

ON-BOARD QUALITY CONTROL

Preparing Mid-Atlantic Fisheries For the Future

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The U.S. population is eating more seafood than at any time in the nation's history. Strong national and local marketing and consumer education programs have encouraged this increased consumption. As consumers become more knowledgeable about seafood products, and as sales respond to competition, high quality products will be the rule rather than the exception. This guide focuses on the very beginning of quality assurance, on-board handling.

Areas of focus for on-board quality control measures include vessel sanitation, icing-temperature control, harvesting techniques, on-deck handling, and storage. These procedures, outlined on the following pages, are in line with preliminary requirements being set forth under the developing mandatory federal inspection program, which, in part, governs vessel sanitation and handling practices.

Introduction

Deviating from traditional on-board handling procedures in order to land higher quality fish at the dock will initially mean modification costs and extra work for the crew. However, the goal of a quality control program is to maximize the net return from the product. Maximum return for quality products occurs in many U.S. fisheries where high value species generally command a premium price. Currently, the benefits to fishermen implementing quality control procedures for mid-Atlantic fisheries are not obvious, since trip lengths are short and a number of the species harvested are considered underutilized and of low market value. A cooperative effort between fishermen and processors will be required to increase the benefits to both sectors of the seafood industry. As consumers begin demanding fish of consistent quality, buyers will be more likely to pay greater premiums for higher quality products.

Foreign suppliers are consistently providing quality fish to the U.S. market. Increased quality control measures are being applied to some domestic catches, and there is a mandatory federal inspection program being formulated. For these reasons, the mid-Atlantic fisheries should consider implementing quality control procedures to maintain their current share of the market.

Sanitation

Cleaning and sanitizing the fishing vessel is commonly overlooked by fishermen. A thorough cleaning with detergents

followed by sanitizing should be done prior to beginning a trip. Reducing the amount of exposure the catch has to bacteria and other contaminants will aid in preserving fish quality. Cleaning and sanitizing should not be restricted to end-of-the-trip cleanup, but should be incorporated into daily work habits to adequately reduce bacterial contamination.

All fish contact surfaces must be kept clean including, but not restricted to, the decks, rails, checkers, processing tables, knives, gaff hooks, picks, gloves, boots, rain gear, hatches, fish hold, and pen boards. Proper cleaning steps include:

1. Flushing all fish contact surfaces with potable freshwater when at dockside or clean seawater when offshore;
2. Applying suitable detergent using stiff plastic-bristle brushes;
3. Rinsing thoroughly with flushing water source.

Do not use seawater for cleaning while dockside because diesel fuel and other contaminants may be brought on board. The cleaner used can be a common household laundry detergent; however, commercial alkaline-based detergents used in food processing plants are recommended. Plastic-bristle brushes should be used rather than straw-bristle brushes. Plastic brushes clean easily, drain well, and harbor fewer bacteria than straw or wooden handle brushes.

Work decks should be hosed down between tows to remove slime and gurry. Attention should be given to crevices, such as

between deck tiles, to prevent accumulation of contaminants.

After a thorough detergent cleaning, a sanitizing solution should be used to kill any remaining bacteria. A commercial grade chlorine-based sanitizing solution is recommended for its purity and less corrosive properties. As an alternative, a sanitizing solution for the deck and hold can be made from ordinary liquid chlorine bleach by mixing 1/2 cup of bleach to 5 gallons of water. Do not use straight bleach or higher concentrations than recommended. No sanitary benefit is derived from such practices, but disadvantages include health hazards to crew inhaling fumes, possible catch contamination and water pollution when the solution is flushed from boat surfaces. Chlorine is also corrosive and could wear out the seals in the bilge pump. To minimize corrosive action, use only the recommended chlorine solution strength and make sure bilge is free to pump out any water collected. To sanitize hands and fish handling tools, a weaker chlorine solution or, preferably, an iodine-based compound can be used. Iodine is preferred because its concentration can be monitored easily. One tablespoon of iodine compound per gallon of water will produce a golden yellow solution. Upon use, the color of solution will begin to clear, indicating that its sanitizing effectiveness is decreasing.

