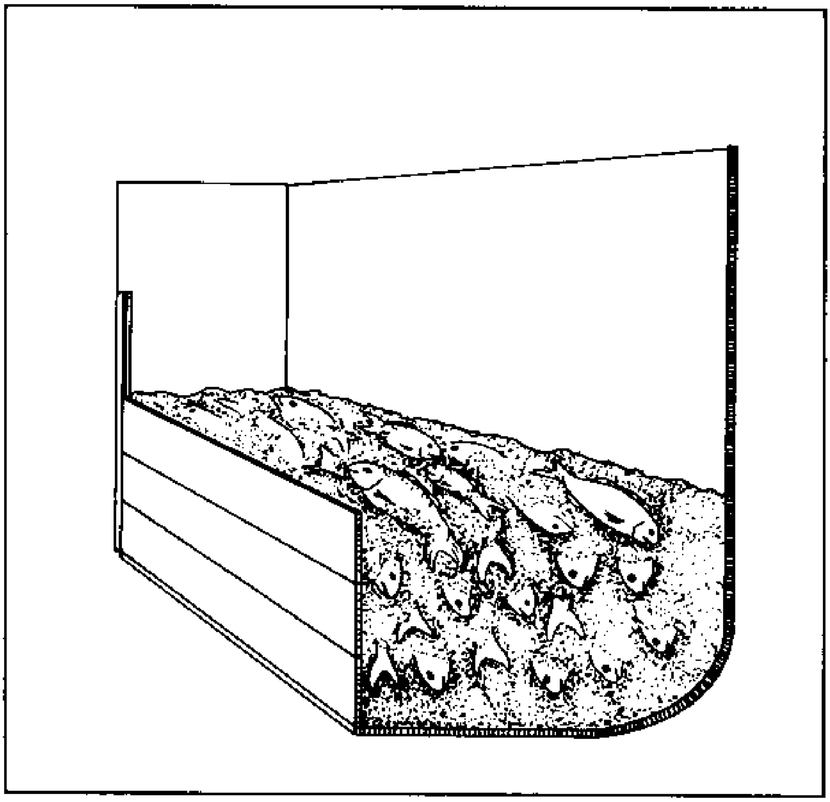


Figure 11b. Typical "bulk pen." Hold showing the recommended icing method.

A major problem with traditional pens is weight loss. Research in Canada and the U.S. has demonstrated that product on the bottom of the bins frequently loses as much as 15 percent of its original weight. Crushing of the lower layers is another problem. These fish will be soft, will decompose faster and will give lower recovery. Frequently these misshapen and compressed fish are rejected by the buyer. The pens themselves lend to another major problem from the processors standpoint, the mixing of the catch by age. Most of the processors want to process the fish received in the order of catch time. That is, the oldest fish are processed first as they are most likely to reach decomposition first.

General comments on different methods of stowing in ice:

	Advantages	Disadvantages
Boxing	• Fish are handled less • Crushing is prevented • Shrinkage is reduced • Easy to unload • Date of catch known • Species & size of fish easily segregated • Shelf life is extended • Bruising is reduced	• High labor input • High cost of good boxes • Reduced hold capacity • Boxes must be emptied if buyer wants to inspect the fish
Shelving	• Fish protected from crushing • Shrinkage is reduced • Date of catch identified • Conversion costs minimum • Good quality product stowage • Best quality product	• Handled more times • Melt water carries bacteria to lower fish • Softer flesh & increased bruising • More labor than bulk
Bulk	• Low labor input • No added costs • Easier unloading	• Crushing & bruising • High shrinkage rate • Not segregated by date • Lower average quality • Shortened shelf life

Refrigeration can be of considerable advantage on ice boats. Its primary advantage is conservation of ice. Having refrigeration coils on the engine room bulkhead, deckheads and hatch combings will absorb much of the heat transmitted from outside. Maintaining hold temperatures at 31°F will preserve ice and make it much easier to use. Small pieces of ice will leave fewer pock marks on the fish.

Only clean ice made from potable water should be used. The hold should be watertight so that no bilge water from the shaft alley can come in contact with the fish. The engine room bulkhead must be watertight for the same reason. There must be one or two sumps at the lowest point of the hold so that melt water can be pumped out on a regular basis. Melt water, slime, blood and fish juice make an ideal medium for bacterial growth. Holds should be lined with fiberglass or other nonporous material. Wood hold linings must be covered because they cannot be properly cleaned.

