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Construction and Sea Trials of a Contrawl Containerization System Prototype

Part I

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April 1988

Canadian Industry Report of Fisheries and Aquatic Sciences No. 195A

Fisheries and Oceans Pêches et Océans

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Cat # 111117

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PART I

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BY

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MINISTER OF SUPPLY AND SERVICES CANADA 1988
CAT. NO. 97-14/E195A ISSB 0704-3694

CORRECT CITATION FOR THIS PUBLICATION:

BOND ARCHITECTS AND ENGINEERS LTD., 1988. CONSTRUCTION AND SEA TRIALS OF A CONTRAWL CONTAINERIZATION SYSTEM PROTOTYPE: Part I. CAN. IND. REP. AQUAT. SCI. 195A: iv + 26 p.

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Note: Copies of appendices to this report are available from:

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1.0 INTRODUCTION

It has long been recognized that the current Canadian practice of storing fish, on offshore wet fish trawlers, in a penboard and stantion system results in a high percentage of less than top quality fish and significant loss of product due to poor processing yields. This is largely due to the difficulty of off-loading bulk or pen-stowed fish.

In an effort to overcome these problems, in the early 1970s, Fishery Products Limited (FPL), purchased three (3) new trawlers fitted with European boxes. Unfortunately for the company, the effort proved unsuccessful.

In 1980 Contrawl Limited approached FPL for assistance in the development of a novel trawler containerization system. The company agreed to support Contrawl's application through funding of a full scale prototype under the Enterprise Development Program (EDP). The BAE group was engaged by Contrawl to provide engineering for the prototype development.

The first prototype was subsequently fabricated and its operation demonstrated at the premises of Colda Mechanical Limited. During that period a second EDP project resulted in the development of a computer system which could be used to automate the Contrawl system loading and discharge operations.

This report provides details of the further and subsequent development of the Contrawl system, utilizating a significant modification to the in-hold mechanical system (developed by ACCO, Canadian Material Handling of Burlington, Ontario, in association with the BAE Group) but otherwise using the Original Contrawl concept.

Construction of the Contrawl prototype was substantially completed on the MV Atlantic Margaret by mid-October, 1985. Following a one (1) day sea trial and demonstration on October 19, 1985, the vessel made her first full fishing trip from October 21, 1985 to October 30, 1985 following installation of the system. That trip confirmed Contrawl's expectation that the system would function as intended in rough weather, that it would simplify the icing and storing operations, and deliver high quality fish to the plant.

The system has continued to be utilized and, up to March 31st, 1986, ten (10) regular fishing trips had been completed. Despite some earlier problems, which have since been corrected and other problems which have not as yet been remedied, (although solutions have been proposed), the containers have been filled every trip.

This report covers the utilization and effectiveness of the mechanical systems during the 5½ months of sea trials.

2.0 PROBLEMS AND SOLUTIONS

2.1 The Problems with Canadian Wetfish Trawlers

With few exceptions, until the past three to four years, Canadian trawlers have used a method of holding the catch in a penboard and stanchion system. IN this system, vertical stanchions set usually in a square pattern in the hold, are fitted with 8" wide corrugated aluminum penboards which fit into the stanchions to form the floor and walls of cubicle pens, typically 1.5m square and 1m deep.

As fish is taken on board, it is dressed (gutted), washed and director by conveyor to the hold where the crew places it into the pens which are constructed from loose penboards previously stored in the hold. Using shovels, ice stored in other pens prior to leaving port is then added.

To this point, no significant damage has been caused by the on-board operations except, perhaps, that which occurs because of the necessity of someone having to walk on the fish in the hold in order to place penboards, etc. and the dropping of fish into the hold.

However, there are major problems subsequent to storage these include: (1) often the pens are too high resulting in loss of weight and softening of the flesh; (2) the fish/ice mass becomes hard and extremely difficult to remove from the pens and from the vessel; (3) discharge systems, including both conveyor/elevator systems and air system, cause significant damage.

The results are: (1) final quality is relatively low, especially of the older fish, thus restricting the product mix potential and resulting in relatively low average selling price and, (2) yield, which depends to a large extent on quality, is also low resulting in less product availability for sale.

