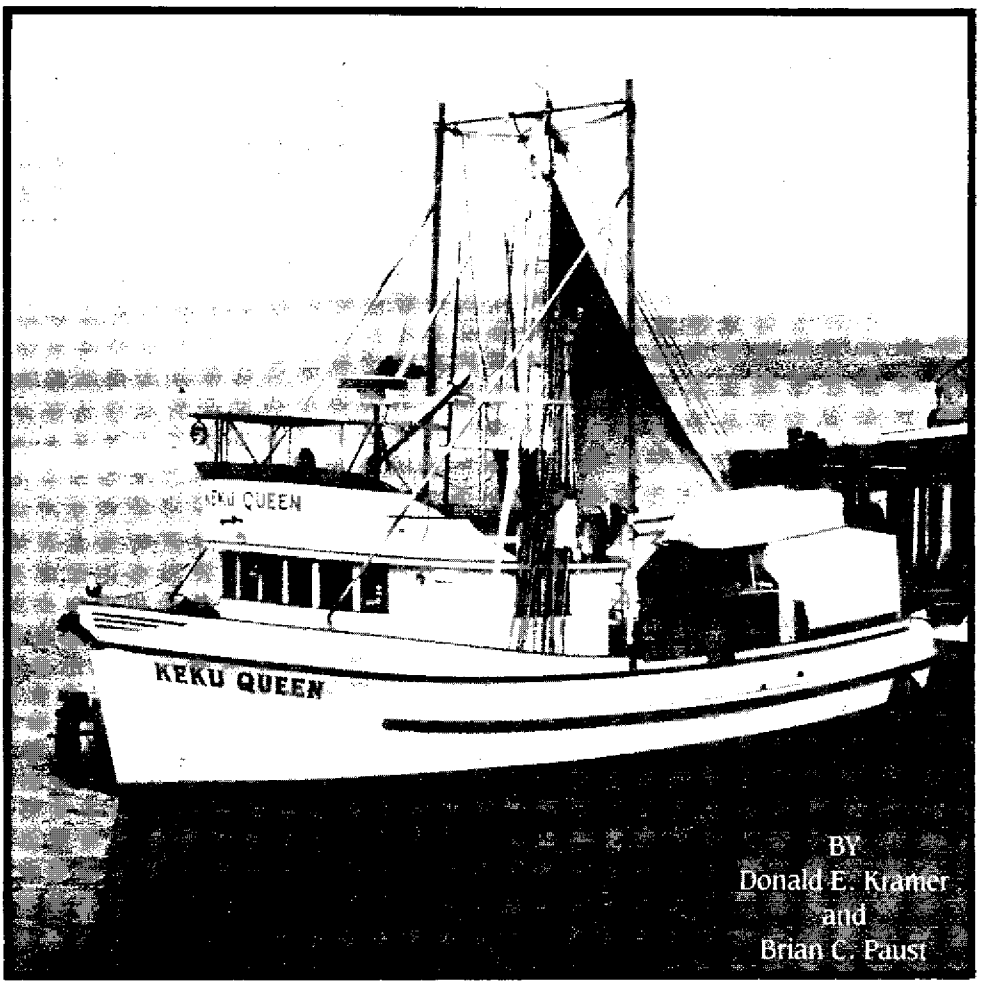
CARE OF HALIBUT ABOARD THE FISHING VESSEL



BY
Donald E. Kramer
and
Brian C. Paust

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University of Alaska
Alaska Sea Grant College Program
590 University Avenue, Suite 102
Fairbanks, Alaska 99701

Alaska Seafood
MARKETING INSTITUTE

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BY

Donald E. Kramer
Seafood Technology Specialist
Marine Advisory Program
Anchorage, Alaska

Brain C. Paust
Agent
Marine Advisory Program
Petersburg, Alaska

Illustrations by Susan Ogle

Editing and graphics by Grant Sims

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Cover photo: the fishing vessel "KEKU QUEEN" at Kake, Alaska outfitted for longlining. (photo by D.E. Kramer)

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SPECIAL NOTE:

Our hope is that this entire publication will be read by all participating halibut fishermen. For the convenience of those in a rush, however, a number of the more important instructions have been highlighted by placing them in **highlighted** print. Please contact one of the authors if you have questions.

ACKNOWLEDGEMENTS

We wish to thank the following fishing industry members for reviewing parts of this publication.

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Catching, processing, and marketing any species of fish for food can be successful only when the consumer is assured of a consistently high quality product. After death, fish begin to lose quality. If they are not handled, dressed, and stored properly, or if they are held too long before freezing, spoilage odors and flavors develop which make the fish unfit for human consumption. The growth of bacteria and action of fish enzymes responsible for quality loss in seafood are controlled mainly by regulating temperature. Professional halibut longline fishermen traditionally have taken very good care of their fish, and most has been landed with good quality.

Management of the halibut fishery has provided good preservation of the resource. With no limit on effort, however, the present quotas can be taken in a few days and the season consists of a few short openings rather than a fishery spread from April to October. In the past, voluntary fleet programs used layup rules which provided for some extension of the fishing season and a more orderly delivery and marketing of halibut by establishing rest periods or layups for the fishing vessels. These are not in use today and the halibut season consists of what has become referred to as a series of "derby days."

This mad race to harvest the quota has resulted in many handling and processing problems. There are problems with new fishermen who lack knowledge of the handling, dressing and icing aspects of the halibut fishery. There are also problems of handling the glut of fish at the processing plant. Both on fishing vessels and in processing plants, the major problem has been inadequate chilling of the fish due to use of too little ice or improper icing procedures. Halibut have been landed with internal flesh temperatures in excess of 50°F. Handling and holding conditions will have a major effect not just on landed quality but also on the frozen storage characteristics of the fish.

The extreme competitiveness of the fishery often interferes with proper icing and storage procedures. Fishermen exceed operational limits by setting too much gear or pulling faster than they can handle fish. They must stop pulling gear when necessary to dress fish and get them into chilled storage. Managers of processing operations exceed their operational limits when they purchase so much fish that their inspection and processing capacities are exceeded. A quality control protocol must be set up which will anticipate and facilitate processing during time of glut so that quality is not sacrificed. Both fishermen and processing plant workers must be made aware of the steps necessary to ensure preservation of quality.

For fishermen who take pride in their abilities, there should be no such thing as a No. 2 halibut. The only excuse for landing No. 2 halibut should be shark bitten halibut or halibut damaged by sand fleas. Cuts, bruises, and inappropriate gaff marks are evidence of poor handling. Discoloration, sour odor, and soft texture are evidence of poor storage conditions due to inadequate vessel preparation. Halibut which are No. 2 because of poor handling or storage should, in the best interest of this fishery, be directed to the reduction plant.

Halibut is a fish with excellent intrinsic quality and storage characteristics. Maintaining the quality requires observance of uniform standards of handling and processing. This publication will present the steps needed to land uniformly high quality fish and eliminate the problems of yellowness, softness, and sourness. Our focus will be on small boats, in particular newcomers to the halibut fishery. References are listed to support the information given and to supply additional information.

Gaffing Halibut

Gaffing is the most practical way to land halibut. With species of fish such as halibut which have a large gill cover, it is recommended that for small fish that the gaff hook be inserted under the gills when this is possible. This is often an impossible task due to the orientation of the fish upon surfacing, particularly on vessels with considerable freeboard. Consequently, the recommendation for halibut is to gaff only in the head and never through the body or tail. For very large fish requiring more than one gaff, all gaffs should be used in the head. The practice of inserting a second gaff in the tail is not recommended. Lifting by the tail can break the spine and cause discoloration of the flesh due to the breaking of the blood vessel which runs along the spine. It also can result in muscle fiber separation (gaping) which shows up as holes or gapes in the flesh.

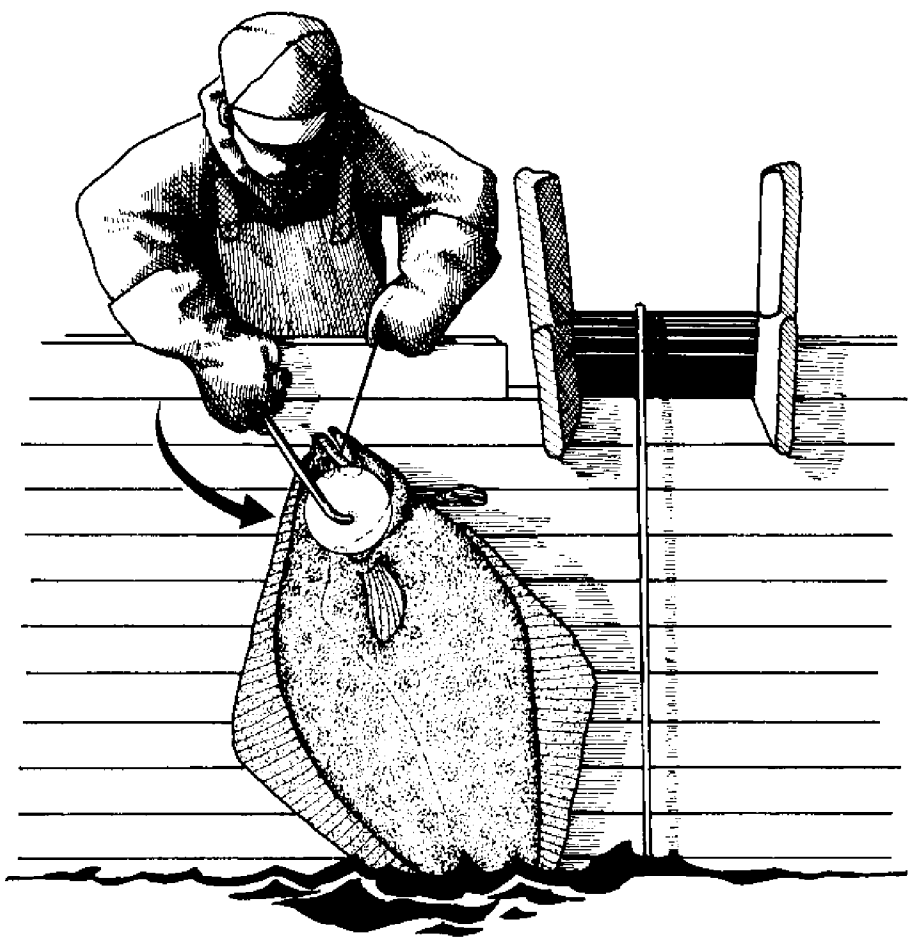

Figure 1. Gaff only in head or under gills. Try to gaff at the upper edge of the circle shown, as gaffing in the middle ruins the cheek meat. Never gaff lower than the circle shown as you may hit the body flesh.