Chlorine solutions should be made just prior to use because chlorine evaporates quickly, usually within 24 hours. To properly sanitize after cleaning:

1. Apply sanitizing solution to all fish contact areas previously cleaned;
2. Let stand for 5-10 minutes;
3. Rinse thoroughly with potable freshwater or clean seawater.

Special attention should be given to the fish hold since that is where the fish are stored at sea. First, always remove dirty ice from the previous trip. Check the hold for leaks coming from the deck. Deck water containing bacteria from fishy fluids, the hydraulics, and/or chlorine from the sanitizing solution leaking into the hold will contaminate the fish. Caulk all leaks discovered. Wooden pen boards should be replaced with easily cleaned, lightweight aluminum pen boards. Wood boards contaminate the hold with paint chips and bacteria that is absorbed into the wood. They are also bulky and require more upkeep. After unloading a catch, the hold should be pressure cleaned with detergents, rinsed, sanitized and then rinsed again, prior to receiving clean ice.

All cleaning and sanitizing agents should be stored in a specific place off the working deck and away from the fish. Accidental contamination of the fish can occur if cleaning agents are left lying around.

Icing and Temperature Control

The primary reason for icing a catch is to quickly reduce its temperature in order to slow spoilage and ensure a longer shelf life. A longer shelf life can result in a higher price paid for the fish. Fish are of the highest quality possible at the time of capture. From this point on, fish undergo

irreversible quality loss over time at rates directly related to temperature. Figure (A) illustrates the effect temperature has on quality as expressed by shelf life.

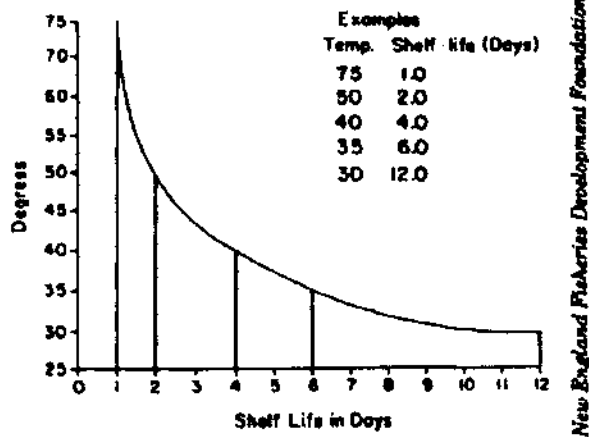


Figure (A). Temperature effects on shelf life.

Fish keep best when stored at 32-34°F. It is important to achieve this temperature quickly and maintain it throughout the trip. Research has shown that for every day a codfish is stored 2° above 32-34°F, one day of shelf life is lost. Similar results can be expected from mid-Atlantic species.

The ideal hold temperature is 34°F, which is just enough above freezing to allow some melting to occur, but cold enough to maintain quality. The melting action of the ice gently washes bacteria and other spoilage agents away from the fish while drawing heat from the fish.

Most vessels will have "hot" spots in the hold that need to be heavily iced before the fish are stowed. Potential warm areas include engine room bulkheads, shaft alleys, deck overheads and oversized pens where temperatures often range from 38-45°F. The placement and monitoring of thermometers in various locations in the

hold during a trip is a good way to locate these temperature control problems. The addition of extra ice to these locations is the easiest means of solving the problem.

Icing the catch properly is important regardless of stowage method. Fish are properly iced when:

1. Finely crushed, clean ice is used to speed cooling (by producing greater contact between fish and ice) while minimizing bruising of fish;
2. Enough ice is carried to properly stow the maximum amount of fish that a given vessel can hold (the amount of ice used will vary according to season, trip length, and the actual size of the catch);
3. Ice completely surrounds the fish—top, bottom, and in-between (if fish are gutted, gut cavity should be packed with ice);
4. Extra heavy ice layers are given to "hot" spots in the hold;
5. All fish stowed in pens are top-iced with at least one foot of ice throughout the trip.