2.2 The Solution - Criteria

Quite obviously, the solution will overcome the above mentioned problems. The solution objectives are to:

(a) Store the fish at such a height as to prevent excessive weight loss and softening of the flesh.

(b) Store fish and ice together to facilitate fish removal from the vessel without damage.

(c) Minimize or eliminate the storage of wetfish through the use of freezer trawlers or factory trawlers.

These objectives must, of course, be achieved at a cost which is less than the benefit provided. The higher the benefit/cost ratio, the more viable the solution.

All fish handling systems proposed in recent years, including European boxing systems, claim to achieve these objectives.

The Canadian fishing industry, now recognizing that it <u>must</u> convert its trawler fleet to systems using other than the penboard and stanchion method, has to choose between these various options. This report on the Contrawl System discusses and compares these alternatives.

2.3 The Solution - Tank Systems

Tank systems, utilizing large tanks for holding fish in a mixture of ice and water (chilled seawater or CSW) or for holding in refrigerated sea water (RSW), have been used with reasonable success, mainly for pelagic species. They are not considered appropriate for groundfish for the following reasons: (1) softening of the flesh is apparent after a few days in such storage; (2) either removal of the large tanks would be difficult and costly or the alternative of pumping the fish out would be damaging to quality; (3) there would likely be vessel stability problems. Tank systems are therefore not considered a viable alternative for groundfish trawlers.

2.4 The Solution - Freezer/Factory Trawlers

This solution is discussed in some small detail in the discussion paper on Factory Freezer Trawlers, published by the Department of Fisheries and Oceans in August, 1985. It is unfortunate that this paper compares new FFTs with state-of-the-art technology to new wetfish trawlers with old Canadian technology. This is a most inappropriate comparison.

While it is not the purpose or intent of this report to analyse FFT operations in any detail, nonetheless, we have included as Appendix "A" a revised Table 8 from the above-mentioned discussion paper which illustrates the probable effect on wetfish trawler operations of using boxing and the Contrawl containerization system while retaining intact the remainder of the Table 8 analysis.

These figures suggest strongly that FFTs are not at all more profitable than wetfish trawlers in fact they could be significantly less profitable if the assumptions used by the department relative to FFTs are correct.

2.5 The Solution Boxing Systems

Boxing systems are in general use in Europe and other areas and are currently being tried (again) by FPI and NatSea. There is no question that the proper use of 70 1 or 90 1 boxes (such as the PERSBOX) results in the delivery of excellent quality fish. Experience in Newfoundland, for example, has shown that up to 80% of the boxed fish from wetfish trawlers is of a satisfactory quality for use in "premium" packs. This compares with a typical figure of only 20% to 40% for fish held in a penboard and station system.

There are of course costs associated with the use of boxing systems. These costs will vary with the degree of sophistication used to handle boxes on board and on shore, the style of box used, etc. but, in general, can be defined as follows:

(a) Boxing drastically reduces the volumetric capacity of a given hold space. The greater the mechanization used in the hold for refrigeration and to facilitate box handling the greater the loss of space and the greater the capital cost. Typically, a "boxed" trawler will hold 60 to 80% of that which the same trawler would hold in a pen system, or, for the same holding capacity, the hold would have to be 25 to 67% bigger. In any case, significant space is required outside the hold to store boxes to provide working space in the hold.

(b) Boxes are somewhat more expensive than penboards and stantions and their replacement rate is a significant factor, typically being as high as 30% per year.

(c) Unless rather sophisticated box handling equipment is used (in which case the capital cost of boxing systems rises significantly) the labour cost associated with boxing is quite high. It was probably this high labour cost that caused FPI to abandon its boxing efforts in the 1970's. Boxing was not adopted because of lack of interstructure on shore.

(d) In most boxing systems, icing is a serious problem due to the inefficiency of storing ice in the boxes or the extra space required if ice is stored separately.

(e) Because boxes are relatively small, inventory control becomes difficult since such large numbers required for a given trawler (typically, 4,000 to 5,000 per vessel). Loss, by theft, for example is relatively easy, both of box and fish in some situations.