Special attention should be given to icing over the shaft alley. This area is often overlooked as the slaughter house is the last area of the hold to be filled. The shaft alley is a major heat source. This is especially true for vessels that have fuel tanks in the lazaret where hot oil in the return lines causes a major problem. Significant heat can be added to the hold from hydraulic lines. Only experience on a particular vessel will let the "iceman" know how much ice is needed in this case. PROPER ICING AND STOWAGE CANNOT BE OVEREMPHA-SIZED.

Refrigerated and Chilled Sea Water Systems

Refrigerated sea water (RSW) systems depend on mechanical cooling of the sea water which cools the fish. Chilled sea water (CSW) systems use a mixture of ice and sea water as a cooling medium. When compressed air is added to a CSW system, it is referred to as "champagne ice" because of the air bubbles in the mixture. The RSW system is the most popular in the

North Pacific. These systems lend themselves to short fishing periods and extremely high volumes, for example, the pollock fishery of the Gulf of Alaska and the herring fishery of the northern Bering Sea. The biggest quality advantage of these systems is that cooling is more rapid since fish can be gotten into the cooling medium faster and removal of heat is more efficient due to better contact of fish with the cooling liquid.

RSW

Operator control of temperature and system sanitation are key factors in proper operation of the RSW system. The ideal holding temperature is -0.5°C (31°F). Bacterial and enzymatic action will be low with no danger of freezing the fish or freezing up the system. It is absolutely necessary to have the sea water in the tanks chilled to 31°F before fish are added. The refrigeration capacity of each system differs. Only by experimenting can the operator learn how long it will take to bring the water temperature to the desired level. Our investigations have shown that during summer operations it can take as long as 30 hr to lower the tank temperatures on many vessels to 31°F. It is often difficult to achieve desired temperatures. Each tank must be equipped with a thermometer so temperatures can easily be monitored. An ideal system would have several thermistors in each tank connected to a digital readout in the pilot house. When a large tow is added to a tank the temperature will rise. Temperature fluctuations must be minimized as much as possible.

Another advantage of RSW is that it greatly reduces labor input. The fish will also be chilled faster than they are with ice. The disadvantages are the system does not allow its use in the storage of any kind of butchered fish as salt uptake would be a major problem. Salt uptake in round fish also limits the trip length. "Dead spots" can occur where there is poor circulation of RSW causing high temperatures. A mechanical breakdown in the system can lead to the loss of an entire load.

Recent studies have shown that the uptake of salt in pollock held for more than three days in RSW can adversely affect the gel forming properties of surimi produced from those fish. Loading densities in RSW systems are very important. The ideal loading density is about 45 lb per ft^3. Denser loading cuts down circulation causing warm spots while lighter loading leads to increased salt uptake and scaling.

Thorough cleaning of the entire system, including the heat exchanger, between trips is absolutely essential. Because RSW systems are closed, oxygen is soon depleted. This provides a good environment for the growth of anaerobic bacteria (bacteria that grow in the absence of oxygen) which are sometimes called "stinkers." These bacteria will quickly produce a putrid odor and can quickly contaminate the load. Complete instructions for cleaning are given in Section VII.

To hold down bacteria in the system, wait until well out of the harbor area to take on fresh sea water. The bacteria levels are normally many times higher in harbor areas than they are even a short distance to sea.

CSW

CSW: Champagne systems (ice and water with air being introduced to provide mixing) are also utilized in fisheries that require cooling large amounts of fish in a short period of time. This system requires a watertight tank with a grid of properly spaced air circulation pipes to keep the cooling medium mixed in the tank. Proper mixing allows the fish within to be maintained at the coolest temperature possible, about -1°C (30.5°F). CSW systems are prone to "warm spots" because the ice and melt water float on top. To overcome the stratification, sea water must be agitated. Otherwise it is possible to find water temperatures up to 45° to 48°F within a tank. The most effective method of agitation is using compressed air forced through properly placed pipes in the bottom of the tank (Figure 12). The advantages of the champagne system are: rapid misxing of the fish, ice and sea water giving faster chilling; the system is less complex than RSW with fewer mechanical problems; and most important, there is far less temperature fluctuation than with RSW systems. Fish will stay at approximately 30.5 ± 0.5°F once the temperature of the sea water melting ice mixture has been reached. In an optimally loaded system (45 lb per ft^3) this will take about 2 hr of air pumping to properly cool the load. When a tank is fully loaded and the fish are cooled the air pump can be turned off. If the tanks are properly insulated, i.e. 3 to 4 in. of polyurethane, it is only necessary to turn on the air several hours each day to maintain an even temperature in the tank.