Reasons for not gaffing the body or tail include:

(1) the skin and flesh will be torn, disfiguring the fish,

(2) blood vessels will be broken and there will be bruising or discoloration caused by the blood,

(3) the natural barrier of the skin against bacterial invasion will be lost when holes are made in it and bacteria are injected into the flesh by the gaff,

(4) tissue fluid and blood released by gaff damage are good food for bacteria and result in more rapid bacterial growth and multiplication, and

(5) tail gaffing can result in much stress on the backbone and lead to bruising and tissue separation along the backbone.

Stunning the Fish

Stun and bleed halibut as soon as they are brought on board. They are very active fish; allowing them to struggle on deck before killing can result in several problems including physical damage to the muscle which later shows up as bruising. For this reason, large halibut should not be allowed to flop on deck or on a layer of previously killed fish. Take special care when stunning a fish positioned on top of other halibut to be sure that all stunning blows are accurately directed. In addition, allowing excessive exhausting of halibut may impair quality and lead to a condition called "chalkiness" (see section on chalky halibut).

Stun by striking only on the head with a blow in the immediate area of the eyes (see diagram 2).

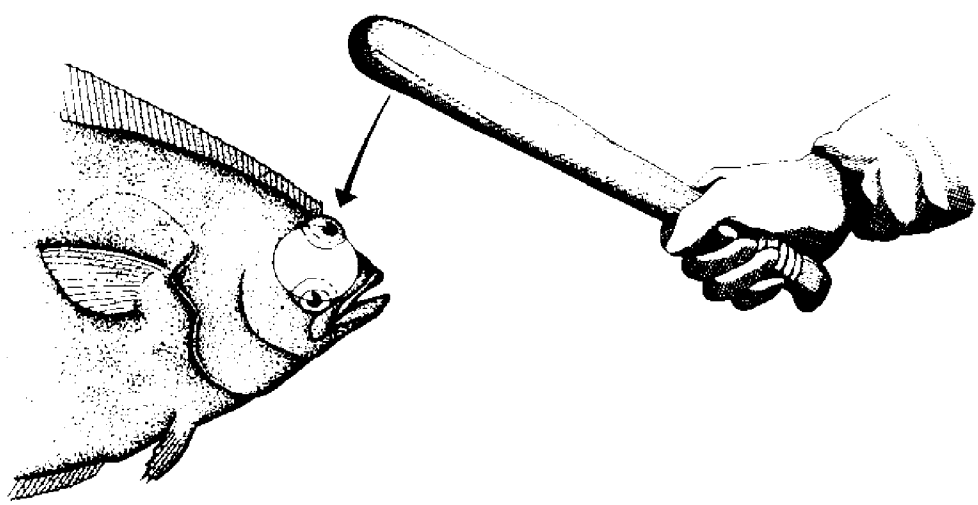

Figure 2. Stun by striking in area of eyes.

The stunning blows should be accurately placed, as blows to the body cause as much physical damage and bruising as if the fish had been left to flop around on the deck.

Bleed halibut immediately after they are stunned (see section on bleeding and dressing). If fish are bled just after stunning, most of the removable blood will drain out in five to ten minutes. Less blood will drain when fish are not bled until after they are dead. When halibut are not properly bled, flesh color will be poorer (darker).

The use of a pistol or rifle of any caliber to stun or kill halibut is considered poor practice. Not only is personal risk involved, but bullets or bullet fragments can lodge in the meat, presenting an obvious hazard for the consumer.

When practical, halibut should be dressed 20 to 30 minutes after bleeding.

Handling Halibut on Deck

Good deck management requires the proper order and arrangement of equipment on the fishing vessel so that the fish can be handled quickly, yet in ways which minimize physical damage, prevent contamination, and allow for proper stunning, bleeding, dressing, washing, and chilling. Good deck management also requires efficient use of crew labor to reduce handling time to a minimum. Fishing vessels used today in the halibut fishery differ so greatly in size, facilities and crew requirements that each fisherman needs to carefully consider the handling steps needed for his particular boat. **The catch rate permissible for a particular boat is determined not only by the size of boat and crew, but also by how rapidly and efficiently the fish can be handled on board.** Even when confronted with a very short season, the fisherman should stop pulling gear when the capacity to handle and process is in danger of being exceeded. To do otherwise can cause a tangle of fish and gear, lower fishing efficiency while the gear is being overhauled, and most importantly, result in a lower quality product.

At all times fish are on deck, efforts should be made to keep the fish temperature from increasing. Control of temperature is the most important means the fisherman has of protecting quality. Both bacterial spoilage and deterioration due to enzymatic action will proceed much more rapidly at high temperature. If considerable time is expected to elapse before the fish are dressed, they should be kept wet and iced. If it is not practical to use ice, a number of other materials can be used to cover the fish to provide evaporative heat removal. Clean burlap sacks saturated with water are good and, if nothing else is available, wet seaweed fronds can be used. Protect halibut from sun and weather with an awning, ice, clean wet burlap, or canvas whenever there is a delay in getting the fish dressed and into chilled storage. As any conscientious fisherman will recognize, the use of above deck icing, burlap sack coverings, or other evaporative cooling methods are temporary measures only, and should be used for not more than a few hours. Long term reliance on these temporary cooling practices marks both the fisherman and the vessel as being inadequately prepared for proper handling and storage of halibut.

When fish are being put into the hold, keep hatch covers open only long enough to get the fish down so as to minimize temperature increases in the fish storage area.

Some halibut fishermen "cool" their halibut by holding them along side their boats. The actual result of this practice is to cause a "warming" of the fish. Delays in getting halibut up out of the surface water will result in a rise in flesh temperature as the water at the bottom where the halibut are caught is about 10 to 15 °F colder than the water at the surface. The recommendation given for holding tuna at the surface in sea water to cool is the opposite of what should be recommended for halibut. Tuna are pelagic fish, meaning that they live closer to the sea surface, in warmer water. In addition, the body temperature of a tuna can be considerably higher than that of its environment (as much as 10-15 °F). As a result, holding tuna in sea water can result in cooling. Halibut, however, are demersal (bottom-dwelling) fish which live in water much colder than at the surface. Immersion of halibut in sea water at the side of the boat is *not* a practical means of keeping the fish cool. An increase in temperature due to delays in bringing the fish aboard will be faster in small halibut. A rise in temperature due to delays on deck in getting the fish dressed and into chill storage will also be faster for small fish. **The important point is that fishermen be aware that halibut cannot be cooled in water at the side of the boat and that the temperature of this water is usually much higher than the proper storage temperature for fish.**

The time element is very important in minimizing a rise in temperature during handling on deck. The deck arrangement must allow the quick sequence of landing, stunning, cutting to bleed, holding while the fish bleed, dressing, washing, and stowing to be accomplished quickly so the fish can be placed in chill storage as soon as is possible.

All boat surfaces which will contact fish should be of a finish that can be properly cleaned and sanitized. Fish, especially those which have been dressed and washed, should be handled with clean hands or gloves. Fish guts contain large amounts of bacteria and enzymes and should not be dropped or thrown on the deck or onto other fish. **Probably the most important sources of bacterial contamination are the mats and other fabric surfaces used to hold halibut on dressing tables.** If a mat is used, it must be washed and sanitized after each period of dressing fish. (See section on vessel cleaning and sanitation). Contamination of the fish must be kept to a minimum to obtain the best storage life.

Always handle fish carefully to prevent bruising. They must not be thrown or dropped. Arrange storage on deck so that fish are not stepped on or trampled. Move halibut into the fish hold or other storage space by handing the fish down, lowering them in containers, or sliding them down a chute. Dropping them heavily will result in damaged tissue and the problems of softness, bruising, and gaping.

Bleeding Methods

"Kill" the halibut as soon as it is boarded. A halibut is seldom instantaneously killed by the stunning club since the heart continues to beat after the stunning. Bleeding is absolutely necessary for the production of quality fish. It can be quickly accomplished by either opening the gill cavity and slashing one or more of the gill arches, or by severing the narrow band of tissue known as the isthmus that connects the halibut head to its lower body. Both cuts cause rapid arterial bleeding, which is completed in approximately five to ten minutes.

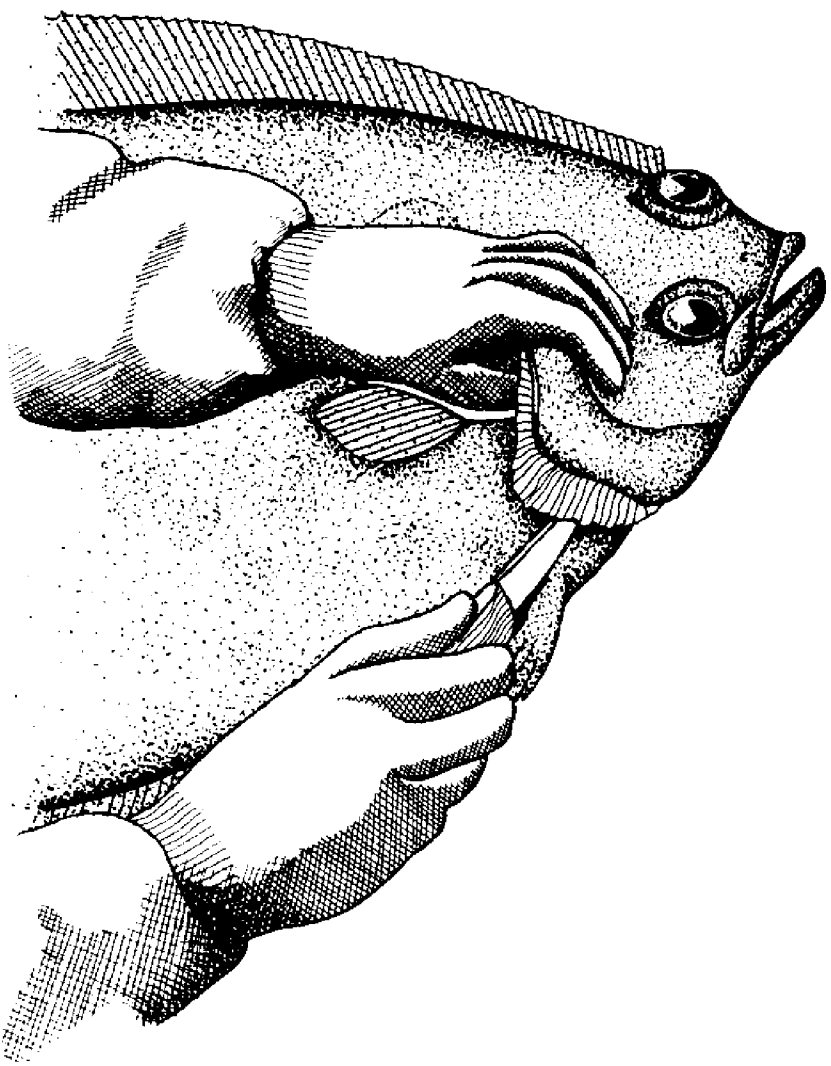

Figure 3. Cut to bleed immediately after stunning.