(f) If boxes are used for holding and transportation on shore, insulation and/or refrigeration is required in the holding and transport facility to prevent excessive ice melting and subsequent loss of quality. Insulation of such small units is impractical in terms of relative cost and loss of volumetric efficiency.

2.6 The Solution - The Contrawl System

Recognizing that boxing systems did have serious drawbacks and having had considerable experience in the development of the Inshore Fish Handling Program (IFHP) for handling inshore fish in Newfoundland with insulated, relatively large containers, the principals of Contrawl set about to devise a new and different trawler containerization system. The following criteria for such a system were established:

(a) Quality was recognized as a major consideration, perhaps the most important since both market price and yield (raw material productivity) depend heavily on good quality. Thus, delivered fish quality should be equivalent to that obtained from boxing systems.

(b) Similarly, hold capacity utilization should be at least equivalent to that achieved by boxing.

(c) The containerization system should be capable of keeping abreast of the maximum anticipation catching/gutting/washing rate. This was stated by Fishery Products Limited to be approximately 7 tons per hour. Maybe with large cod.

(d) The discharge rate should be at least as high as that achieved by boxing systems of air unloader systems. Thus, a minimum of 15 tons per hour was set for the discharge rate. However, lower discharge rates were encountered due to the prototype system.

(e) Based on experience using insulated containers on shore, it was felt that the container should be insulated and as large as possible to minimize purchase and handling costs) without significantly affecting quality. Hence, the existing prototypes have internal dimensions of approximately 1140 x 800 x 520mm or a capacity of 0.46m cubed, sufficient for approximately 270 kg of cod with ice ratio of 2:1 (fish to ice).

(f) The system must be safe in all sea condition suitable for fishing.

(g) T he system should be relatively easy to use (overcoming one of the major drawbacks of boxing systems which are typically awkward to use in the confined space of a fish hold).

(h) Ice storage and ice handling should both be relatively simple and convenient.

(i) Adaptable to existing wetfish trawler.

Criteria (c), (d), and (f) indicated and eventually led to a system which would handle more than one (1) container at a time in order to keep operating speed of equipment within a safe range. Thus, although the Contrawl in-hold and on-deck systems were designed to operate at the extremely low speed of 0.05 mps at sea, the filling rate of 7 tons per hour was considered achievable. Multiple container handling at a higher speed in port will result in a very high discharge/re-load rate, equivalent to 100 tons per hour or more. A suitable shore-based system will, or course, be necessary to accommodate such a high rate of discharge.

A fuller description of the Contrawl System is provided in the following sections, the photographs of Appendix "B" and the As-Built Drawings. Briefly, the system has an in-hold mechanical system capable of traversing the hold just below the deck and of engaging three (3)* containers in a horizontal row at any level from just below the lifting system to the bottom row of containers in the hold. This system can therefore place a row of containers (which have been positioned in the hold by an above-deck system) from a position immediately below the hatchway to any other defined position in the hold or take a row of containers from one of these defined positions and place them in a position immediately below a (centralized) hatchway.

A factory deck lifter system brings rows of containers, in turn, from the position below the hatchway to a position in the hatchway where they may be conveniently filled with fish and ice from a conveyer. After filling, the reverse operation replaces the filled containers back in their original position in the hold.

* A full-size Contrawl System is expected to use four (4) containers in the row but the principal, operational requirements and constraints are the same.

Icing may be achieved in a variety of ways. For the present, a system of placing several bags of ice in each container (sufficient to ice the fish which will be placed in the container) has proven to be an acceptable solution for the operation of the prototype.

For loading and discharge from and to dockside the prototype utilizes an upper deck mounted, hydraulically powered, articulated crane, to handle containers one at a time. For a vessel which has a complete Contrawl System, it is anticipated that each of 2, 3 or 4 hold compartments (depending on vessel size, etc.) would discharge via a shore-based conveyor system. By such a method, a feasible as well as a similar loading rate from shore.

The prototype has a nominal capacity of sixty-three (63) containers in twenty-one (21) rows of three (3) containers. Two (2) additional rows could be added, one (1) immediately beneath the hatch covers and one on top of the hatch covers, if this additional capacity was seen to be desirable.