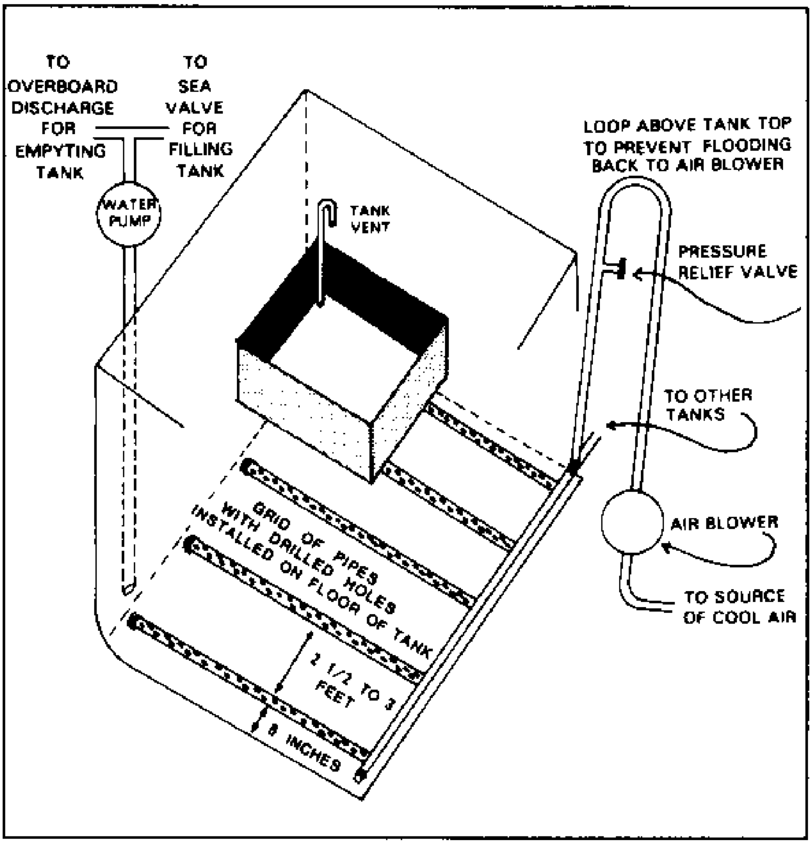


Figure 12. Diagram of a chilled sea water system (CSW). Air is bubbled through the holes in the pipe grid on the floor of the tank to mix the ice and sea water mixture. Spacing of the air pipe grid is critical. Adapted from Kramer 1980.

Take on fresh sea water after leaving the harbor to lower initial bacteria load. Air should be turned on while taking on sea water to prevent the ice in the tank from forming a solid mass. The quantity of ice needed per trip depends on a number of variables including how well the fish tanks are insulated, sea water temperature, volume of fish expected, ambient air temperature, trip length and others. Taking too much ice wastes money and too little means lower quality or spoiled fish when the ice is melted. The Canadian Department of Fisheries and Oceans developed a simplified formula for tons of ice needed per trip. This formula is based on the assumption that the tank is filled with sea water before fish are added so that the sea water spills when fish are added and the tanks are adequately insulated.

$$\text{tons of ice needed} = \frac{W + F + D}{6}$$

where: W = tons of water in tank
F = tons of fish to be chilled
D = trip length in days

For example, assume that the tank is 1,100 ft^3 which is the capacity for 25 tons of fish at 45 lb per ft^3. The 1,100 ft^3 tank would hold 34 tons of water. Also assume a trip length of 3 days.

$$\text{tons of ice needed} = \frac{34 + 25 + 3}{6} = 10 \text{ tons}$$

This would be an excess of ice for most vessels operating under Alaskan winter conditions. A better estimate of ice needed can be obtained by using a computer program developed by scientists at Oregon State University (see Kolbe, Crapo and Hilderbrand 1985). Copies of this program can be obtained through the Oregon State Sea Grant Program, the University of Alaska Marine Advisory Program, or the National Marine Fisheries Service Utilization Research Centers. This program has been found to be very good for predicting ice needs for Alaskan operations and its use should save the operator money. The best loading densities are the same as for RSW (42 to 45 lb per ft^3) and for the same reasons as for RSW systems. The advantages of CSW over RSW are that temperature fluctuations are less, that passive refrigeration still exists even if the air pressure system breaks down and the system is far simpler to operate. However, if you run out of ice the CSW system will heat up very rapidly. It is always better to have too much ice than not enough. There are two additional disadvantages: in the long-term, the cost of ice may be greater than the operation of refrigeration for a RSW system and compressed air mixed with the fish slime produces large volumes of foam. Although this is not harmful, it will cause the deck to be slippery and increase the danger of an accident.