A third bleeding cut involves making an incision at the lower part of the body just forward of the tail fin, upwards to the spine. The cut severs a major artery lying just below the spine. Some buyers consider the tail cut a blemish and potential source of bacterial contamination. Consequently, this cut should be used only with prior approval of the processor involved.

Gutting Halibut

Adequate onboard dressing of halibut involves a sequence of "time honored" steps. Departure from these procedures increases the probability that the fish will be graded No. 2 upon delivery.

The following description assumes that the fisherman is right handed. (The left handed fisherman can follow these same procedures by placing the halibut on the dressing table with the dark side up).

(1) Place halibut on the dressing table with dark side down.

(2) Using the left hand, lift the gill flap.

(3) Cut the muscle and connective tissue attachment that keeps the gill flap shut (see diagram 4). This provides for easy access to the gill cavity.

(4) Firmly grip the gills with the left hand. This grasp will be maintained through all the remaining steps.

(5) Cut the lower gill-to-head attachment at point A (see diagram 5), retaining grasp of gills with left hand.

(6) Carefully cut the connective tissue around both sides of the "food tube" or esophagus, but do not cut last gill attachment at point B (see diagram 6).

(7) Now, cut along midline of halibut from point C to point D or the anus ("vent") as shown in diagram 7. Caution: at this point be certain that cuts are not made into the meat.

(8) Cut the upper gill attachment at point B (see diagram 8). This will free the entire gill and gut mass.

(9) Still holding the gills with the left hand, pull the entire mass from the halibut, cut the abdominal tract loose at the vent, and immediately discard the gill and gut mass overboard.

Note: After practice, these steps can be completed in 30 to 60 seconds.

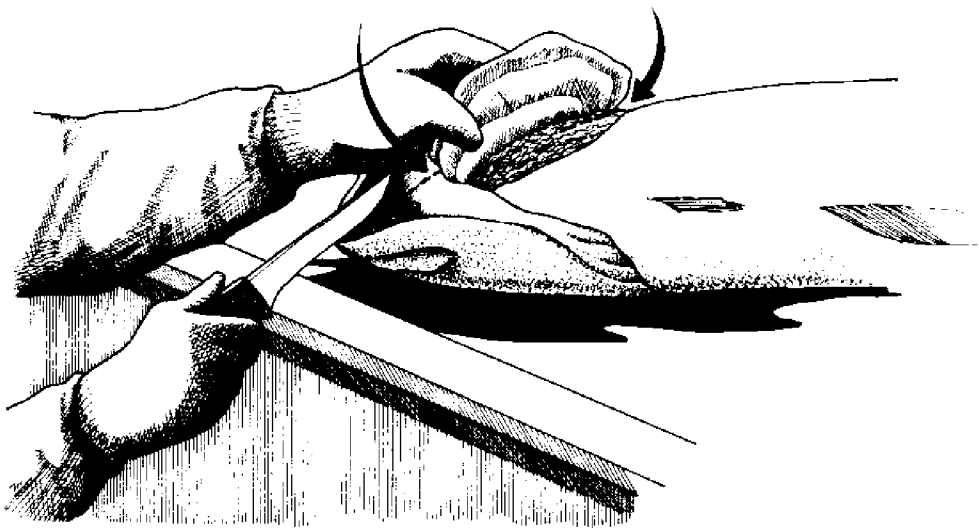

Figure 4. Lift gill cover and cut tissue at each end which holds it down.

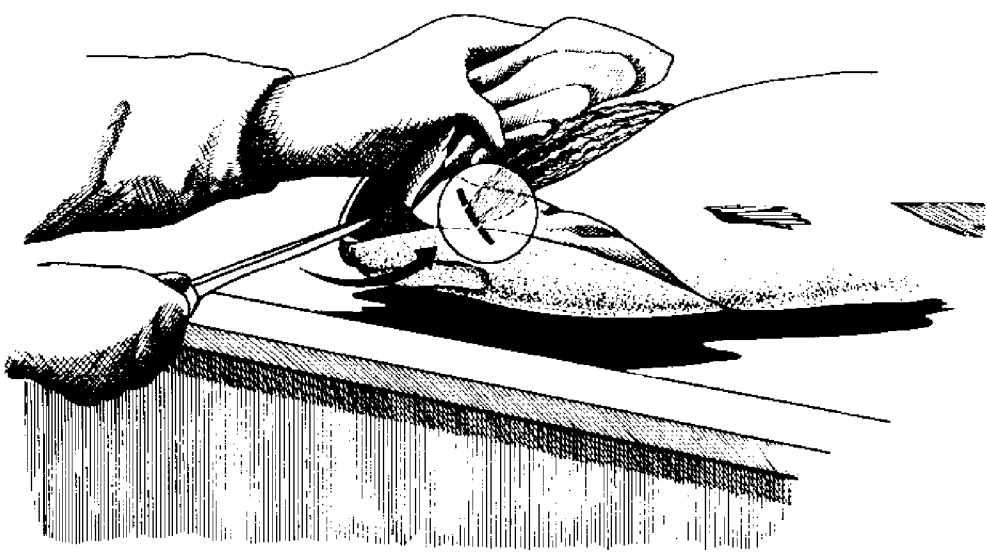

Figure 5. Cut the lower gill-to-head attachment.

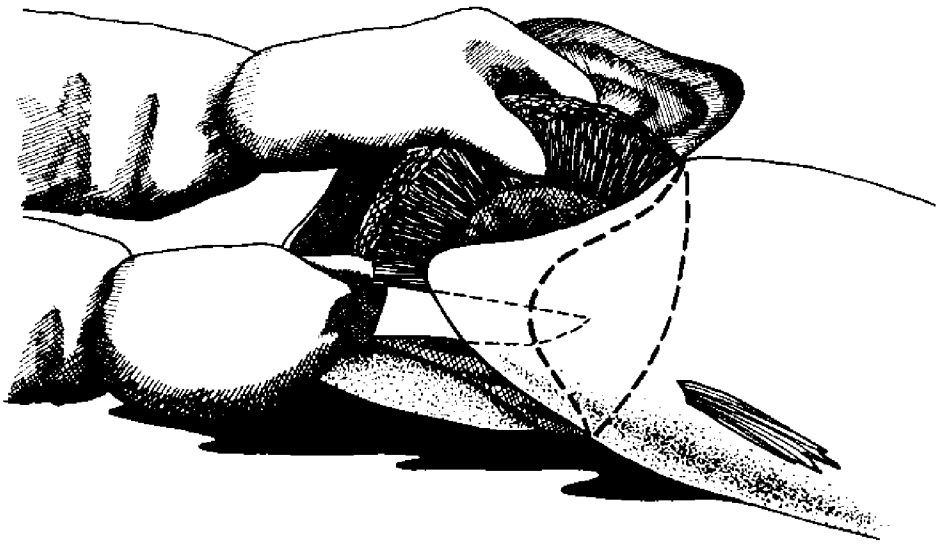

Figure 6. Cut connective tissue around esophagus or gullet to free viscera from connection to body of fish.

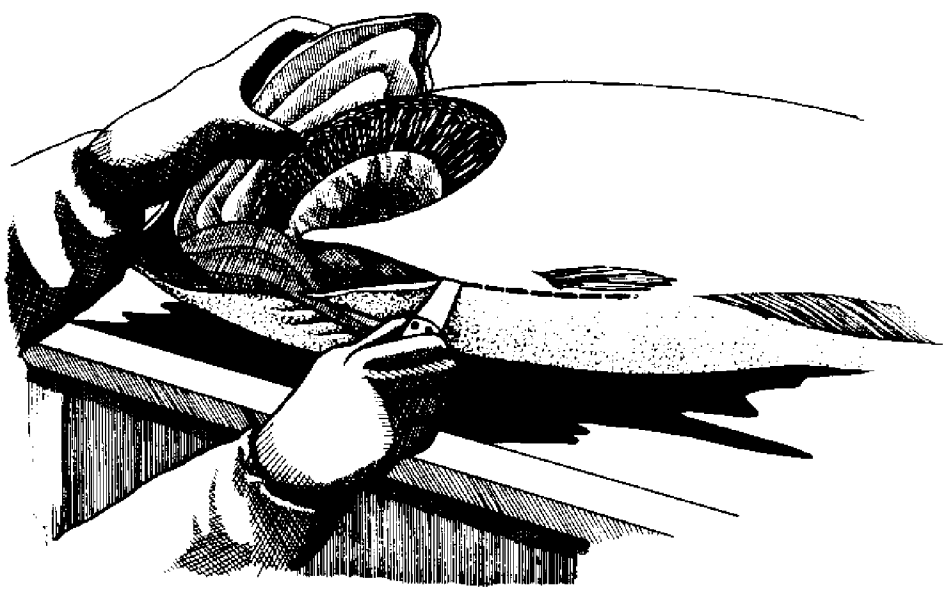

Figure 7. Cut along midline from throat to vent.