At the conclusion of a trip, always discard used ice. Previously-used ice is contaminated with bacteria from fish and by other spoilage agents contracted on board, and should not be introduced to new catches.

Harvesting

Uncontrollable biological factors such as feeding, spawning condition, age, sex, bottom type, and water temperature determine the initial quality of the fish upon capture. However, once captured, fish

quality maintenance is dependent on effective quality control procedures which start with monitoring tow durations.

Depending on the species targeted, gear type used, and current economic concerns, the tow time should be kept to a minimum in order to maintain the quality of the fish captured. During long tows that produce a large set, the cod end could be overloaded with fish resulting in dead and bruised or exhausted fish. An overly large set also increases the time the catch is on deck exposed to the weather, posing a safety hazard for the crew on deck, and interfering with the landing of subsequent tows, all of which curtail quality control procedures. If heavy fishing resulting in large tows is expected, more frequent hauling is recommended. Shorter tows take in less weight per tow, allowing the crew time to handle the fish more efficiently. It has been suggested for mid-Atlantic fishing operations that an extra crew member be added to help maintain quality control procedures during heavy fishing periods when more than 3,000 lbs. per tow is expected.

On-Deck Handling

Once on deck, the fish must be handled quickly to minimize time spent on deck. The use of gaffs or shovels to move fish should be limited to prevent physical damage to the fish. Picks, forks, or any other device which will puncture or tear fish flesh should be avoided. When necessary, gaffing should be confined to the head area, not to the body where usable flesh can be contaminated. Anytime the fish flesh is punctured, bacterial contamination occurs and spoilage is ac-

celerated. Standing or stepping on the fish causes bruising and should also be avoided.

The general steps involved in handling commercial species on board may include 1) sorting; 2) bleeding, gilling and gutting; 3) washing; and 4) stowing.

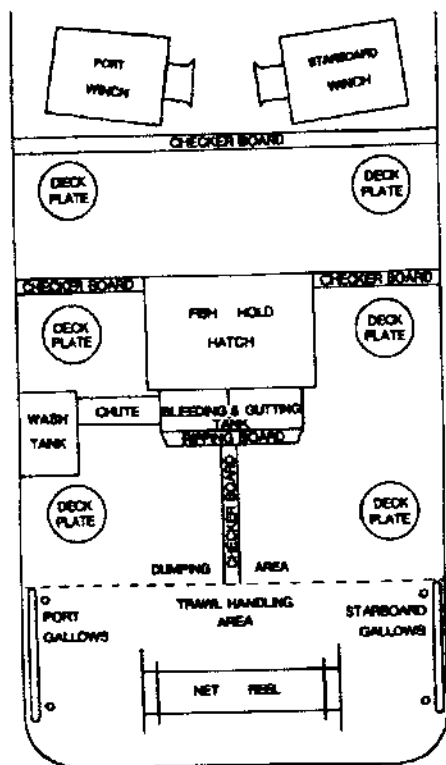
Presently, it appears to be impractical for mid-Atlantic fishermen to bleed, gill, and gut an entire catch on board. The major obstacle to implementation of quality control procedures is the apparent lack of financial incentives, in the form of appropriate premiums paid at the dock. In a recent study, a small premium was paid for fish processed on board using quality control procedures. The premium paid was insufficient compensation for the extra work and the weight loss due to gut removal. However, quality control procedures may eventually have to be integrated into all fisheries in order to remain competitive in the market. In the mid-Atlantic region, quality control procedures may prove most practical when applied to:

- Species that will bring the highest net return under quality assurance processing;
- A portion of large tows that can benefit from quality control procedures (lively, undamaged fish) while the other part is handled in the traditional manner;
- Small tows where the crew has time for quality control procedures before subsequent tows are brought on board;
- By-catches of directed fisheries which include flounder, sea bass, and monkfish.