For proper cleaning of CSW systems see Section VII. Both CSW and RSW systems MUST BE PROPERLY ENGINEERED. Poorly designed systems will fail. Some species of fish have shorter shelf life in well designed RSW and CSW systems than they do in ice, therefore, anything less than the best available system is unacceptable.

Flatfish and rockfish must be kept in separate tanks. Experience has shown that when most species of flatfish are mixed with other species, an increase in bruising and soft flesh results. Rockfish spines puncture other fish letting bacteria into the flesh and speeding up spoilage. Vessels concentrating on rockfish should not use CSW or RSW as the skin will bleach resulting in a less attractive, lower value product.

The comparative advantages and disadvantages of cooling systems are:

	Advantages	Disadvantages
Ice	• Holds fish at constant temperature • High heat absorbing capacity • Requires little hold conversion expense • Easy to sort fish • Some species have longer shelf life	• More labor • Cost of ice • Longer unloading time • Slower cooling
RSW	• Less labor • Faster chilling than ice • Can handle large volume	• Complex design • Mechanical breakdown • High initial cost • Salt uptake • Large temperature fluctuations • Can develop hot spots
CSW	• Less labor • Faster chilling than ice • Can handle large volume • No refrigeration equipment needed • Less complex than RSW • More constant temperature than RSW	• Cost of ice • Salt uptake • Can have hot spots • Large volume of foam

The keys to success in the use of RSW and CSW systems are:

- A well designed system.
- An engineer who knows the system and can keep it running at an optimum level.
- Controlling the temperature at 30 to 31°F to minimize temperature fluctuations.
- Control of loading densities to between 42 and 45 lb per ft^3.
- Proper cleaning and sanitizing of the system between trips.

Freezing at Sea

Many people believe the best method of assuring a high quality product being delivered to the processor is to freeze the product while at sea. When properly done this is undoubtedly true. To do it properly, however, is complicated. The vessel must meet regulatory standards of the state and the Food and Drug Administration. In this section only those aspects peculiar to processing at sea are discussed. For a complete discussion of white fish processing see Marine Advisory Bulletin No. 28, "White Fish Processing Manual" by Chuck Jensen. Adequate freezing, cold storage temperature and capacity are essential. Freezer capacity should be sufficient to freeze the expected catch, and harvest levels and freezer capacity must be carefully coordinated to ensure the product does not remain on deck for long periods of time. This is especially critical on small catcher/processors.

The freezer should reach a temperature of -30°F. The product should not be removed until the center of the product has reached -5°F and immediately placed in the frozen storage hold. The hold must be well insulated to prevent temperature fluctuation. Temperature fluctuation increases the rate of rancidity and also increases toughness. Hold (i.e., cold storage) temperatures should be maintained at -23.6°C (-15°F).

Rigor mortis is the most critical factor in processing at sea. Fish can be filleted and frozen pre-rigor as is common in European factory trawlers or post-rigor as is the practice in shore plants. Never handle or freeze fish in rigor. Bending fish in rigor will cause physical damage which will show up in tears and gaping in the fillets. Freezing in rigor will cause even more severe physical damage including extreme gaping, twisted fillets and toughness. Thaw drip loss will increase drastically. Up to 20 percent of the fillet weight can be lost. A fish in rigor is easily recognized as it will be very stiff (Figure 1).

There are pitfalls to freezing at sea. The major problems encountered are:

1. Refrigeration failure which could cause the loss of an entire trip.

2. If the center of the fish, block, or pack is not frozen, it is possible to have decomposition of the product.

3. Failure to meet proper market standards.

All these difficulties aside, freezing at sea can be one of the best methods of assuring a good product is delivered to the consumer.

Points to remember:

- Rapid chilling is essential for good quality
- For iced fish
  - use clean freshwater ice made from potable water
  - use a 1:2 ice fish ratio for winter and short trips, more for longer trips
  - adequate hold insulation is essential
  - boxing will consistently give best quality
  - use 50 to 70 pound capacity high density polyethylene boxes
  - shelving with 24 in. maximum depth will prevent crushing
  - bulk stowage will not yield a top quality product
  - refrigeration of ice holds will conserve ice and help yield a better product
- Refrigerated sea water
  - cool sea water to 31°F before adding fish
  - control temperature fluctuations
  - make short trips to lessen salt uptake
  - load system to between 42 and 45 lb per ft^3
  - take on fresh water away from the harbor
  - thoroughly clean tanks and heat exchanger after each trip
  - do not carry dressed fish in RSW
- Chilled sea water
  - take adequate ice
  - load system to between 42 and 45 lb per ft^3
  - check for hot spots in the tanks
  - clean system thoroughly after each trip
- Stow rockfish and flatfish in separate pens or tanks
- Freezing at sea
  - do not freeze fish in rigor
  - freeze at -30°F
  - stow at -15°F

VI. DISCHARGING PRODUCT

The method of unloading the catch will depend upon the unloading equipment at the processing plant. Regardless of the method, catch should be unloaded without delay and must be handled carefully in a manner which prevents flesh damage.