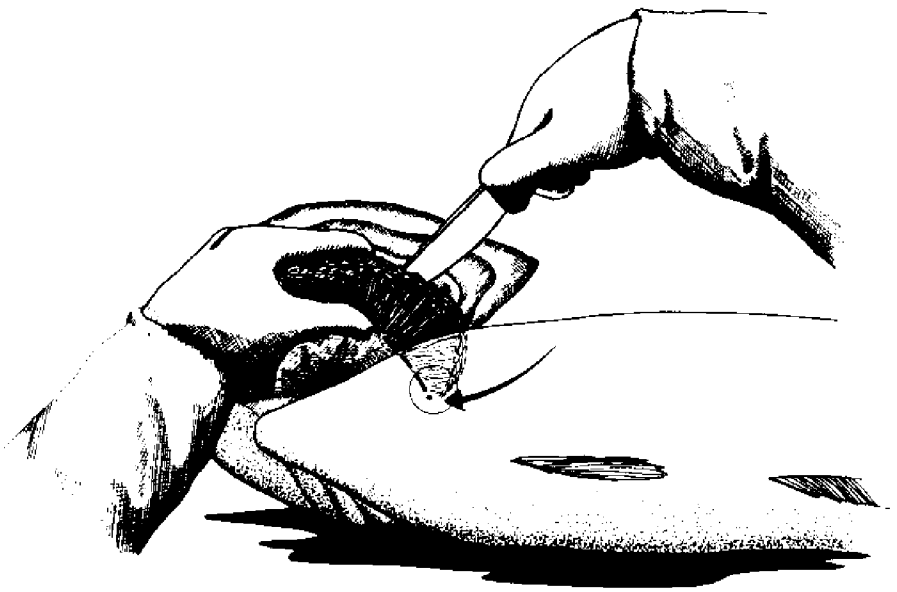

Figure 8. Cut the upper gill-to-head attachment.

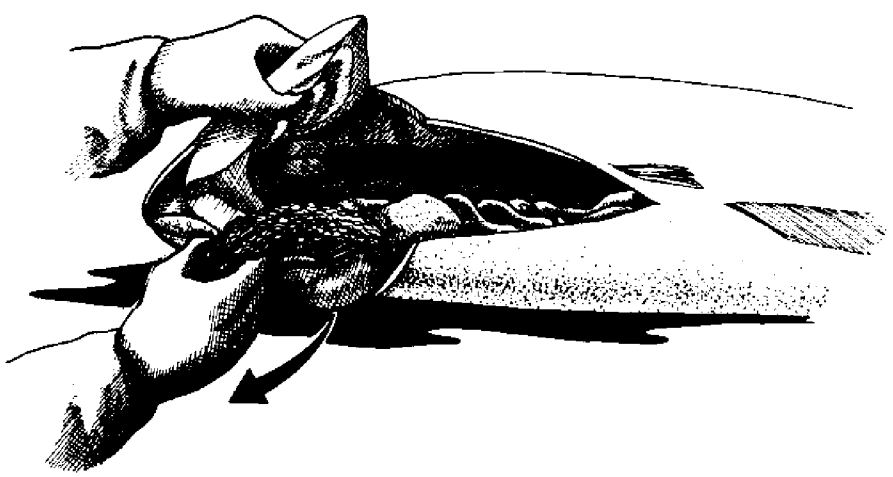

Figure 9. Pull out visceral mass, cut loose at vent, and discard.

After the gills and guts are out, the next step is to remove the gonads, kidneys, and two glandular structures known as the sweetmeats. The reproductive tissue (commonly called gonads, balls or nuts) is located in the back of the gut cavity and can be dislocated and pulled loose by two fingers. The kidney tissue, lying immediately below the spinal column, is then removed with a sharpened steel scraper. Dry scraping, or scraping without the use of a wet or irrigated scraper, is not effective in cleansing the poke and is to be discouraged (see the next paragraph for description of a wet scraper). The sweetmeats, lying in the upper forward part of the gut cavity, are then scraped out by use of the scraper. In some cases, a knife may be needed. **In all cases, remove the internal organs completely and scrape away adhering tissues. No trace of blood, viscera, gonads, kidney or adhering glandular tissue should remain after the fish is washed. Otherwise, rapid souring can lead to ultimate rejection of the fish.**

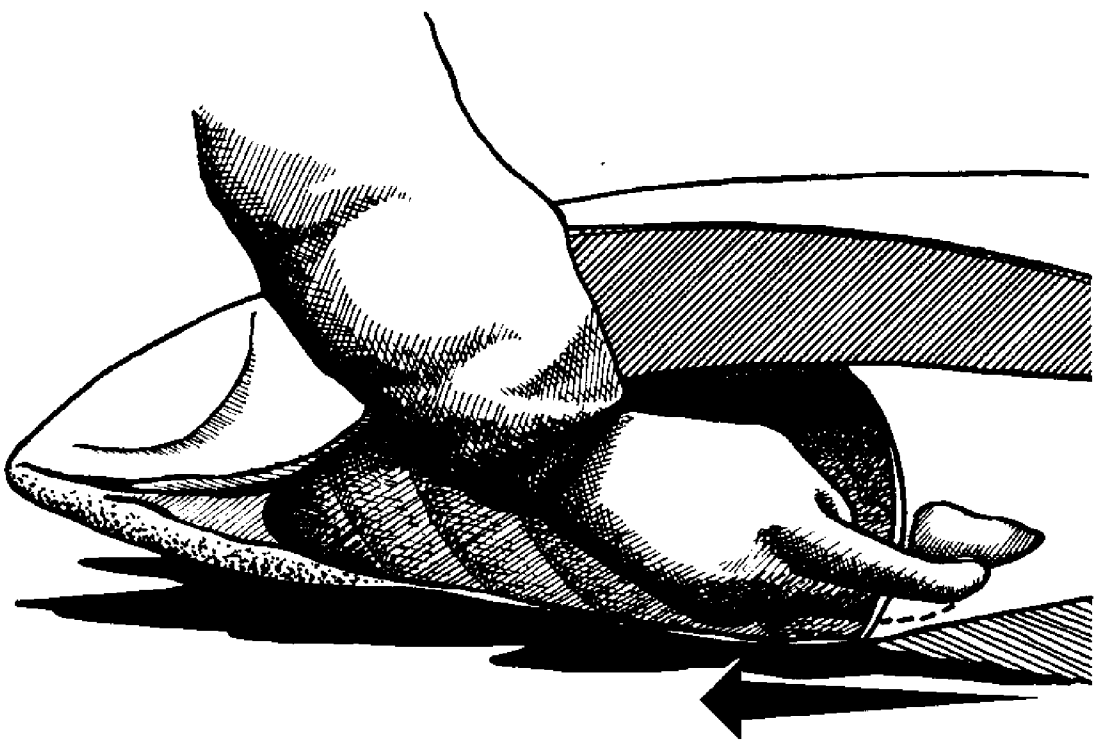

Figure 10. The gonads or balls are removed and discarded.

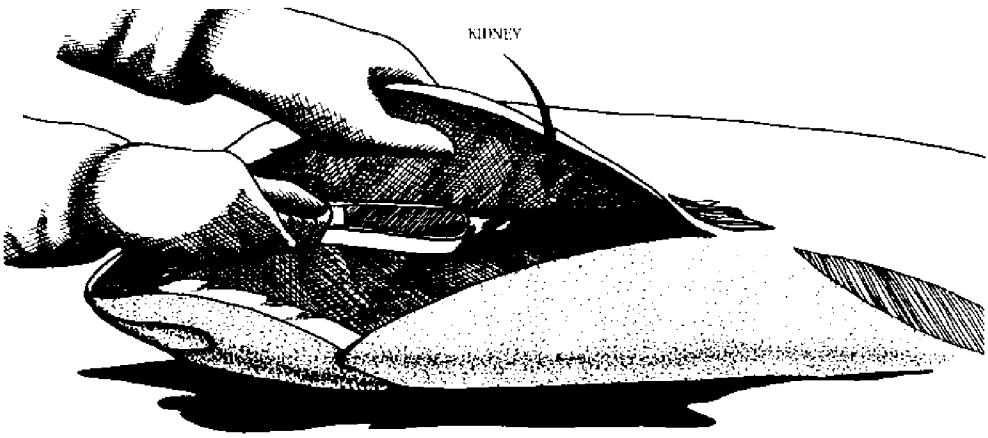

Figure 11. A scraper is used to remove the kidney tissue.

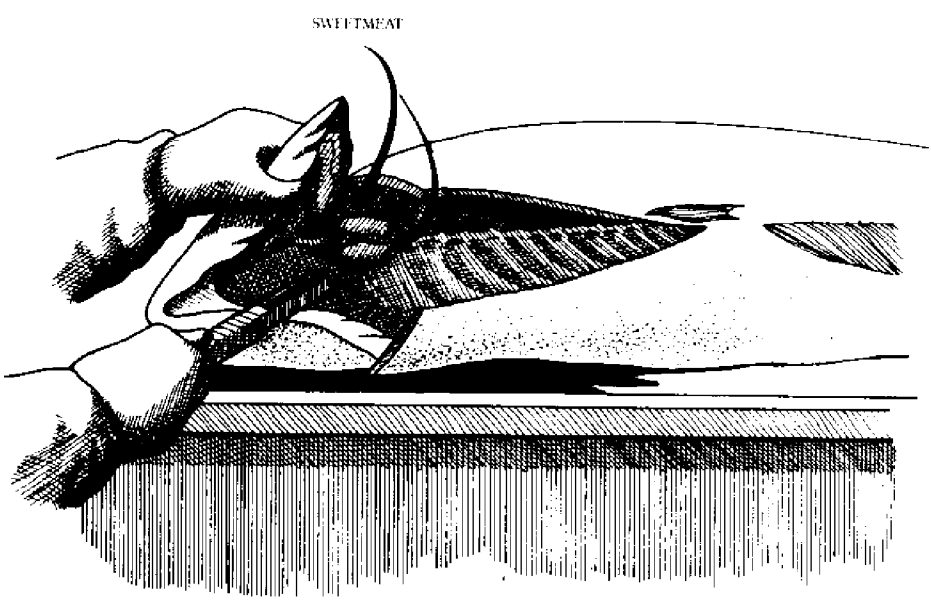

Figure 12. The sweetmeat must be scraped or cut away.

