Multi-Purpose Processing in the Seafood Industry

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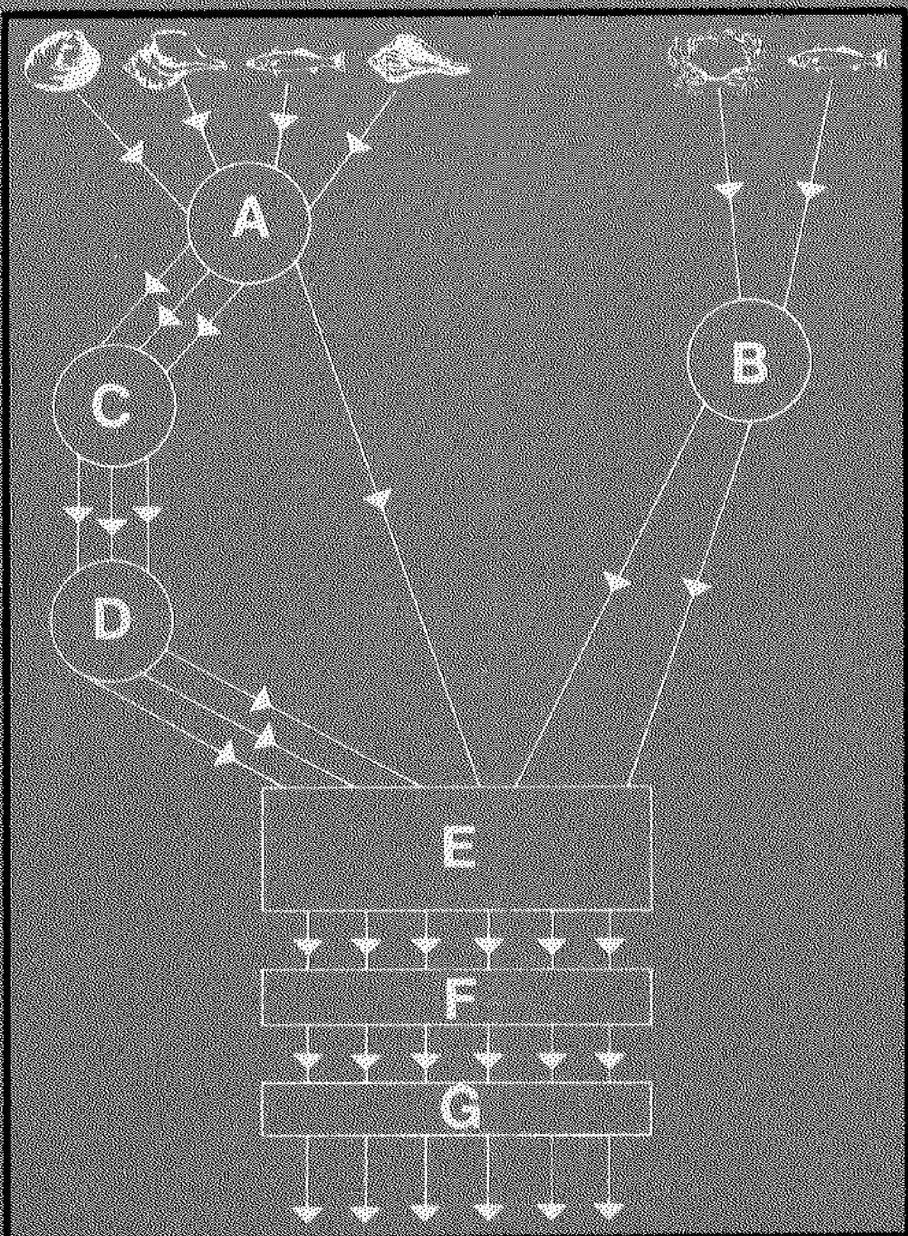

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Acknowledgments

The authors wish to express their sincere thanks to the many people who were involved with bringing this project to fruition. The numerous hours of preplanning, equipment selection, construction and trials taxed everyone's patience and perseverance. A note of special thanks is due to the owners of Amoriggi Seafoods, Johnston, Rhode Island, who never lost faith and organized, designed and contributed whole-heartedly to fathering a new concept in the seafood-processing industry.