Mechanical Unloading

Vacuum pumps and elevators are common throughout the state. They provide a rapid method for unloading fish stowed in RSW or CSW and fish stowed in bulk ice. Two general kinds of pumps are in use. The wet pump requires the hold be flooded so that a mixture of water, fish and ice are pulled out by vacuum to a dewatering/deicing screen before they are weighed. The other type, a dry pump, uses air to lift the fish.

Dry pumps tend to have a greater unloading capacity but do slap the fish around violently. The wet pump is gentler and causes less bruising and damage when unloading fish. The wet pumps are preferred but a supply of fresh, uncontaminated sea water must be available for flooding the hold. Harbor water taken at dockside is most often contaminated with processing waste and sewage and should not be used.

Some flatfish should not or cannot be unloaded by pumps. Starry flounder do not slide to the pump well because of their rough skin. Large Dover sole, arrowtooth flounder, Greenland turbot and starry flounder should not be unloaded by pump because they may be larger than the suction hose diameter which will cause folding of the fish. This will lead to bruising and soft flesh. These fish should be unloaded by hand.

Hand Unloading

This can be the gentlest method of discharging the catch. Unfortunately it is the method which is most abused. Pughs, forks, shovels, etc., SHOULD NOT BE USED. All cause considerable damage and are unnecessary. Fish should be picked up by hand and put in totes. On smaller boats, problems arise when they are loaded to the hatch combing. The tendency is to jump in and wade through the fish. This can be avoided by using web brailers every 12 in. which can be lifted out with a dock crane as is commonly practiced in the Bristol Bay salmon fishery (Figure 13). It's a fast method of unloading and is easier on the fish.

Ice will glaze over and congeal as it melts. Care must be taken when breaking up the ice to prevent damage to the fish.

Boxed fish are easy to unload. If the hatch is large enough, boxes can be loaded on a pallet. Lacking that, boxed fish can be taken out by sling. This will eliminate one more handling step.

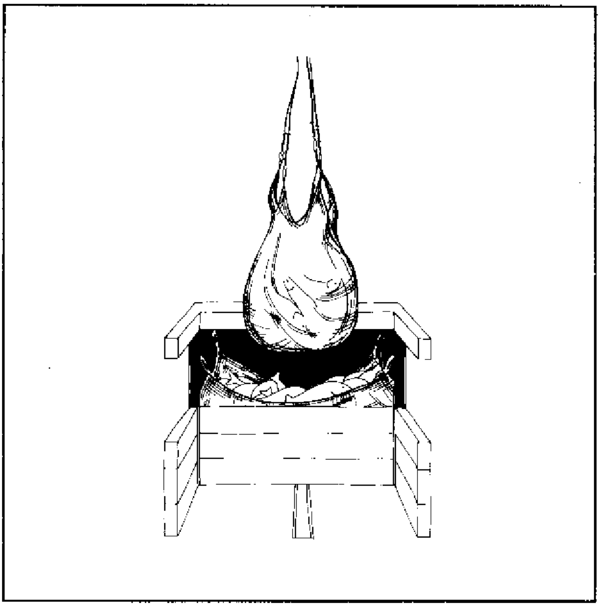


Figure 13. The use of inplace web brailers to unload fish from the hatch and slaughter house.

Points to remember:

- Do not use pughs, forks or shovels when unloading
- Large flatfish should be unloaded by hand
- Use web brailers in slaughter house and hatch combing so fish will not be walked on during unloading
- Wet pumps cause less damage to fish than dry pumps

VII. CLEANING AND SANITIZING THE VESSEL:

The first and last step of any fishing trip is cleaning up the ship. It is necessary to remove bacteria and potential contaminants from all surfaces that fish may come in contact with. Fish contain enough bacteria when they come from the water, the fisherman doesn't need to add more. Dirt, debris, rust, oils and grease are all potential contaminants that can lead to rejection of fish by the buyers.