The small vessel halibut fisherman should be aware of two labor-saving devices traditionally used in the fishery. The first is needed in situations where mechanically pressurized wash water is not available. It involves the use of a small water keg or barrel connected by means of a small diameter hose to the scraper. Water is manually put into the keg enabling the fisherman to more adequately and efficiently dress the fish. The second device is a dressing table with the working surface slanted at an angle of approximately 20 degrees. Many variations are used, but all are designed to provide the fisherman a better view and easier access to the halibut poke. The fish is placed on this table dark side down with the poke and head in an elevated position close to the fisherman. Blocks or boards along the lower edge and sides hold the fish in position.

Washing

During washing of the gut and gill cavities, all remnants of intestinal, kidney, sweetmeat, and gill tissues must be removed, and all traces of blood washed away. The irrigated scraper will significantly ease this chore. Improper washing hastens souring of the halibut. The skin of the fish should be checked for obvious contamination such as adhering blood clots that can be removed by light scraping. Washing the skin of the fish will reduce numbers of bacteria. The slime removed by washing is quickly replaced by the mucous glands, as these are active up to several days after death.

ICED STORAGE OF HALIBUT

Period of Storage

The temperature of halibut when taken from the water ranges from 40 to 55 °F. Bacteria grow quickly in this range, so the temperature must be lowered quickly. The chill storage temperature at which fish keep best is at or near 32 °F. Icing is an excellent way of cooling the fish and holding them at this temperature. The chill storage life of fish is limited because bacterial growth and enzymic action are slowed but not stopped at 32 °F. Halibut has very good storage characteristics and the quality will still be very high after six to eight days of proper chill storage. Halibut has been landed after 15 to 20 days of iced storage and was still of acceptable quality. **If not handled and stored properly, however, loss of quality can take place in a few days.**

Freshwater ice is recommended but saltwater ice can be used if freshwater ice is not available. Saltwater ice may, however, result in partially frozen fish or in salt uptake by the flesh. Freshwater ice should be made from potable water and stored in clean bins on the vessel. Saltwater ice should be made from clean uncontaminated sea water. If ice is made from poor quality water, the fish will be contaminated. Crushed or flaked ice which is finely divided should be used because small particles give best contact with the fish for more effective cooling and will cause less pock mark damage to the surface of the fish.

Aged ice is said to keep fish better. In the past, fresh or "green" ice was avoided by fishermen. This is, no doubt, due to the aged ice having been cooled at least 10 to 15° below its melting point, making it easier to handle and longer lasting. Ice cooled to 5 °F at the ice plant will flow easily, load well, and not fuse together into large chunks. Most ice used on the West Coast today is flake ice which is generally 20 °F or below when it is made and doesn't require much aging.

All ice should be discarded at the end of the fishing trip. Even ice which has not been used for holding fish will have much higher bacterial counts at the end of the trip and should be discarded. Use of contaminated ice will result in shorter storage life of the fish. The storage of groceries in the ice to be used for the chill storage of halibut is another obvious source of bacteria and other forms of contamination and, consequently, should not be done.

The quantity of ice needed is calculated on the basis of the length of the trip, amount of catch, water temperature, air temperature, length of time the fish are on deck after being brought aboard, insulation in the fish hold, and whether mechanical refrigeration is used. Use enough ice to chill the fish to 32 °F and maintain them at this temperature until they are sold. Ice calculations also should compensate for heat leakage into fish storage area so that at the end of the trip the fish are still surrounded by ice. Extra ice also will be needed to provide for cooling when delays in unloading occur or when long trips to alternate markets are necessary. Sufficient ice should be carried to provide for a margin of safety in case of delay due to weather or other unanticipated events. For long trips, halibut should be iced using at least one part ice to two parts fish. For short trips, the ratio should be at least one part ice to three parts fish. For short trips on a vessel with an insulated hold, this ratio should be at least one part ice to four parts fish. A rule of thumb is that a halibut vessel should carry one pound of ice for each pound of halibut expected to be caught on a ten-day trip.

Halibut which are well-fed and in a good nutritional state appear to have better storage characteristics. This possibly is due to a higher amount of glycogen in well-fed fish which is converted to lactic acid during storage. This results in lower muscle pH (higher acidity) and lower rates of bacterial growth. It must be recognized that this will make the fish more susceptible to development of the condition referred to as "chalky" halibut described in the section on chalky halibut.

Icing and Placing Fish in Chill Storage

The delivery of quality fish requires that the temperature of the halibut be lowered and maintained at 32 °F within a short time after being brought aboard. The fish hold, whether improvised or built in as an integral part of the vessel, must protect the fish from temperature rise, oil and gas contamination, bacterial contamination and physical damage. In addition, the fish hold must be kept sanitary (must be capable of being properly cleaned) and must allow for the proper drainage of the iced fish.

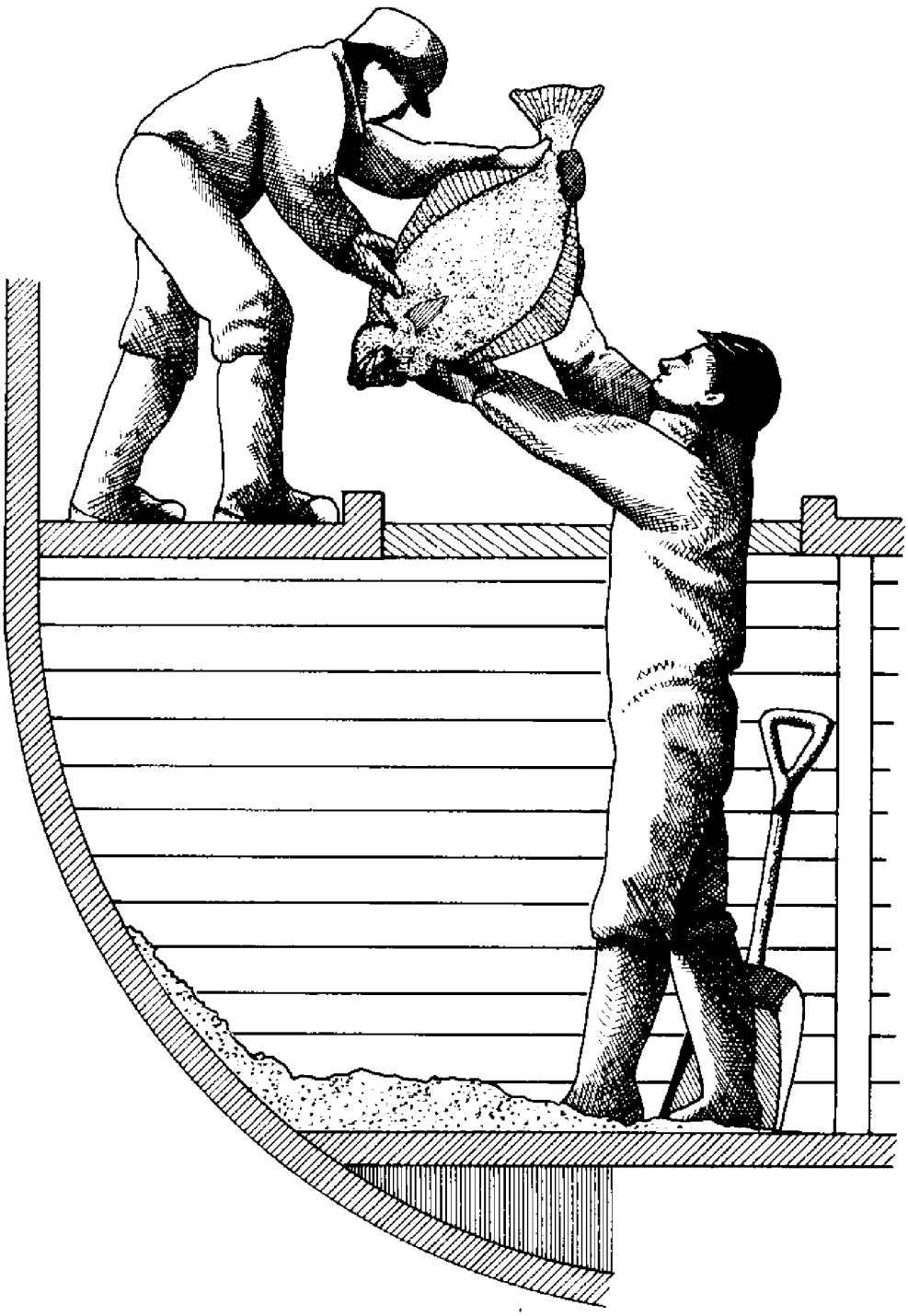

Figure 13. Do not drop halibut into the hold. Pass them down or slide them down a chute.

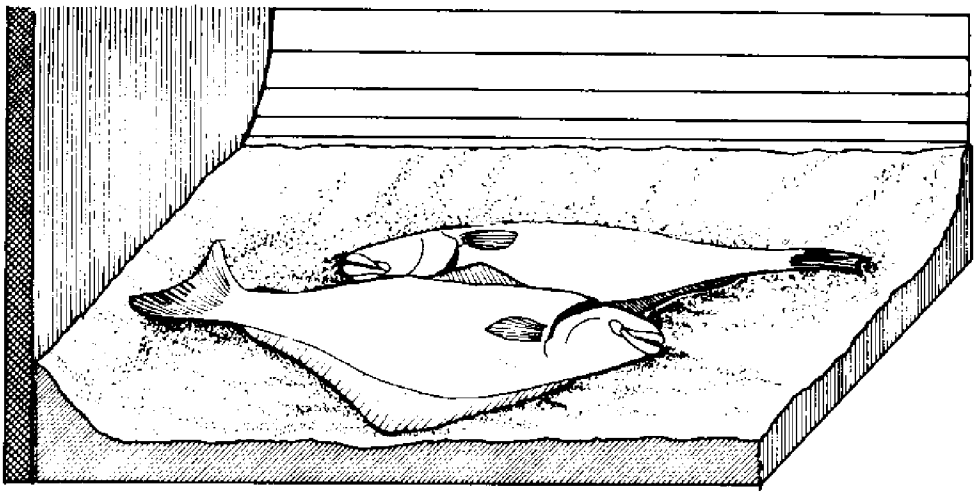

Figure 14. Use enough ice at bottom and sides of pen to keep halibut away from vessel sides, and to prevent a temperature rise.