Introduction

Seafood processing in the New England region has been traditionally conducted by small operators who have concentrated on one or two similar species. As business costs rise, it is becoming increasingly difficult for enterprises that are centered around only one or two species to maintain good profits. There has been a trend toward markets opening for additional seafood resources; however, spiraling capital costs and uncertainty of these markets have made it extremely risky to invest in new processing lines. Thus, the concept of diversifying into multispecies processing of fish and shellfish has surfaced as an attractive and intriguing one.

Discussions about undertaking such a processing project began in 1975. Provisions for extending United States fisheries jurisdiction out to 200 miles were being hammered out and the seafood industry was viewing the passage of the 1976 Fishery Conservation and Management Act as the start of a prosperous new era. The seafood industry began to focus on improving its efficiency in handling new fishery resources and on maximizing dollar potential in these efforts. Unfortunately, at the time, existing companies, both large and small, did not have the technological background or equipment to expand from processing traditional species in order to handle lesser known seafoods. In the years since the FCMA passage, traditional species that processors relied on have been put under management regulations which have altered their availability. This variable, added to prior limitations—natural biological cycles and constantly changing harvesting patterns—has made it difficult to procure desired species for processing.

Within this climate, both encouraging and discouraging, interest developed in the multispecies-processing approach. A Rhode Island industry expressed the desire to work with the University of Rhode Island Marine Advisory Service in developing a new multi-purpose processing line. Experience with the seafood industry and other food-processing industries guided refinement of the initial concept into the design of a single, basic processing line. With a minimum of equipment, this line was intended to process year-round multiple species into a variety of high-quality products.

This report explains the results of the project, which was started in February 1976 and completed in March 1979. The main intent of the project was to demonstrate the feasibility of combining five different pieces of equipment into one functional processing line. Since the legal requirements of the cooperative agreement between the industry and URI (see Appendix B) protects the proprietary nature of the complete processing system, no details could be prepared for inclusion in this article.

Funding for the lease of critical equipment and for this project's support was obtained through the Southern New England Fisheries Development Program. This program, made available through the efforts of former Rhode Island Senator John O. Pastore, was administered through the National Marine Fisheries Service within the National Oceanic and Atmospheric Administration, Department of Commerce.

Selection of Equipment and Operation

The result of the multispecies processing had to be a saleable product, either raw or partially cooked, which had an established market but also had potential for wider distribution. The species chosen would have to be readily supplied by fishermen and would have to be similar enough to each other to be processed in the same fashion. Keys to the production of this product were a high-temperature cooking system, meat-shell separator, freezing units and packaging machine. All the above components embody the philosophy of maintaining high quality through rigid quality control procedures. Never before have these particular pieces been assembled in a multispecies-processing line. The remainder of the components for the line were selected by the participating firm based upon the needs and requirements of its business.

The processing line was tested in a three-month operational period using the species nobbed whelk *(Busycon carica),* channeled whelk *(Busycon canaliculatum),* ocean quahogs *(Arctica islandica),* and Jonah crabs *(Cancer borealis)* available in Rhode Island waters. Toward the end of this period, interested industry personnel in the region were invited to demonstrations.

The next section contains a discussion of the key components, including how they were chosen and how they worked, followed by an evaluation of performance and results.

Components

Component #1
Conveyorized Inspection and Sorting Table

This piece of gear (Figure 1) located near the beginning of the processing line was considered essential to the line's efficient operation. It was custom-produced to fit into the process at a specific point and to provide proper loading rates. Specifications were for a stainless steel of Type 304-2B finish, 16 feet long and 3 feet wide. The conveyorized belt running down the middle is food grade, driven by a one-horsepower variable speed motor. The flexibility given to this unit by the variable speed motor could allow the table's use in other positions in the processing area.

In addition to maintaining proper flow rates to the process, this equipment provides an inspection area in which to view the incoming product for broken or damaged pieces. It also allows the removal of any extraneous material which might damage equipment farther down the line.