To operate the system, the top row of containers (a total of fifteen (15)) has to be stored outside the hold. There are a number of possible storage spaces on the Atlantic Margaret but it is proposed that these will be stored above the hatchways where they will cause little interference with other operations and be most readily placed in the hatchway for filling. A suggested storage system using penboards is shown in Appendix "D". The storing of these containers and their eventual positioning in the hatchway will be a completely manual operation. Since the containers will be empty (bags of ice stored therein having been first to be removed), this is not seen to be a difficult operation.

3.0 CONTRAWL SYSTEM PROTOTYPE

3.1 Construction

With the continued support of Fishery Products Limited (later, Fishery Products International) and that of the Department of Fisheries and Oceans, Fisheries Development Branch, DSS contracts were issued in October, 1984 to fabricate a prototype Contrawl System on an FPI trawler and to conduct sea trials to evaluate the system in terms of its operational usefulness, its stability and safety at sea and its anticipated costs and benefits.

Since Contrawl Limited is a small, and at this point, solely a development company, its contract called for subcontracting various components of the supply to five other companies:

(a) Xactics Limited of Saint John, New Brunswick, would inject foamed insulation into prototype containers which they had earlier supplied under the EDP Project.
Estimated Cost: $15,000.00

(b) Acco Canadian material Handling of Burlington, Ontario would construct and text the in-hole mechanical system (the Contrawl Mark II System);
Estimated Cost: $127,423. (since revised)

(c) The BAE Group, at St. John's engineering firm, would provide engineering design, construction drawings and supervision.
Estimated Cost: $60,000. (since revised)

(d) Newfoundland Marine Design Limited, a St. John's naval architectural firm would provide structural drawing and structural construction supervision.
Estimated Cost: $29,755. (since revised)

and

(e) Digital Electronics Services Limited (DES), a St. John's based electronics system maintenance company whose principal had been involved in the earlier EDP development of the automatic control system, would provide the manual and upgrade the automatic control systems and install both.
Estimated Cost: $44,510. (since revised).

A second contract to Fishery Products International provided for the installation of materials, labor costs and use and operation of the prototype system during subsequent sea trials at an estimated cost of $44,510. (since revised).

The fishing trawler, MV Atlantic Margaret, one of the old atlantic-class fishing vessels operating out of Marystown, was brought into the Burin refit center in mid February, 1985 for installation of the Contrawl System and necessary maintenance requirements.

Meantime, the "ACCO" system had been fabricated and successfully demonstrated at their shop in Burlington in March, 1985. The containers had been foamed in Saint John, New Brunswick, and construction drawings had been prepared by The BAE Group. During this period, DES had fabricated and tested much of the control system.

As was expected for this type of work the installation and on-board testing of the various components resulted in many minor changes to the design and show drawings. The reason for most of these was that viewing the various systems during or after construction together with discussions among engineers and installations technicians provided a better insight into the many rather complicated design problems that had been possible in the earlier design stage.

These changes are incorporated in the As-Built drawings.

Construction of the prototype was substantially completed by mid October, 1984 and, following a one(1) day sea trial and first full fishing trip following installation of the system on October 21, 1985, to October 30, 1985.

3.2 Operations

3.2.1 Mechanical Systems

The mechanical systems have performed well, for a prototype, in that the containers are held in a secure and safe condition even in very rough weather while permitting movement of containers between the hold and the factory deck. Thus, the concept is clearly valid. Wear and tear on the containers have, at times, proved to be insecure.

Several deficiencies have been noted which, in a new system design, would be corrected to ensure trouble-free operation. These include:

MATERIALS OF CONSTRUCTION

(a) Critical components, such as the end truck assemblies, lifters, etc. should be fabricated largely of stainless steel to eliminate problems caused by rusting and for longer life.

(b) Structural components should, perhaps, be either aluminum or galvanized steel. If of steel, they should be properly treated (sandblasted and epoxy coated, etc.) to prevent rusting. Bearing surfaces (guide surfaces) should have plastic wear pads attached to reduce friction and noise and, again, ensure longer life.

SYSTEM DESIGN

(a) To minimize utilization of space on the factory deck, chain takeups and drive shafts would be located below deck.