Depending on the species harvested and the feasibility of implementing quality

control procedures, an appropriate deck layout to process the catch more efficiently should be considered. Various deck layouts facilitating quality control procedures have been successfully demonstrated in the New England ground fishery. A version of these deck layouts, illustrated in Figure (B), has been tested for mid-Atlantic fisheries application with limited success.

Using this general plan, an appropriate deck layout can be devised for a specific vessel. When considering a deck layout, keep in mind that it should maximize crew efficiency by keeping the fish moving systematically, it should be readily accessible to wash water, and it should not interfere with the landing of fish or create hazardous working conditions.



Adapted from New England Fisheries Development Foundation

Figure (B). General plan for deck layout to facilitate quality control procedures.

Sorting

Fish should be sorted by species and/or market size into separate checkers using the required size guidelines. Once sorted, all fish should be thoroughly washed with clean seawater from the deck hose.

Bleeding

Bleeding, gilling, and gutting are not readily practiced in the mid-Atlantic fisheries because of the small size of the harvestable species, the large tows periodically encountered, and the shortness of fishing trips. However, these procedures should be incorporated when at all possible to maintain the quality of the fish. To facilitate these procedures, a processing station can be situated on deck as illustrated in Figure (B).

The bleeding of fish prior to storage greatly reduces the incidence of bruises and blood spots, and improves the overall color of the flesh. Furthermore, biochemical implications related to the maintenance of the nutritional quality and enhancement of the fish product by bleeding are being considered. Substantial evidence indicates that a heme-iron substance, such as hemoglobin in blood, interacts with molecular oxygen resulting in the depletion (*oxidation*) of unsaturated fatty acids in the fish tissue. These fatty acids, including the omega-3 polyunsaturated fatty acids which have been proven beneficial to human health, are important in maintaining fish tissue quality during storage.

Bleeding should be done while the fish is still alive. This allows the heart to ac-

tively pump the bulk of the blood from the body. Bleeding is performed with a sharp, clean knife commonly by a throat cut which severs the gills' main artery, or by slashing one or more gill arches. In many fisheries, bleeding is initiated during sorting when a large number of fish are still alive. This allows bleeding to occur prior to gutting. Flowing water over the fish cools them and rinses away blood.

Gilling

Fish gills accumulate mud and silt that harbor bacteria. Upon the death of the fish, the bacteria multiply, causing off-odors and subsequently off-flavors. The gills should be removed to eliminate this source of contamination. However, the gills are also a good indicator of fish quality and certain markets may require the gills to be intact. In this case, thorough washing of the gills with clean seawater is recommended to remove contaminants.

To remove the gills, lift the gill cover and cut the lower and upper gill-to-head attachments, then cut the remaining connective membrane while pulling the gills from the gill cavity. Repeat for the other side.

Gutting

While a fish is alive, digestive enzymes break down the food consumed by the fish. Upon death, both these enzymes and bacteria in the gut begin to digest the gut at an accelerated rate. If the gut is not removed after death, this self-digestion will spread to the belly flesh resulting in spoilage. With the gut removed, the body

cavity can be packed with ice to retard this spoilage. If the effort to gut the fish is made, it should be accompanied by boxing or short shelving to obtain the quality benefits desired. The quality of two mid-Atlantic species, trout and bluefish, benefits substantially from gutting and boxing.

The gut is removed by first making a cut from the vent up between the pectoral fins to the throat cut. Cutting from vent to throat instead of throat to vent helps prevent unnecessary cuts into the body meat, which create avenues for bacterial contamination of the flesh. Carefully cut the attachment of the gullet at the head end of the gut cavity. With guts exposed, grab the gut near the vent and, with a twisting motion, pull that end free from the body. Discard the guts and remove all entrails from the cavity. Do not throw guts onto fish piles. This increases the amount of contaminants available to promote fish spoilage. With finger or knife, scrape out the kidney which is located along the backbone in the gut cavity.