General Principles

There are three steps to cleaning a boat or a fish plant. The first is the removal of dirt, oil and gurry. This is done with the aid of cleansers or detergents and physical force. The latter can be a well applied brush or high pressure spray. The second step is sanitation to kill the bacteria. Chlorine, in some form, is the most common sanitizer, but others have their special uses as described later. The last step is the removal of the chemical residues left by the cleaners and sanitizers. This should be done with clean fresh water. If fresh water is in short supply, it is better to rinse the cleaners off with clean sea water and leave the chlorine solution on the surfaces. Never use water from the harbor for cleaning as it is highly contaminated with bacteria.

Remember there are three steps. Even if the compound you use says it's a cleaner/sanitizer, it will not do an effective job of sanitizing with a short contact time.

Before the Trip

Before fishing begins, all debris, oil, grease and dirt should be cleaned from the fish deck and hold. Hydraulic oil lines, grease fittings and fuel lines in the hold or on deck must be shielded to prevent contamination of the product. Fuel oil spilled when filling tanks must be scrubbed from the deck as even small amounts can contaminate any fish it contacts.

If it has been more than a few days since the vessel has unloaded, the hold should be scrubbed down with a cleaner or detergent. This should then be rinsed with clean fresh water and the surfaces should be sanitized to kill bacteria and rinsed again.

During the Trip

After each trawl haul has been stowed or at each break in a longline operation, cleanup is necessary. Bleeding tanks should be drained and scrubbed down to get rid of blood and slime. A mixture of fish blood and slime provides a perfect growth substance for bacteria. Checkers should be washed down and the deck cleaned. The checkers and bleeding tanks should be sanitized with common household bleach. Bleach contains sodium hypochlorite which when properly diluted, breaks down to form hypochloric acid, a strong bactericide. The secret here is proper dilution, most people use too strong a solution which is corrosive and does not kill bacteria. The proper solution is one-half cup per 5 gal of sea water. This will give a chlorine solution of about 50 to 100 parts per million (ppm).

Knives, gloves and other utensils should be cleaned and then left in the 50 to 100 ppm chlorine solution. Rain gear should be washed down and then rinsed with the same solution. This will leave them sweet and prevent spread of bacteria to other surfaces.

After Unloading

Thorough cleaning should start immediately after unloading before slime and gurry can dry on surfaces. Dry blood and gurry is very difficult to remove and may require special techniques to clean.

For boats carrying ice, the first step is to discard all of the used ice. It is contaminated and not suitable for reuse. Cleaning starts at the top so dirt is washed overboard or to the bottom of the hold.

Most fish processing plants have mobile pressure cleaning systems available. This is by far the fastest and easiest method of cleaning the vessel. The pressure will force the cleaning agent into crevices and cracks that are difficult to reach by brush. These plants will have the proper cleaning compounds. If not, the operator should get a compound containing an alkaline cleaner such as trisodium phosphate or sodium metasilicate. The systems should be operated at approximately 45 to 50 psi and at a temperature between 43° to 49°C (110° to 120°F). Higher pressures are not necessary and higher temperatures will coagulate the protein and can cause minor burns to the operator. The operator should wear goggles to protect the eyes. Allow the detergent to soak in for several minutes and give a light brushing paying strict attention to sharp corners. Rinse with fresh water to flush away cleanser and gurry. Give strict attention to cleaning pen boards, shelf boards and stanchions. Cracks and crevices will protect bacteria which is a problem with wooden holds.

If pressure systems are not available, a stiff brush and a deck bucket with detergent is the only answer. If the plant can't supply a general purpose cleaner, use a strong laundry detergent and apply to all surfaces using plenty of pressure. Pay particular attention to corners, stanchions and sharp joints.

The next step is sanitation. All surfaces should be sprayed with fresh water or clean salt water containing 50 to 100 ppm chlorine. All seafood processing plants will have an in-plant chlorination system. Ask for a cleanup hose and the chlorine concentration you want. Give all working areas and the hold a thorough wash down. Leave the surfaces wet. Chlorine at that concentration will be anticorrosive and will kill acid secreting bacteria.

If you cannot get the concentration you want, revert to the deck bucket of water containing one-half cup of bleach and wash all surfaces with this mixture. Do not use powdered chlorine compounds (calcium hypochlorite) as they are very alkaline and have to be diluted from 60 percent down to the desired strength (or by 10,000 times). At higher strengths calcium hypochlorite does not kill bacteria and is very corrosive.

On deck the checkers, bleeding tanks, hatch combings and other surfaces which the fish contact should get the same treatment as the hold.

RSW and CSW Systems

Because of the heat exchangers, pumps and piping, these systems present special cleaning problems. Due to the small volume of water compared to the fish volume (i.e., 1:5) the sea water will have extremely high numbers of bacteria. For this reason, it is absolutely essential that the systems are thoroughly cleaned after each trip.