(b) Drive systems and electronical gear would be mounted on common bases and/or combined in "standard" motor control centers.

(c) All leading edges of the various pieces of moving equipment would be faired to prevent shock loading when entering guides, etc.

(d) The factory deck lifter system was specifically designed to permit moving the lifter aside to discharge containers through the upper deck. In a commercial installation, this system can (and would) be greatly simplified.

(e) Hatch beams require re-designing for better operation. These units may also require heavier drive motors as the existing units have all but worn out. In addition, the hatch beams will be designed to facilitate loading and discharge of the containers.

3.2.2 Hold Space Utilization

It is understood that the capacity of the forward hold compartment in the pen-type holding system was approximatly 85,000 lbs. Capacity of the installed system is 37/40,000 or less than 50%. However, this system is only three containers long, not four as it could be without the bucket elevator shaft, in which case the capacity would increase to about 57,000 lbs. or 67%. This is quite good considering that the vessel narrows dramatically through this compartment (from 27 feet to about 16 feet).

Utilization of the main section of the hold would permit holding an additional 344 containers (at least) for about 78% of the bulk storage capacity in that section. This is certainly equal to or better than that obtained using available boxing systems.

3.2.3 Icing/Filling

For the first trip, two boxes in each row of three were filled with ice; the third box held three (3) bags (about 50 kg each) of ice. Ice is the relatively thick "turbo" ice produced in Marystown.

This was found to be too much ice and for the second trip four bags of ice was loaded into each container. The use of bags was found to be reasonably satisfactory. The procedure is as follows:

(a) The system delivers three (3) containers (with ice) to the hatchway.

(b) The bags are removed and dropped 2 or 3 times to loosen up the ice.

(c) The conveyor is started and as fish is directed into the containers, ice is added in the right proportion.

This operation was found by the crew to be much easier than the pen-building and shovelling operations normally used however, bags of ice had to be removed from containers and crushed since the ice hardened quickly to fill the pen type hold. It had been proposed that the ice to fish ratio be gradually reduced to determine the optimum fish to ice ratio. To date, this has not been done.

One of the icing crew stated that the system does not work fast enough. This comment has some validity in that the in-hold and on-deck mechanical systems move at only 0.1 m/s or less which means that the average time to return a set of full containers to the hold and place a set of empties on deck for filling is 3½ to 4 minutes under normal conditions. With manual operation, the fish icer/stower has to be at the controls and cannot perform other functions, such as breaking up ice in the bags which could otherwise be done. The maximum filling rate required to match the gutting rate is approximately 4 tons/hr. Allowing 550 lbs/container, 15 containers will need to be filled every hour which is equivalent to a set of 3 containers every 12 minutes. Subtracting 4 minutes of each cycle for changeover of containers, this leaves 8 minutes to break up ice and stow the fish. This appears to be sufficient time; however, it is relatively easy to speed up the mechanical systems too shorten the changeover time and allow an additional 2 or 3 minutes for icing and filling and it is suggested that this be done. Automatic control will also save a few minutes in each cycle since the operator could initiate the container exchange operations and then proceed to break up the ice (from previous container loads) while the exchange is being made.

In any event, the Contrawl system is designed as an intermittent system, and for it to work well buffer storage, at least sufficient for the changeover time between one set of full containers and the next set of empties, is essential.

Thus, a minimum of 5 minutes of storage at the gutting rate or about 1,000 lbs. Buffer storage should be provided. It is assumed that this amount of buffer can be readily provided by storing fish on the conveyor belt for the 5 to 8 minutes required delay. If not, buffer storage should be provided in the washer.

Speed of the on-deck lifter and the in-hold horizontal lifter motion have been doubled, reducing the cycle time from the original 3½ to 4 minutes to about 3 minutes.

One equipment option suggested to facilitate icing is an ice hopper/feeder unit. It is suggested this could be mounted at factory deck level so the bags of ice could be readily dumped into the hopper whence an inclined screw feeder would break up the ice and feed it into the conveyor belt with the fish. A sketch of a suggested design is provided in Appendix "C". No action has been taken on this proposal.