Washing

A thorough washing should conclude the gutting process. Wash the gut cavity out with fresh seawater or place the fish in a deck wash tank if available (Figure B). *A wash tank should allow the gutted fish to be agitated slightly to properly rinse out the gut cavity.* This can be achieved by running a constant flow of seawater into the tank and allowing it to overflow.

When trawl-netted squid (*Loligo*) are harvested, a thorough washing helps to maintain a higher quality product. Wash-

ing squid prior to stowage can extend shelf life 3-4 days.

Stowage

The method of stowage is critical to the maintenance of the quality of the landed product. Methods include bulk stowage, short shelving and boxing. The method selected should both maximize the quality of the fish and be practical for a given fishery. Short shelving and boxing offer several advantages over bulk stowing.

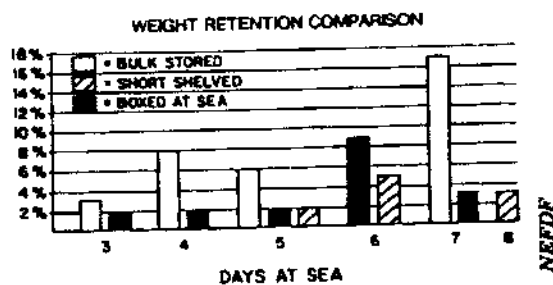


Figure (C). Fish weight retention by storage (percent weight loss over time).

The most important advantages are less weight loss and less visually-apparent damage to fish resulting from compression. An example of weight loss due to compression was demonstrated in New England fisheries, where haddock and cod lost up to 16-18 percent of their weight after seven days of bulk pen stowage (Figure C). This is a direct loss to the fisherman that could be minimized by short shelving or boxing.

Softer-fleshed fish, such as trout, flounder and bluefish, lend themselves to short shelving or boxing because of the compression factor of bulk stowage. However, firmer-fleshed fish, such as porgy, have also been demonstrated to hold up better with short shelving and boxing.

Short Shelving

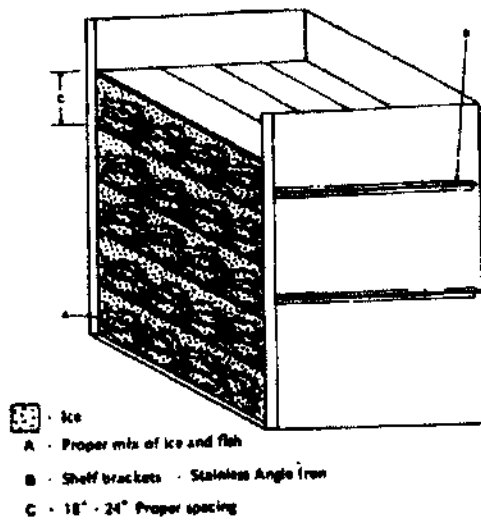
Short shelving consists of layering fish and ice between shelves that help support the weight. This method requires the use of easily cleaned, removable shelves preferably made of materials such as corrugated aluminum. Aluminum shelving is preferred over wood because it is easier to clean, lighter in weight, and takes up less space when stored. The shelves should be placed 18-24 inches apart. This permits only 18-24 inch stacks of fish and ice instead of the 5-6 foot stacks as often seen in bulk stowage. Figure (D) illustrates the short shelving method. When practical, round fish are laid head to tail with belly cavity down, and flatfish are layered horizontally. A layer of ice should surround the fish without overfilling the shelves (i.e. the shelf should not be packed solidly from top to bottom).

In addition to the benefit of reduced compression with short shelving, the use of shovels and pitchforks during unloading is minimized. Fish may be slid out to the unloader as the shelves are dismantled, reducing physical damage to the fish.