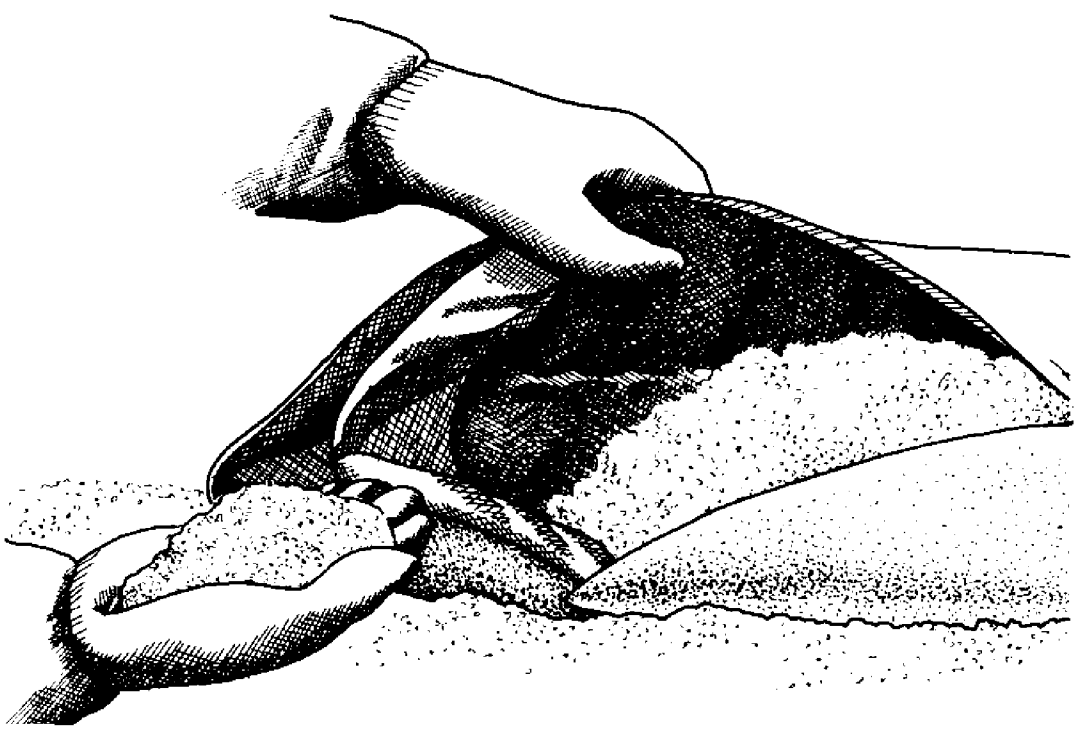

Figure 15. Fill pokes of all halibut, small as well as large, with ice.

ICED STORAGE OF HALIBUT

Halibut traditionally are iced in pens of various dimensions. The first step in the process is to build an ice bed or bottom layer six inches deep (much thicker in areas where unusual heat gain is expected). The first layer of halibut is placed on this ice bed dark side down with the poke oriented slightly downwards. Just enough downward slant of the poke is needed to allow melt water to drain out of this cavity. The poke and gill cavities are then completely filled (packed) with finely divided ice. On the average, the poke will only hold enough ice to equal 9% of the body weight when the ice is firmly packed in. Ice is shoveled over the heads of the halibut. The purpose of this is to prevent the ice from falling out of the poke and head during the course of the trip. Additional layers of halibut are then placed on the first layer dark side down and in a head-to-tail orientation (head of fish in first layer being matched with the tail of fish in second layer). Again, the poke points lightly downward and is completely filled with ice. A thin layer of ice is spread over the heads, but no ice is distributed over the bodies of the fish. The top layer is stowed white side down and then covered with six to eight inches of ice.

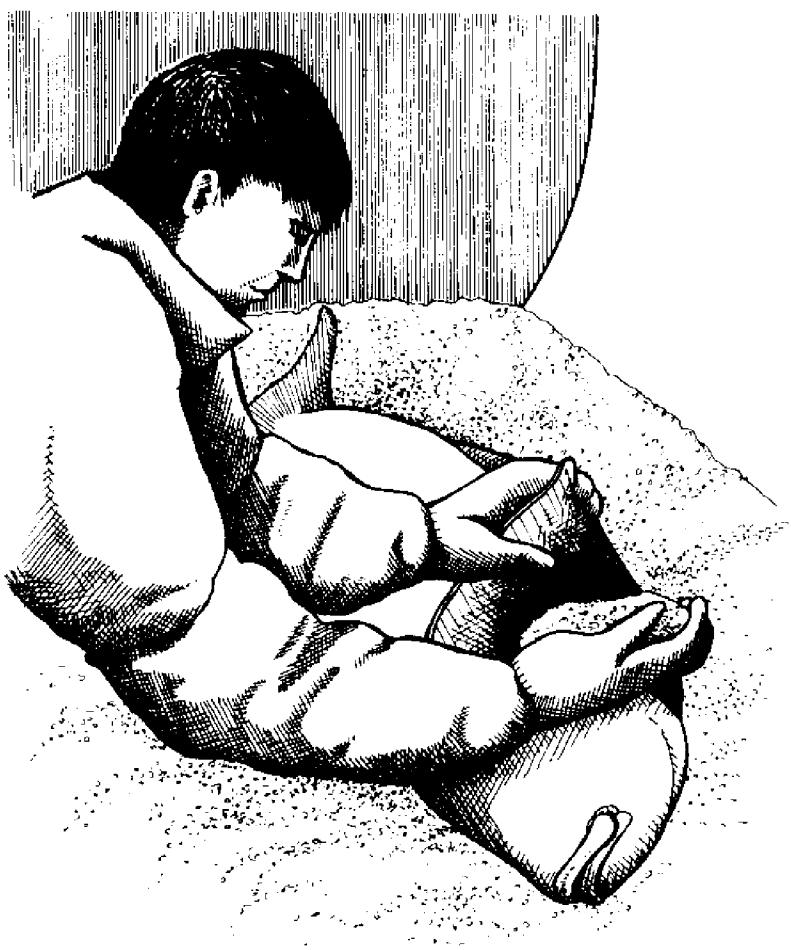

Figure 16. Pack as much ice in poke as you can to drop the temperature of the fish quickly.

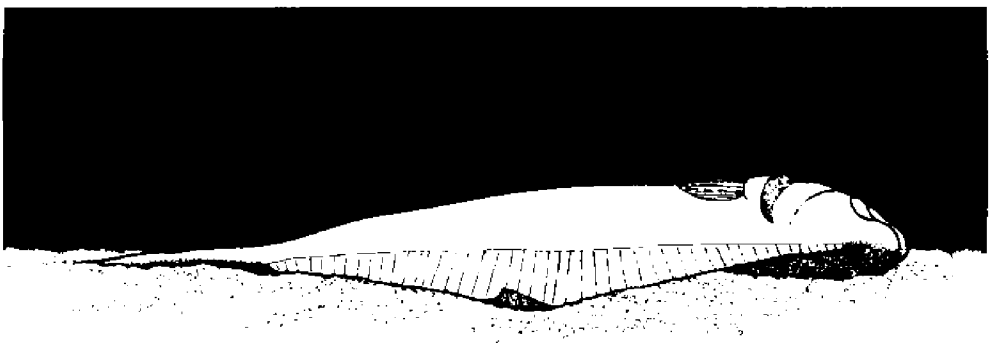

Figure 17. Ice halibut in layers with dark side down.

Give proper attention to icing the top and sides of the pen to prevent temperature rise resulting from vessel heat. Use a minimum of six inches of ice. Both the side and top ice layers should be renewed as needed.

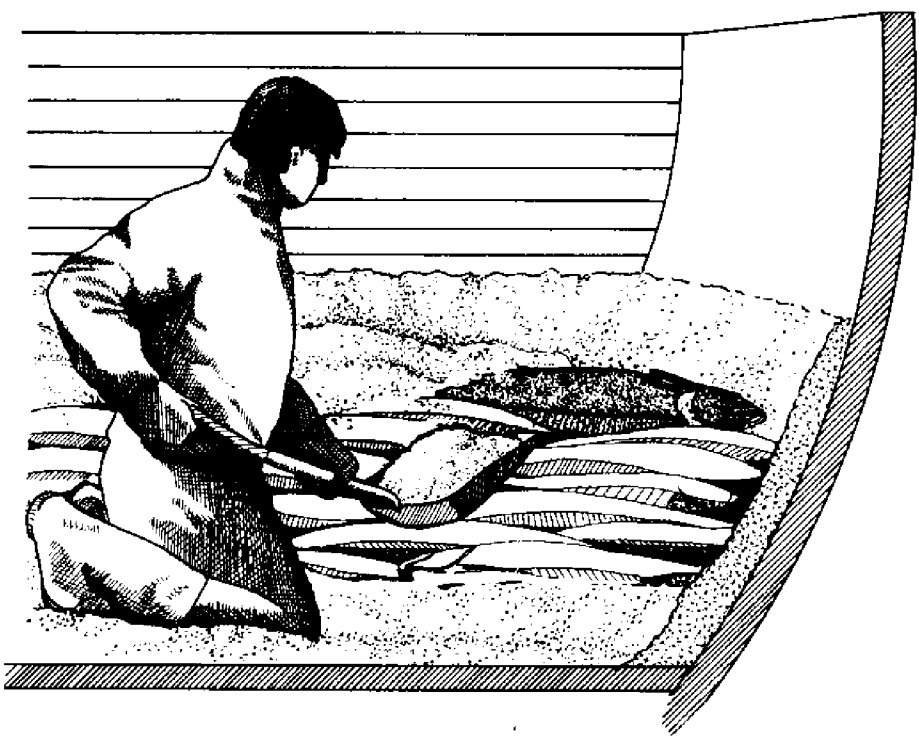

Figure 18. All layers of halibut are iced dark side down except top layer which is iced white side down.

STORAGE OF HALIBUT IN CSW OR RSW

The storage of halibut in chilled sea water or slush ice (sea water chilled with ice) or in refrigerated sea water (sea water chilled with a mechanical refrigeration unit) has several advantages. The most important is that it is much less laborious than icing; as a result, large catches can be handled more efficiently. Circulating chilled liquid over fish permits very fast cooling rates as liquids provide excellent heat transfer. Circulation is accomplished with a pump. Chilled sea water (CSW) systems which use bubbling of compressed air through the tank to obtain good mixing are called champagne systems. Drawbacks of sea water systems for halibut include a leached out appearance of the skin and sometimes the development of slight off flavors.