A support system is required to stow the top row of containers to maximize hold capacity for fish. Appendix "D" provides a suggested design for the support and feed system for the top layer containers. No action has been taken on this proposal.

3.2.4 Containers

The prototype containers supplied and later foamed with polyurethane insulation by Xactics are rather extensively deformed. These deformations have been caused by outdoor storage over the years, the foaming operation, a mold construction defect and use at Marystown.

Despite the severe dimensional variations, the mechanical system works remarkably well. To line up the tops of the containers, several long aluminum beams were placed along the edge of the top row of containers (see photo 3, Appendix "B"). It was felt that these beams would be necessary to prevent containers from falling into empty columns (as occurs when the column of containers is moved out for temporary storage and filling). Although the trip was quite rough, there was no apparent indication that the beams are necessary for this purpose. However, beams or container joiners connecting adjoining containers on the short side (see photo 3, Appendix "B") will be necessary at least as long as the existing defective containers are used.

Two or three times during discharge, it was necessary to either wedge the lifter frame into a row of containers to achieve engagement or to lift the end of one of the containers so the lugs could rotate into the lifting holes. New containers would certainly solve these problems.

In transferring containers to and from the vessel by forklift, it was noted that at least one container had jammed into one positioned below it. This problem was caused by rough terrain.

In the holding room, it was noted that when containers are close stacked, it is not possible to pick them up with a standard forklift. Two or three corners of containers were damaged, probably as a result of picking them up on one edge only. Accordingly, containers have to be stacked with about 200 mm to 300 mm space between stacks.

To overcome these and other operating deficiencies and to provide greater strength, new containers have been fabricated with modifications noted in Appendix "E".

Lightweight, uninsulated covers, supplied under the Xactics contract were not used on the first trip and fish in these containers had very little, if any, ice cover at the end of the trip. For subsequent trips, the top layer of containers had covers placed and these reduced the ice meltage considerably. For shipboard use it is suggested that lightweight insulating covers should be made from insulating blanket materials, perhaps fastened with velcro tabs. Such suitable covers will be developed over the next several months, as well as heavier insulated covers for transportation/storage on shore. In any event, it will only be necessary to cover the top containers in a stack.

3.2.5 Safety

The system provides a good, safe environment for the crew. Nevertheless, some potential hazards were noted and should be corrected, as follows:

(a) A ratchet-type latch is suggested to positively engage and support the on-deck lifter in its maximum raised position. This will ensure that, should the cables fail, it cannot fall on workmen filling containers beneath the lifter. Appendix "F" illustrates a suggested method. The method has not been adopted.

(b) A handrail installed along the bulkhead opposite the hatchway provides a grip for workers who might otherwise be thrown off balance above an open hatchway or when peering into the hatchway to observe operation of the in-hold system, etc.

(c) It was originally felt that sloped covers would be necessary to divert fish or ice outside the hatch coaming from the filling operation. This is not now considered necessary and, to assist workers in the filling and ice bag removal operations, a treadplate was installed above the hatch beam supports and between the hatch coaming and the row of containers. This also prevents a foot from slipping into this opening (See Appendix "G").

(d) Storage should be provided for aluminum container joiners. A plastic container may be suitable for this purpose. No action was taken on this suggestion.

(e) The lifter frames may be used as elevators and/or working platforms for the ship or maintenance crews. Accordingly, they were to be covered with removable treadplates to prevent falling between, etc. while allowing access to drives, etc. for maintenance (See Appendix "H").

(f) Loading and Discharging: The upper deck hoist (see photo, Appendix "B) is used to engage one container at a time for loading or discharge. It had been estimated that a loading/discharge rate of one container every 1.5 minutes could be achieved, but to date the best speed has been about 3.75 minutes per container (equivalent to about 5 tons per hour). To increase this rate and to prevent the corners and edges of containers from catching on hatch beams, hatch coaming, etc. with the possibility of being jarred loose and falling, it is proposed that a guide system be installed between the upper and lower hatch coamings with lead-in tapers above and below. A suggested design for these guides is provided in Appendix "J". This was tried, but proved unsuccessful and was abandoned.