Component #2
Stainless Steel Retorts, Controls, Baskets and Hoist

These items when joined together (Figure 2) form the heart of a processing operation of this type. High temperatures obtained with the retorts provide relatively short cooking times, which preserve the product's yield and nutritive value. This high-temperature short-cook technique begins the separation of the meat from the shell portion and readies it for further processing.

This technique can be applied on a continuous basis, or the slower batch process can be used. Recently there has been a large thrust on the part of equipment manufacturers for the use of continuous cookers, which were developed in the food industry, for the seafood industry. Some have been tried, but they have failed to perform adequately or economically. Therefore, a decision was made to stay with the batch process for this project and to make it as automatic as possible.

This equipment was also custom-manufactured, and designed to process specific amounts of various seafood products. Two special vertical retorts were fabricated of Type 316 stainless steel, as this type of steel is most resistant to saltwater exposure. Only exterior parts were constructed of mild steel. Each retort was equipped with a quick-close hand wheel and a hydraulic system for raising and lowering the cover (Figure 3). All instrument pockets and control equipment fittings were also made of stainless steel.

Special control systems were installed to automatically steam and pressure cool the products. The controls were mounted in individual panels next to each retort (Figure 4). These controls allow a presetting of temperatures (from 212° to 270°F) and time (from 1 minute to 180 minutes) for accurate control.

The retorts still have to be loaded, closed, opened and unloaded manually. The product is placed in the retorts in special perforated baskets for easy loading and unloading. These baskets are of Type 316 stainless steel to protect them against corrosion and, because they are in direct contact with a food product, to comply with local health standards. The perforations, which are 1 3/16 inches in diameter, are on 2 1/8-inch centers for even steam distribution. The baskets also have trapdoor bottoms for bulk discharge. Loading and unloading these heavy baskets from the retorts is handled by an electric chain hoist with a two-ton capacity. The hoist is specially geared for fast retrieval, and moves horizontally on a motorized trolley by a hand-held control panel.

Component #3
Meat-Shell Separators

Normally, the total separation of meats from shells in mollusc production is a three-phase operation. The first phase, discussed above in the description of the cooking process by Component #2, can partially or fully detach meats from the shells. The second phase is an attempt to achieve 100% separation, known as the release phase. The third and last phase is the physical sorting of the meats and the shells.

Originally tried for phase two was a commercially produced inclined vibrator 30 inches wide and 5 feet long, with a vibrating surface constructed of Type 304 stainless steel perforated with holes 1/8 inches in diameter. This machine accepted products directly conveyed from the retorts. Initial trial runs demonstrated that this piece of equipment released meats from the shells at a percentage far below tolerances and was totally unacceptable. The cause of the low percentage was that vibrating action was not severe enough to produce release. However, the built-in versatility of the machine coupled with the flexibility of the processing line allowed the machine to be located further downstream (Figure 5). There the vibrator was successfully used to evenly meter the flow of shells discharged from phase three to the conveyor, which removed shells from the processing plant.

Many other types of commercially available pieces of equipment were tested for use in phase two, none of which provided a tolerable percentage of release. The problem was eventually solved by a machine principally designed and built by the plant owners, which provided close to 100% release.

Phase three of this operation is the final sorting of the released meats from the shells. The machine employed for this phase is known as a brine separation tank and utilizes the theory of specific gravity differences in high-density brine (Figure 6). The tank is continually filled with a highly agitated brine solution, which flows in a fore-to-aft direction consistent with the flow movement of the processing line. Density differences allow the meats to remain on the surface of the brine solution and the shells to collect on the bottom of the tank.

The meats and shells enter the separation tank directly from phase two. A drag-link conveyor along the bottom of the tank allows for easy shell and sand removal. To better facilitate shell discharge, this conveyor is controlled by a variable speed drive powered by a one-horsepower electric motor. Agitation of the brine solution is accomplished by a 7 1/2-horsepower stainless steel sanitary pump supplied by a 6-inch pump, which drains the full width of the tank.