Considerable study has been done in Canada on the use of refrigerated sea water (RSW) in place of ice to chill fish. Halibut was one of the species which was part of these studies. It was reported to be in very fine condition after 15 days of storage in RSW, and one experimental lot was reported to be in good condition after 29 days holding in RSW. It must be pointed out, however, that this work was done in a laboratory under ideal holding conditions. In commercial practice, a storage time of this length would not often be obtained. Nevertheless, the results show that halibut can be held successfully in RSW or CSW. No serious problems are apparent with storage of eviscerated halibut in sea water, and the flesh does not become significantly salty. Weight increases for this method of holding halibut are approximately one per cent when the fish are held one week, three per cent for two weeks, and five per cent for three weeks. This gain in weight results in increased thaw drip when fish are frozen and then thawed for use.

At least three British Columbia vessels fished halibut for several seasons using RSW storage successfully. Although RSW and CSW are effective methods of chilling hablut and are labor-saving, they still have not been generally used. During the past few seasons there have been some disappointing results with sea water systems for halibut. To successfully use CSW or RSW one must have good clean fish and water, proper temperature control during holding, and proper cleaning and sanitizing of the system between trips. Lack of attention to any one of these three criteria can result in ruining a whole tank of fish.

In using either CSW or RSW systems, care must be taken to minimize the addition of contaminants to the tanks. Fish slime, blood, and viscera can have high concentrations of bacteria and enzymes, so addition of these to sea water systems must be kept as low as possible. Only clean ice and sea water should be used. Halibut should be dressed and thoroughly washed before placing in the tanks. Both CSW and RSW operate as closed systems so any contaminants added to the tanks are continually in contact with the fish and will result in more rapid spoilage.

Temperature must be maintained between 30 to 32 °F. The lower side of this range is best. Keeping the sea water temperature as near 30 °F as possible will give the best storage conditions. For CSW systems, use enough ice to cool the sea water added, to cool the fish added, and to maintain the temperature at 32 °F or below until the fish are

landed. RSW systems should be operated to keep the temperature as near 30 °F as possible and to minimize temperature fluctuations. Circulation should be effective in preventing stratification or channeling of the circulating water so that warm areas do not occur in the tank. The temperature in the tank or hold should be monitored closely at several places so any circulation problems are detected early and corrected.

Immediately after the fish have been landed, all tanks or holds, pipes, and heat exchangers must be properly cleaned and sanitized. Flush with clean water to remove as much slime, blood, and scales as possible. Then wash with a good alkaline detergent. The design of some heat exchangers make them difficult to clean. If a strong lye solution is used for cleaning, the people using it must be made aware of the dangers of strong lye to skin and eyes. After cleaning, flush with water to remove all trace of the cleaning solution. Sanitize tanks and holds with a chlorine disinfectant such as bleach. For RSW systems, sanitize the pipes and heat exchangers with a noncorrosive disinfectant such as an iodophor. After a final flush with clean water the system is ready for the next trip.

ONBOARD FREEZING OF HALIBUT

Freezing Halibut on the Fishing Vessel

There was considerable interest in freezing halibut on the fishing vessel in the early 1970s. The salmon troller fleet in British Columbia had a large number of freezer trollers, and as the halibut season at that time extended over a much longer period than today, there was reason to consider freezing at sea. Presently, however, the short halibut openings make it unlikely that vessels engaged in catching halibut will freeze their catch. Nevertheless, we will briefly discuss freezing of halibut at sea in case management of the fishery changes to provide for longer openings.

As with any species of fish, the freezing process should be kept to as short a time as possible. It is desirable to get the core temperature of fish to below 0 °F in less than 12 hours. With large halibut this may not be practical; but if it takes several days to get the fish frozen, there will be much greater quality loss than if freezing is complete in a day or less.

Effects of Rigor

Rigor or rigor mortis is the stiffening of the muscle of an animal shortly after death. It is sometimes called death stiffening. There is no simple answer to the question of whether it is best to freeze pre-rigor, in-rigor, or post-rigor. In general it is best to complete freezing before rigor begins or to wait until the fish is completely through rigor before putting it into the freezer. Fish which are frozen when going into or during the process of rigor will have more breakdown of the muscle connective tissue and the result will be softer texture and more pronounced gaping (holes or pockets in the flesh). Fish frozen pre-rigor or in-rigor and held frozen for a short time will undergo thaw rigor (rigor after thawing).

Thaw rigor can result in high drip loss and tougher texture. To prevent thaw rigor keep fish frozen for at least eight weeks; or if it is necessary to thaw them, carry out the thawing process very slowly.

Experimental work with frozen halibut has shown the best quality product will be obtained if the freezing is done pre-rigor. Halibut frozen pre-rigor at sea rather than ashore after five to 15 days in ice or refrigerated sea water has been shown to have better and more uniform quality as judged by a sensory panel on the cooked fish. Also, the pre-rigor frozen fish had a lower amount of drip.

Glazing

Glaze is a coating of ice put on a frozen fish by dipping it in a glazing solution. Glaze is put on to protect the fish from loss of quality and weight. All fish should be glazed after freezing and before storing.

Figure 19. Halibut should be glazed after freezing to protect from dehydration and oxidation.

The recommended solution for glazing at sea is a mixture of 50 per cent sea water and 50 per cent fresh water. Straight sea water can be used if no fresh water or ice is available, but the glaze will not last as long. Glaze water should be cooled and kept as near the freezing point as practical during glazing. Loss of glaze can be prevented during storage by protecting the fish from moving air using plastic sheets or bags and by preventing the fish from contacting the fish hold lining.

Onboard Frozen Storage

Handle frozen halibut carefully to prevent cracking of the glaze or breaking of the fins or tail. Do not drop frozen fish; and store them carefully to prevent movement.

A uniform storage temperature is necessary to maintain good quality. A storage temperature of -15 to -20°F or lower will provide excellent storage conditions if the temperature is not allowed to fluctuate. Storage temperatures in the -5 to -10°F range are less desirable but still acceptable. Frozen storage above 0°F is not acceptable and quality loss will be at a much higher rate than desirable.

"CHALKY" HALIBUT

Description of Condition

The raw meat of normal halibut is shiny and a semitranslucent white. The flesh is firm. The raw meat of "chalky" halibut is a dull, flat, chalky opaque white. Severely chalky fish are soft and flabby with a watery texture. The condition is not apparent when the fish is first caught, but will become evident within one to two days. Protein solubility is lower in chalky halibut and there is less protein in both the free and cooked drip. The free drip when a normal fish is cut is one to two per cent. For chalky fish it is usually four to six per cent and may be as high as nine per cent. The cooked meat of chalky halibut is dry and tough; but other than being of poor texture, it is acceptable.

The chalky condition should not be confused with the mushy or milky condition found in some halibut and several other species of ocean white fish. This is caused by a nonpatogenic protozoan parasite which produces high levels of proteolytic enzymes (enzymes capable of breaking down proteins). The soft texture due to these enzymes usually occurs in pockets or localized areas, not throughout the flesh. Fish having poor texture due to these parasites have been referred to as being in a "milky," "jellied," or "putty" condition. This is found in several species of flounders (most notably arrowtooth flounder or turbot), in Pacific hake or whiting, and occasionally in sablefish or black cod. In contrast to this "milky" condition, no parasites have been found associated with chalky halibut.

Causes

Chalky halibut have been found to have a lower than normal pH (muscle tissue is more acidic than normal). Fish with pH above 6.2 are never chalky, while those with pH below 6.0 are always chalky. Between pH 6.0 and 6.2, halibut are sometimes chalky,

sometimes not chalky and sometimes borderline chalky. A drop in muscle pH is primarily due to the breakdown in glycogen (a complex carbohydrate sometimes referred to as "animal starch") accompanied by the formation of lactic acid. The lower pH results in alteration (denaturation) of muscle proteins giving rise to lowered protein solubility and less water holding capacity. When the muscle proteins are sufficiently altered, chalky halibut is the result.

The following four conditions can result in halibut which have a higher than normal incidence of chalky fish:

(1) harvesting of actively feeding halibut which have high muscle glycogen reserves,

(2) death occurring after much activity or when the fish has become extremely exhausted with resultant high muscle lactic acid concentrations,

(3) halibut which are not able to get rid of a high muscle lactic acid accumulation, and

(4) high holding temperatures which result in more rapid development of chalkiness.

Observations in Canada indicate there is a higher incidence of chalky fish in halibut caught by trawl compared to those caught by longline. A possible reason could be that halibut caught by longline have a period of rest after being hooked before they are brought aboard the boat and killed so that lactic acid formed during the struggle when first hooked can be dissipated. Those caught by trawl will continue to struggle until brought aboard and killed and would have more muscle lactic acid and therefore a lower pH. It could also be that those caught by trawl are well-fed fish with high muscle glycogen levels.

Prevention

Stun and kill all halibut as soon as they are brought aboard to stop physical activity. Those allowed to struggle a long time on deck will have higher amounts of lactic acid formed, and are more susceptible to chalkiness.

Chill halibut as soon as possible. Carry out the deck handling (stunning, bleeding, dressing, and washing) as quickly as is practical so the fish are not allowed to warm before being put in chill storage. Elevated temperatures promote earlier development of chalkiness in halibut.

Those halibut which are potentially chalky (appearance or pH might be used to identify these fish) could be frozen and handled throughout the marketing sequence as a frozen product. If freezing is used to control development of chalky halibut, the fish should be used directly from the frozen state, as normal thawing results in intensification of chalkiness.

Description of Condition

The white ventral surface or belly side of halibut sometimes becomes yellow during storage in the hold of a fishing vessel. This yellowish or greenish color may appear over the entire surface of the white side or may be restricted to one or more small areas of the fish. It develops where there is exposure to air. It will not occur on skin surfaces which have been tightly packed against the surface of an adjacent fish. "Yellowing" was a more serious problem many years ago when halibut trips were longer.

Causes

Yellow discoloration is due to the growth of *Pseudomonas flourescens* or other chromogenic bacteria which excrete a yellowish-green florescent pigment. The color is a visual indication that there are large numbers of bacteria present. It indicates carelessness in handling or too long storage of the fish. The bacteria which produce the pigment and other spoilage bacteria cause deterioration of the fish so the color is often is accompanied by sour odor and soft flesh.