3.2.6 Tools

To simplify operation and/or to facilitate entry of lifter frames into poorly aligned containers some hand tools, such as pry bars and temporary lifting cords, should be provided. These can be very simple devices and no further description is provided in this report.

On shore, however, filling of ice bags is a very tedious and time consuming operation. We suggest, therefore, that a bag filling method be developed to simplify and speed up this operation. Appendix "K" shows a suggested method. To date, no action has been taken on this suggestion.

Also on shore, the spacing of stacks of containers necessitates considerable extra storage space in the holding room. This is perhaps not important with only 60 to 70 containers, but would be unacceptable with one or two shiploads having to be stored (1000 or more containers). Besides this, the forks of the rotating head fork truck tend to block the flow of ice from the container and delays the emptying process. Again, this is not important with only a few containers, but may be a problem when large numbers of similar containers are used. Accordingly, a special shifter attachment, shown in Appendix "L" is suggested for use with the lift truck. Such an attachment could be provided by forklift manufacturers if there is sufficient demand.

3.2.7 Controls and Interlocks

To make it more simple to operate and prevent an incorrect decision by a crew member which could cause system damage and to facilitate system automation the Contrawl system has a relatively large number of limit switches and interlocks.

This control system has largely been developed by Mr. L. Walters of DES, under sub-contract with Contrawl. The guiding principal used in the control system development was that the manual system should be simple to understand and operate since automated systems oftentimes fail.

The success of this approach may be demonstrated by the fact that the loading of containers on the first trip was conducted completely by the ship's crew and the discharge entirely by the discharge crew. In the latter case, less than five minutes instruction was necessary.

Nevertheless, because of the complexity of the Control system, good wiring diagrams and clear trouble-shooting instructions will need to be developed by Contrawl for any commercial installation. In addition, in order to reduce problems caused by limit switch failure, most of the limit switches have been changed from mechanical to proximity type.

A listing of limits and interlocks is provided in Appendix "M".

A new, automatic control system has been designed, fabricated and installed. Because of faulty containers still in use on the last trip, no attempt was made to operate the system automatically.

However, with new containers use of the automatic control system will free the operator to break up ice (see 3.2.3) and also reduce cycle time by eliminating errors in selection of column and centering of the lifter frame.

4.0 IN-PLANT RESULTS FROM CONTAINERIZED FISH

Results of processing fish from the first and second trips using containers have been provided to the Department of Fisheries and Oceans by Fishery Products International. At the time of preparing this report, it is known only that dockside grading of the containerized fish shows it is to be of significantly higher quality than fish of the same age from the same trawler but stowed in pens.

Furthermore, 67% of the eight-day old cod brought in by containers was suitable for premium packs. This compares with an expected average of 30 to 40% for pen-stored cod.

These results were expected and will likely be improved upon by more careful filling and ice procedures.

It is suggested that some effort be made to determine the optimum fish to ice ratio, since the less ice that can be used to achieve the same high quality, the greater the volume of fish that can be stored in each container and the lower the cost of icing.

5.0 FURTHER DEVELOPMENT & COMMERCIAL APPLICATION

The use of large, insulated containers in Newfoundland during the past 10 years has clearly demonstrated advantages of container technology over boxing technology, while delivering fish of equivalent high quality. Since the quality of containerized fish in suitably sized insulated containers is equivalent to that obtained from boxing, an economic comparison of the Contrawl System with typical boxing systems can be readily made.

The analysis provided in Appendix "N" is intended to compare the economics of operating a fleet of wetfish trawlers using Contrawl Containerization Systems and high speed discharge systems with a fleet of wetfish trawlers using relatively sophisticated boxing systems.

The variable costs included in this analysis are:

1. replacement costs of boxes/containers,
2. raw materials handling and transportation,
3. discharge, clean-up and re-load costs,
4. vessel operating costs, and
5. ice costs.

The fixed costs include amortization of the fleet of vessels required to land a given quantity of fish (400,000,000 lbs./yr.) plus an allowance for other fixed costs which may be considered attributable to vessel operations (shore staff, etc.).