Boxing

When economically feasible, boxing at sea is the ideal method of stowage to preserve product quality. Studies have shown a 2-6 day shelf life increase, and anywhere from a 7-14 percent increase in landed weight when comparing boxed-at-sea fish with traditional bulk stowage. Most mid-Atlantic species would benefit by boxing; however, gutted bluefish, trout, flounder, sea bass, and squid are best

Proper Short Shelving Techniques



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Figure (D). Proper short shelving techniques.

suited. Boxed bluefish maintain superior quality and longer shelf life than bulk or short-shelved bluefish. Boxed squid (*Loligo*) are also of superior quality with minimization of torn skin, broken tentacles and loss of texture as seen with bulk stowage.

Boxes are made of easily cleaned molded plastic which provide the supportive structure that eliminates compression. There are several types of boxes to choose from, and the design of the box is an important consideration in making this decision. The New England Fisheries Development Foundation (NEFDF) suggests several features to consider:

- **Construction Design:** straight, smooth sides permit the highest stowage capacity with maximum space efficiency;
- **Safety:** ability to interlock boxes while stacking;
- **Box Capacity:** select a box based on species caught, season, grounds fished



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Figure (E). Properly boxed fish, just prior to covering with ice cap.

and handling ease. (Figure (E) shows a PERS 90 liter box used in a mid-Atlantic study);

- **Drainage:** a box with a sloped bottom and outside drain holes allows for proper drainage without contamination;
- **Ease of Handling:** a box with handles on all four sides makes holding and moving the box easier.

Boxing provides fishermen with better control of quality loss. First, the rate of chilling is increased due to better ice-to-fish contact. Second, contamination of the products stowed beneath other boxes is reduced because the melt water from one box is channeled to run down the outsides of the lower boxes. Third, less product damage occurs due to handling because the

fish are unloaded in the same boxes in which they are stowed. The boxes also serve as insulators, reducing the need to re-ice them prior to unloading.

The benefits of boxing-at-sea will not be realized unless proper boxing procedures are followed. Boxing procedures outlined by the NEFDF are as follows:

1. Stow each cull size of fish in separate boxes and label by day and tow to make unloading quicker and easier;
2. Place a 6-12 inch bed of ice on floor of fish hold to insulate the fish from heat coming through the skin of the boat;
3. Place corrugated aluminum pen boards across the bed of ice to provide a level work platform and good drainage;
4. Set up an area in which to box fish, keeping in mind the need for readily available ice; do not overfill boxes, a box should bear the weight of the boxes above, not the fish; ice is placed on the bottom, top and in-between fish layers;
5. As filled boxes are stowed, make certain the empty spaces are filled with ice and that there is a layer of ice between the pen walls and the boxes at least 3 inches thick; the same applies for between the boxes and the skin of the vessel; no ice is needed between the boxes themselves;
6. Ice around boxes each tow; if a stack is built too rapidly without icing, the possibility of creating a void between the pen walls or skin is increased;
7. Make certain that the top of the box pen has a layer of ice 12 inches thick to insulate the fish from any heat from the deck; check daily, and add ice to this layer as needed;
8. Plan out the work of loading and stowing boxes so that boxes are handled only once during the trip.

Offloading boxed fish is quicker and less labor intensive than traditional methods. Boxes can be removed one to six at a time. To unload one to two boxes at a time, the hydraulic and take-out booms are used in the traditional manner. However, a claw is needed to securely hold the boxes as they are lifted (Figure F). To unload up to six boxes at a time, additional vessel-mounted or dock-mounted booms are needed. Less labor is required not only for unloading, but also for cleaning of the hold after offloading. Since the fish are stowed in boxes which channel the melt water down to the bilge, cleaning and sanitizing the hold should require less time.