Prevention

Pseudomonas fluorescens is a motile aerobic bacterium which will grow under certain conditions on fish slime at low temperatures. It will grow only where oxygen is available. Icing halibut in pens with the fish packed together to exclude oxygen, and limiting the ice between layers of fish to what will melt in cooling the fish, will help eliminate the yellow discoloration as well as indentations (pock marks) in the skin. The poke is packed with ice and ice is used on the bottom, sides, and top of the pen. Use of ice made from good quality water and proper vessel sanitation generally will take care of the yellow discoloration problem. It is not a serious problem at present, because of short fishing periods.

HALIBUT VESSEL HOLD DESIGN AND MODIFICATION

Hold and Pens

The hold of a vessel fishing for halibut should contain watertight bulkheads designed to protect the fish from contamination by waste water, bilge water, smoke, fuel, and lubricants. It should have the proper sumps and pumps to allow pens to drain, and prevent accumulation of blood, slime, and melt water. All hatches should have covers which protect fish from exposure to sun and wind and prevent warming or drying of the catch. Hatch combings should be high enough to prevent flow of contaminants from the deck into the hold.

Pens should be built in the hold to prevent movement of the fish. Pen boards should be easy to remove to facilitate cleaning. Notches may be needed in the pen boards to allow melt water and fish slime to drain. Pipes, hydraulic lines, fuel lines, and waste water lines should be routed away from fish holding areas or should be enclosed to protect against contamination of the fish in case of leakage. Bait should be carried in locations that will not contaminate the catch.

For vessels with below deck holds, some means of moving the fish down which will minimize physical damage should be used. This can involve use of a chute, slanted board or some type of conveyor.

Hold Surfaces

All surfaces in the hold, especially those which are fish contact surfaces, should have a finish which can be properly cleaned and sanitized to prevent bacterial build-up. The ideal surface is smooth, watertight, nonabsorbent, and corrosion resistant. Corners are rounded, with no exposed ribs, pipes or other projections into the fish holding area which could damage the fish or make cleaning difficult. The finish should resist impregnation by bacteria, slime, and water, chemical action of cleaners and sanitizers, and cracking or peeling.

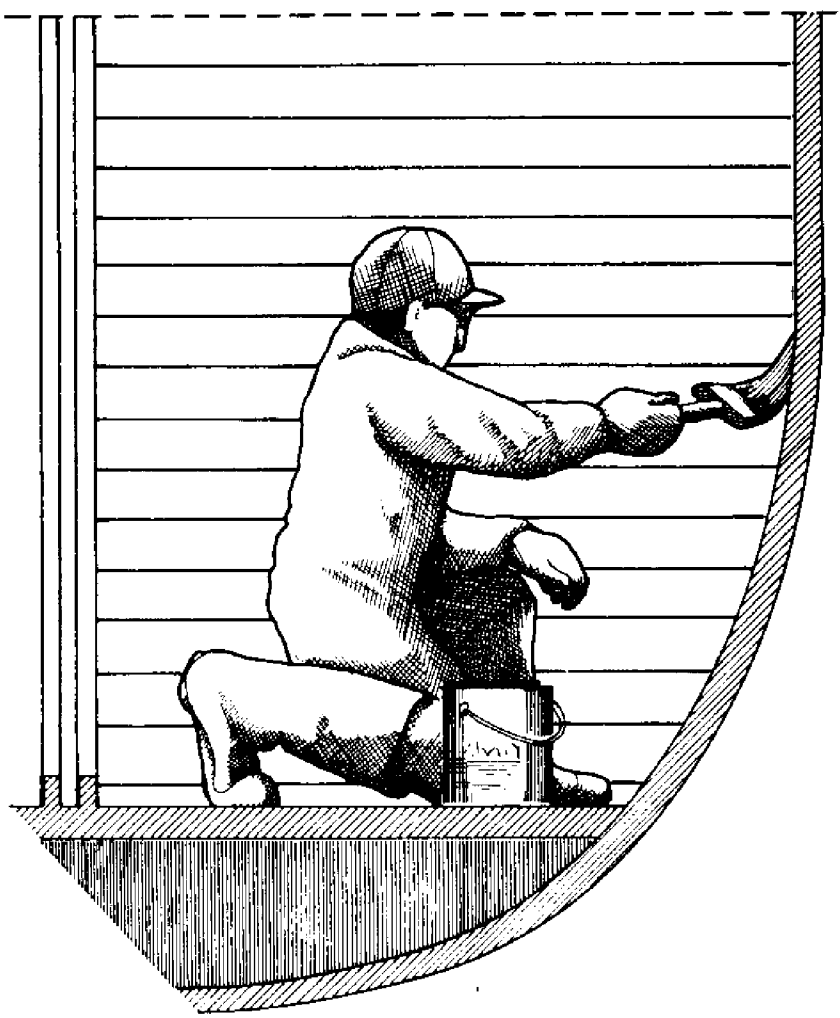

Figure 20. All hold surfaces should be smooth, and painted if wood.

Examples of good fish hold surfaces are sea water resistant aluminum alloys, epoxy or polyurethane coated ferrocement, high density plastic, and fiberglass which is impervious to water. Unfinished or worn wood is not a good surface in a fish hold as it cannot be properly cleaned and sanitized. Worn wet wood harbors anaerobic spoilage bacteria. Fish which are left in contact with it will spoil. Wood must be painted or coated with some type of smooth nontoxic material to make it cleanable. A major problem with painted wood surfaces is cuts and abrasions to the coating will allow the wood to get wet under the paint. This results in fungal decay of the wood. The fungicide, copper-8-quinolinate has been recommended as a preservative. Diesel oil is not a satisfactory wood preservative.

Plastic sheeting has been used successfully as a lining for the hold of halibut vessels to protect the fish from contamination and to make the job of cleaning the hold easier. Polyethylene sheeting of six-mil thickness or thicker is recommended.

Hold Insulation

Fishing vessels should have adequate insulation to prevent heat transfer from the deck, engine room, and living quarters to the fish hold. Ideally the fish hold should be completely insulated, including bulkheads, vessels sides, deckhead, and floor. It is especially important to insulate the engine room bulkhead. Insulation of at least R10 is recommended. We suggest at least two inches of polyurethane foam which gives about R14. All heated pipes, hydraulic lines and structural beams which run through the fish holding area should also be insulated.

The insulating layer must be protected by a suitable lining which has watertight joints.

Mechanical Refrigeration For Ice Vessels

Mechanical refrigeration is sometimes used to cool the fish hold prior to taking on ice and to conserve ice during the fishing trip. Cooling coils are installed under the deckhead and sometimes also along the side of the ship.

It has been recommended that mechanical refrigeration on ice vessels be operated to keep the temperature slightly above 32°F to allow for a slow melting of the ice. The reason given is that cooling of the fish is much more efficient by having melt water run over them and the washing action removes bacteria from the surface. This is no doubt true for most species held in ice, but the method used for icing halibut in pens gives such a tight packing of the fish that very little melt water will go through, however, care should be taken that the system is not operated so low that the top layer of fish begins to freeze.

Cleaning

After each delivery of fish and before beginning another fishing trip, the vessel should be thoroughly cleaned and sanitized. Work areas, especially where fish are being bled or gutted, should be scrubbed frequently with a suitable cleaner. All fish contact surfaces must be kept clean including boat deck, checkers, fish hold, pen boards, cleaning tables, mats, knives, gaff hooks, gloves, and raingear. Proper washing involves the following three steps:

(1) Flush all fish contact surfaces with potable fresh water or with clean sea water.

(2) Apply a suitable detergent in warm water using a stiff brush or a pressure sprayer.

(3) Rinse with potable fresh water or clean sea water.

The cleaner used should be one suited to removal of the fatty and proteinaceous material found in fish slime and gurry. Detergents containing a mixture of alkaline phosphates and a wetting agent work well. Many household laundry detergents are suitable for fishing vessel clean-up.

Steam cleaning is not recommended for wooden surfaces. The high temperature resulting from the use of live steam can cause the wood to take up more water. Also, fatty and proteinaceous material may be taken into the wood. This makes proper cleaning and sanitizing much more difficult.

Sanitizing

Following the three cleaning steps, a sanitizing treatment should be used to kill bacteria which have not been washed away during the cleaning. The following two steps should be used.

(1) Treat all fish contact surfaces with a solution containing chlorine or iodine.

(2) Rinse off after five to ten minutes.

Chlorine is a convenient sanitizing agent because it can be obtained as ordinary liquid chlorine bleach. It must be diluted in a ratio of one-quarter to one-half cup of bleach to five gallons of water. Sanitizers containing phenols (such as Lysol and Pinesol) should never be used on fish contact surfaces.

Cleaning CSW/RSW Tanks

The importance of proper cleaning and sanitizing of CSW and RSW systems cannot be overemphasized. When iced fish spoil, usually only part of a load is affected; but with CSW or RSW systems, neglect of proper cleaning can result in spoilage of a whole load of fish. Fish hold linings and tanks used in sea water systems should be of a material which is easy to clean and disinfect. The three steps outlined under the section on cleaning, followed by the two steps given under the section of sanitizing, should be used for CSW or RSW tanks.

Cleaning RSW Chiller Systems

The piping and heat exchanger units in RSW systems must be kept clean and sanitary to assure landing of good quality fish. Unfortunately the task of cleaning these systems has too often been poorly carried out. RSW system design should include a cleaning loop to allow introduction and circulation of cleaning and sanitizing solutions. The chemical characteristics of cleaners and sanitizers must be known so that materials are not used which are corrosive to the metals in the system, particularly the chillers.

Detergents and alkaline cleaners are common cleaning agents which can be used for RSW systems. Lye (caustic soda) is an excellent cleaner and can be used safely in RSW systems which have a closed cleaning loop and which do not have aluminum in the system. The concentration of lye should be 0.1 to 0.5 per cent by weight. It must be kept in mind that strong lye is dangerous to handle as it causes severe irritation to human tissue.

Iodophors are the recommended sanitizers for use in RSW systems. They have good germicidal properties, and their color change from amber to clear gives an easy visual check that they are still active. Chlorine sanitizers are not recommended because of the corrosion hazard. Quaternary ammonium compounds leave a residue that could contaminate the fish.

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