This analysis, summarized in Figure 1 following, is based on reasonable assumptions provided in the Appendix which are favoured over "boxed" trawlers. It illustrates that a fleet of Contrawl-equipped trawlers provides superior performance in all respects, with the possible exception of annual replacement cost of containers (estimated at $420,000 per year higher than boxes) and annual maintenance (estimated at $1,000,000 per year higher than boxes).

Based on this analysis, further development and commercial use of the Contrawl System is clearly indicated.

The next development phase, which it is suggested will be a full

FIGURE 1

		Boxed Trawler		Contrawl Trawler
			$000	
No. of Vessels		44.44		40.04
TOTAL CAPITAL COST:				
- Of Vessels	$457,732		$451,125	
- Of Discharge Facilities	1,200		1,800	
Total Capital Costs	$458,932		$452,925	
Net Sales Revenue (of catch) @ 33 1/3¢/lb. (ave.)		$133,332		$133,332
Less Variable Costs:				
1. Box/Container Replacement	$ 2,000		$ 2,220	
2. Raw Material Transport Cost	$ 1,800		$ 1,200	
3. Raw Material Handling Cost	$ 5,000		$ 4,000	
4. Discharge/Re-Load Cost	$ 2,800		$ 400	
5. Cleaning of Hold	$ 467		67	
6. Vessel Operating:				
- Crew	$ 28,442		$ 23,220	
- Fuel, Maintenance, etc.	$ 22,220		$ 21,575	
7. Ice Costs	$ 2,700	$ 65,428	$ 2,500	$ 59,943
Vessels Operating Margin		$ 67,903		$ 73,389
Less: Fixed Costs		$ 59,383		$ 58,672
NET VESSEL OPERATING PROFIT		$ 8,520		$ 14,717

vessel operation, would provide Contrawl Systems incorporating latest design and operating features which have been or can be deduced from operating the present prototype together with suitable vessel discharge and shore handling systems to achieve the maximum operating potential of the overall system.

During the planning of this next phase, thorough consultations should probably be held with unionized fishermen's representatives to explain the project in detail, discuss how job opportunities may be affected and obtain the support and co-operation of the fishermen and vessel crew.

Some design modifications which could be incorporated in the new systems include:

1. Simplification of drive systems, such as locating drive shaft and chain takeups below the factory deck level and positioning drive gear motors and winches on a common base.
2. Simplification of electrical system by incorporating all (or most) starters and disconnects in a motor control center (MCC).
3. Incorporating higher reliability into the control systems by using proximity switches and solid state control devices (PLCs, relays, etc.)
4. Materials of construction would be selected to reduce maintenance and downtime costs to a low and acceptable level.

Further, the next system, which will still be prototypes to a large extent, should be constructed on a shore as modular systems. Thus, any required design changes, system tests, controls debugging, etc., can be performed prior to installation of the systems on a vessel.

The vessel, if retrofitted, would not be docked and stripped until final operating tests of the system have been completed. The systems, which will have been built to fit prepared anchor points in the vessel, would then be marked, disassembled and transferred to the vessel for re-assembly and attachment to the deck and hull.

This procedure would save considerable time and cost and eliminate welding stress, inaccuracies and changes in installation which, despite the best of attention, occurred all too frequently during the installation of the present prototype system.

6.0 SUMMARY AND CONCLUSIONS

The Contrawl System offers high potential for optimizing returns from the renewable fisheries resource harvested by relatively large offshore vessels.

While the prototype on the Atlantic Margaret has introduced operational problems (some foreseen, some unforeseen, as described in the text), it has clearly proven that the Contrawl System works well in a very hostile marine environment and does so with safety. Inconveniences being experienced with the prototype can be readily overcome and some low cost solutions have already been identified and described herein. While boxing on board is common in Europe and elsewhere, there can be little doubt that current boxing methods are not entirely satisfactory. On the other hand, the use of containerization over the past 10 years in Newfoundland has clearly demonstrated advantages over boxing, at least with respect to materials handling costs and convenience, while quality would appear to be equivalent to boxed fish. Thus in Newfoundland, containerization is a known, proven and acceptable technology and its adaptation to vessels should appear to be a natural evolution.

Continuation of the Contrawl System development by outfitting a full vessel with the system and providing suitable shorebased discharge/re-charge and handling facilities is strongly recommended.