All RSW from the piping system, the heat exchanger and pumps must be pumped overboard. A cleaning loop in the system is necessary to reduce the amount of cleaning agent and sanitizing agent needed to a practical level (Figure 14). The system should then be flushed. After flushing, a strong alkaline cleaning solution containing sodium metasilicate or

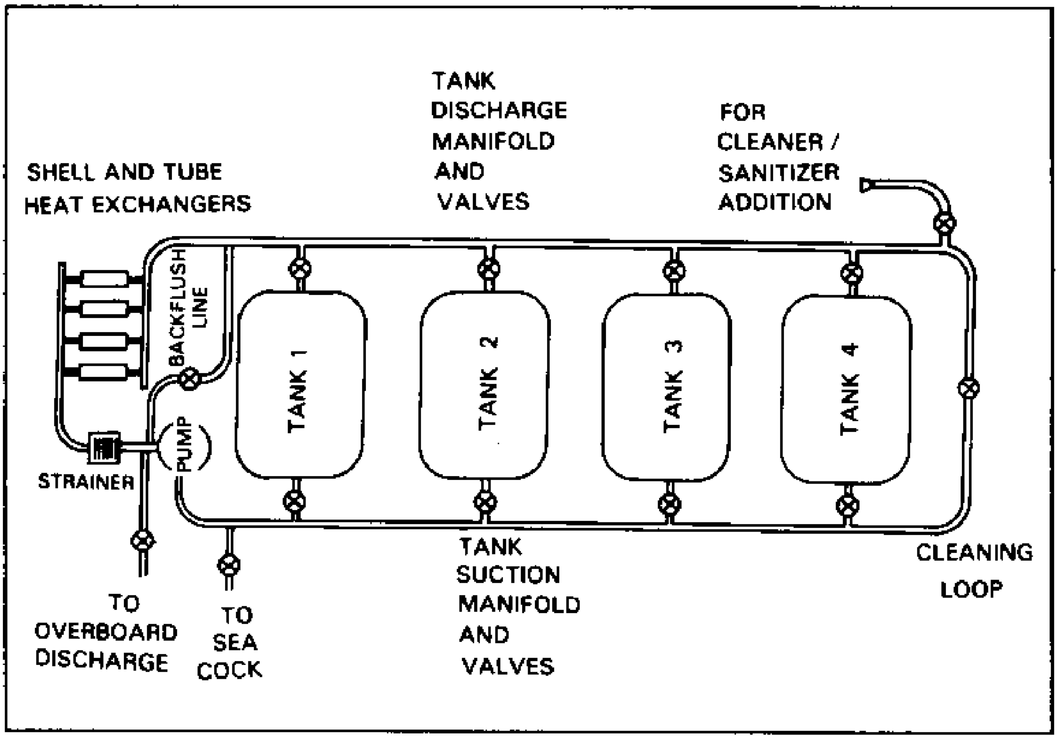


Figure 14. Diagram of a refrigerated sea water system (RSW) using shell and tube heat exchangers in which the refrigerant circulates through the tubes. Note the cleaning loop which shows cleaning pipe and heat exchangers. Adapted from Kramer 1980.

trisodium phosphate should be rapidly circulated throughout the system for 10 to 15 min to remove blood and slime. Then flush and rinse the system. After rinsing, the system should be filled with a bactericide. For this we recommend using an iodine sanitizer (the same chemical used in hand dips in the processing plant). Iodine compounds are noncorrosive and are excellent bactericides. The solution can be left in the system until the fishing grounds are reached. The amount in the pipes and heat exchanger will not contaminate the sea water tanks. For CSW systems the air pipes must be cleaned, because when air pumping stops sea water, blood and slime will flow into the air holes. The same cleaning solution as for RSW systems should be used. If the tanks have a flat bottom, flood the tank bottom with the cleaning solution and let soak for several hours (Figure 12). Then sanitize with 100 ppm of chlorine solution. If the tank bottom is not flat, take the pipes apart and do the above operation in the low part of the tank (Figure 15).

"A clean ship will produce better fish and will be a better place to live. Cleaning can be made easier by following a regular and periodic routine, keeping pets off the vessel and bagging up all garbage."