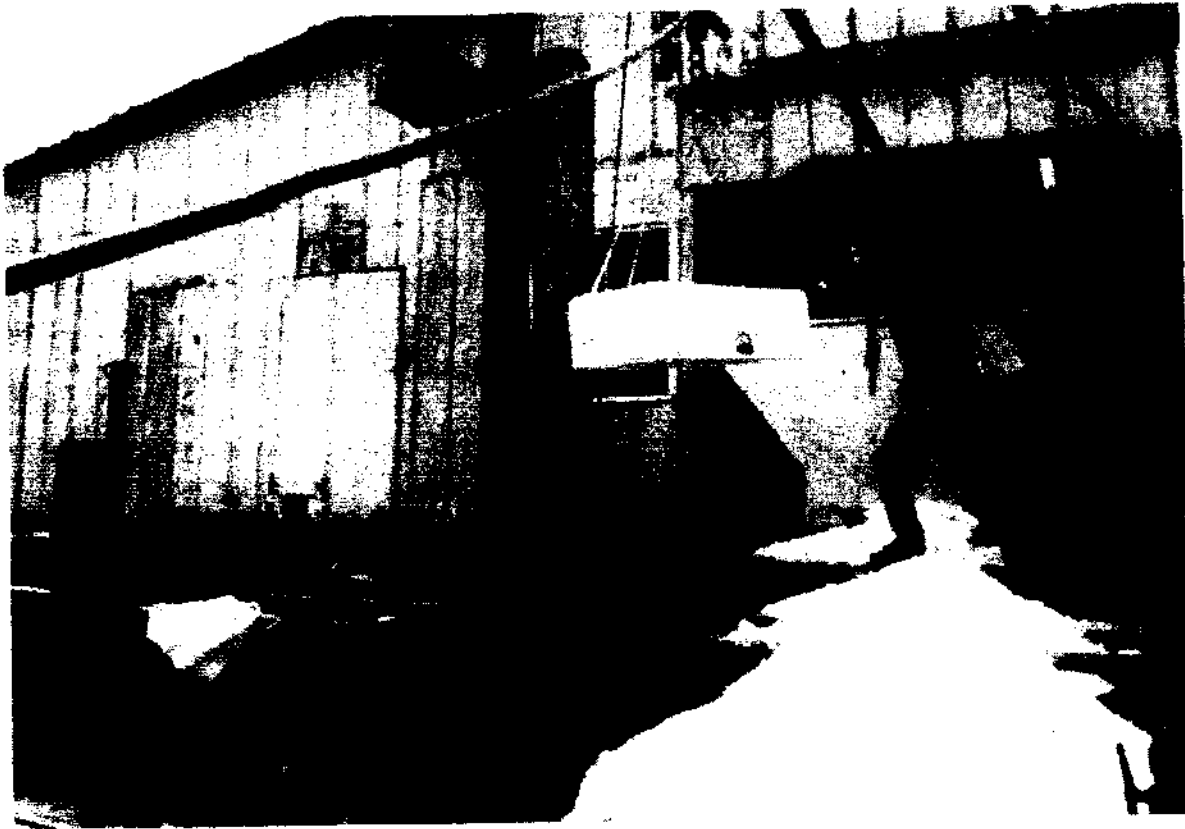
Limited Boxing Program

Unlike high value species harvested in some other U.S. fisheries, such as cod, had-dock and sole, few mid-Atlantic species command premium prices. With this in mind, and realizing the variable harvest rates and shorter fishing trips typical of the mid-Atlantic fishery, it might be feasible to initially implement a limited boxing program. In this program, bulk, short shelving, and boxing stowage methods may all be utilized during a given trip. Fish bringing the highest net return can be boxed while other fish can be short-shelved or bulk-stowed. This provides flexibility in the fishing effort to maximize the profit realized per given trip. The number of pens set aside for boxing, short shelving or bulk stowage would be determined by targeted species and could change by

season or year. On a typical mid-Atlantic trawl vessel, derived estimates show that with a minimal initial investment in such a program, a return in excess of \$1,400 per year is possible with an increased crew share per member per year of \$446.

For further information, refer to:

Conners, G. and J. Ostergard. 1986. *Fishing: Quality at Sea. A Manual for On-Board Quality Procedures*. New England Fisheries Development Foundation, Inc. Boston. 55 pp.



Phil Cahill

Figure (F). Unloading single box with the use of a claw, which holds the box securely during offloading.