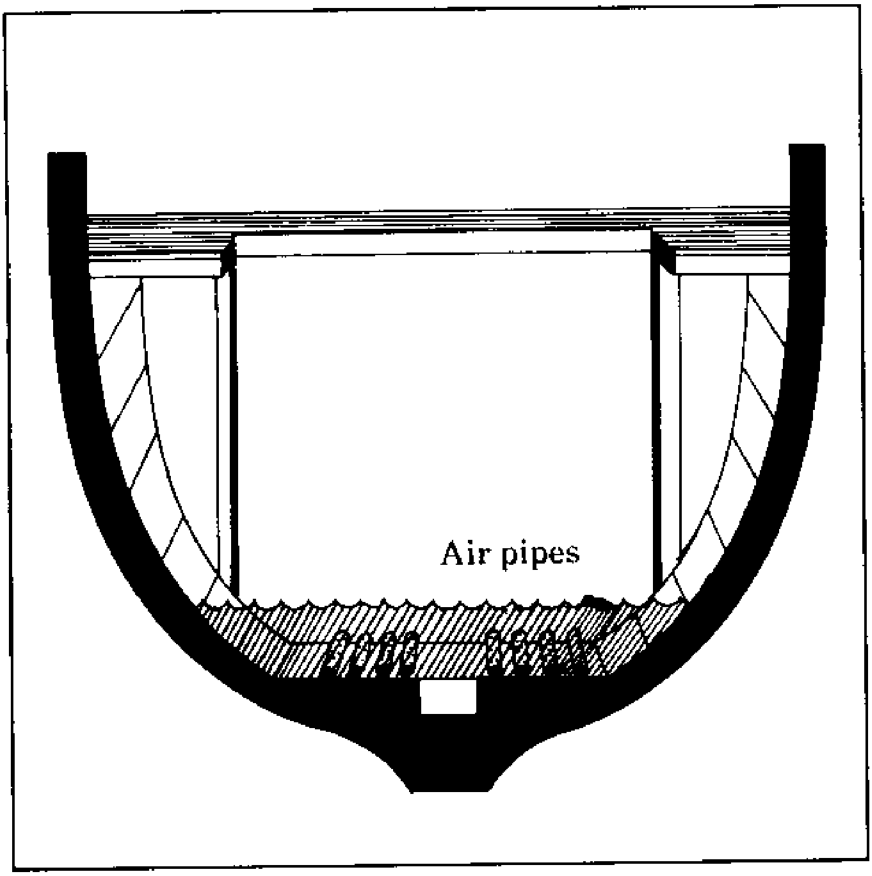


Figure 15. If tanks have a round bottom, take air pipes apart, lay in lowest part of tank, soak in cleaning solution , and then leave in sanitizing solution.

Points to remember:

- The three steps of cleaning a vessel
  - Removal of dirt, oil and gurry with a cleanser
  - Sanitize with a suitable bactericide
  - Rinse with clean water
- Before a trip
  - Clean deck and hold
  - Shield oil and grease lines and fittings
  - Sanitize and rinse
- During a trip
  - Flush and clean checkers at proper intervals
  - Clean deck after each trawl haul
  - Keep knives, utensils and gloves in diluted chlorine solution when not in use
- After unloading
  - Discard all old ice
  - Clean blood, slime and gurry from all surfaces including decks, pen boards, shelving, etc.
  - Clean, sanitize and rinse hold
  - Circulate alkaline cleaners through piping, heat exchangers and pump of RSW systems
  - Kill bacteria in RSW systems with an iodine compound
  - Clean and sanitize piping system in CSW boats
  - Rinse down all areas with potable water or clean sea water

VIII. CONCLUSIONS

Alaskan fishermen have the technology available to produce an ocean white fish product as good as any white fish product in the world. Fishermen hold the key to getting an excellent quality product to the consumers. Fish which are fresh are in highest demand. Quality and shelf life are the most important factors in determining economic returns to the retailer, processor and fisherman. Once quality is lost, it cannot be regained. Fishermen are first to handle the product and their handling practices will determine final quality. A positive attitude toward quality by the fishermen is necessary if he is to maximize the long-term return on investment. By following the ten points listed below, the primary producers will take a big step toward building a reputation for excellence in Alaska's white fish industry.

1. Have a deck layout which facilitates rapid, gentle handling of fish landed.

2. Fish short soaks or short tows to prevent damage on the hook or in the net.

3. Bleed fish as soon as possible and gut when applicable.

4. Handle the fish gently; do not throw.

5. Keep the vessel clean.

6. Wash the product before stowage.

7. Chill fish as rapidly as possible to a temperature of 30.5° to 32°F.

8. Do not mix species or fish caught on different days.

9. Stow in a manner that will not crush the fish. Use boxes or shelving.

10. Keep trip length short so that the species which spoil fastest will still have adequate shelf life when delivered.

11. Clean and sanitize decks, fish holds and storage tanks after every trip.

12. Remember attitude is the most important factor--keep it clean; keep it cold; and keep it moving to the consumer.

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