A 5-horsepower roots-type air blower also agitates the brine solution and helps to move the shellfish meats to the surface, and then toward the discharge end of the tank. There they spill off onto a moving conveyor. The brine solution is constantly monitored for the proper density to facilitate the meat-shell separation. Makeup brine is automatically added when called for by the tank sensor.

Component #4
Tunnel Freezer

The choice of any refrigeration system is not cut-and-dried. The choice is complicated by the variety of freezing processes and equipment currently available. Freezing processes range from simple air-blast types to those that use exotic freezing mediums such as carbon dioxide and liquid nitrogen. A decision also had to be reached as to whether Individually Quick Frozen (IQF) products or bulk frozen packages were more desirable. Another variable is the way the product is introduced to the freezing medium, for this can be accomplished by tumbling action, perforated straight line or spiral conveyor belts, direct contact plates or complete product immersion. The great degree of flexibility of refrigeration equipment allows each application to a processing line to be governed by the line's own degree of sophistication and the ultimate end product desired. However, the variable of economics is important and usually plays the primary role in the selection process. The economics lie not only in initial capital costs for equipment acquisition but also in operational costs. Combinations of different freezing units also appear to maintain the highest quality product and require the minimum amount of energy, the latter equating out in freezing costs per pound.

Careful deliberation resulted in the decision to install a carbon dioxide tumble-style tunnel food freezer (Figure 7). This unit could freeze the various species to be processed, and it also had proven successful with single-species applications in the seafood industry. The equipment offered reliability, rugged construction, simple design, manageable capital investment and high production rates.

The freezer tunnel is 18 inches in diameter and 25 feet in length, with a maximum capacity of 2,200 pounds per hour. Figure 8 shows the entrance to the tunnel. The CO_2 nozzles inject the gas into the tunnel as the products enter, and the product is tumbled the entire 25-foot length, mixing with the CO_2. This provides maximum exposure of the product to the freezing medium. Two of the potential three nozzles were adapted to this tunnel. Naturally, the more nozzles there are, the more CO_2 that can be applied, thus allowing the choice of either freezing products at different rates or freezing more product. The tunnel freezing capacity ranges from 750 to 1,250 lbs/hr., 1,250 to 1,800 lbs/hr., or 1,800 to 2,000 lbs/hr., which allows additional variations in production scheduling and species handled.

Component #5
Packaging Machine

Packaging of seafood products is a science unto itself and has unique problems which have not yet been solved by the food-processing industry. In the past, packaging machinery has been developed to do a specific job under specific requirements. In other words, the machine is developed to give a known, desired end product. There are very few packaging machines developed for seafood industry uses. Therefore, if an already existing packaging machine is to be used in this industry, it must be borrowed from another food-processing area and adapted to meet certain requirements.

The type of packaging necessary for the project presented monumental problems. Since there were a variety of species involved, to be sold in both retail and wholesale markets, the machine had to produce multiple packaging forms. A machine used to package fishery products in Scandinavia was selected for the project (Figure 9). This vacuum packaging machine showed great promise, as it was already employed in a seafood industry application and displayed great versatility. The single disadvantage with the unit was that it had only recently been introduced into the United States and had no proven track record here. Also, the machine was not set up for the types of seafood processed in this project. In adapting this machine, accessories were ordered that would give maximum flexibility. Among these accessories were dies which allowed for maximum package length and the deepest draw the machine could accommodate. These accessories allowed maximum area for loading, a procedure which presented the greatest problem. Dies with appropriate cutting and trimming knives were also ordered which would cut predetermined sizes for wholesale as well as retail packages. A vacuum cannister was installed to control and collect package trimmings. The machine also had the capability of gas flushing the product package with different types of atmospheres such as carbon dioxide and nitrogen. Rounding out the accessories package was an automatic brine-filling unit to be used with any of the dies or package configurations selected. The versatility of this machine was also enhanced by its capacity to handle different types of packaging films. Its ability to use a similar film throughout the package or to join two different types provided additional selection in packaging type. Either semirigid or flexible film could be used.

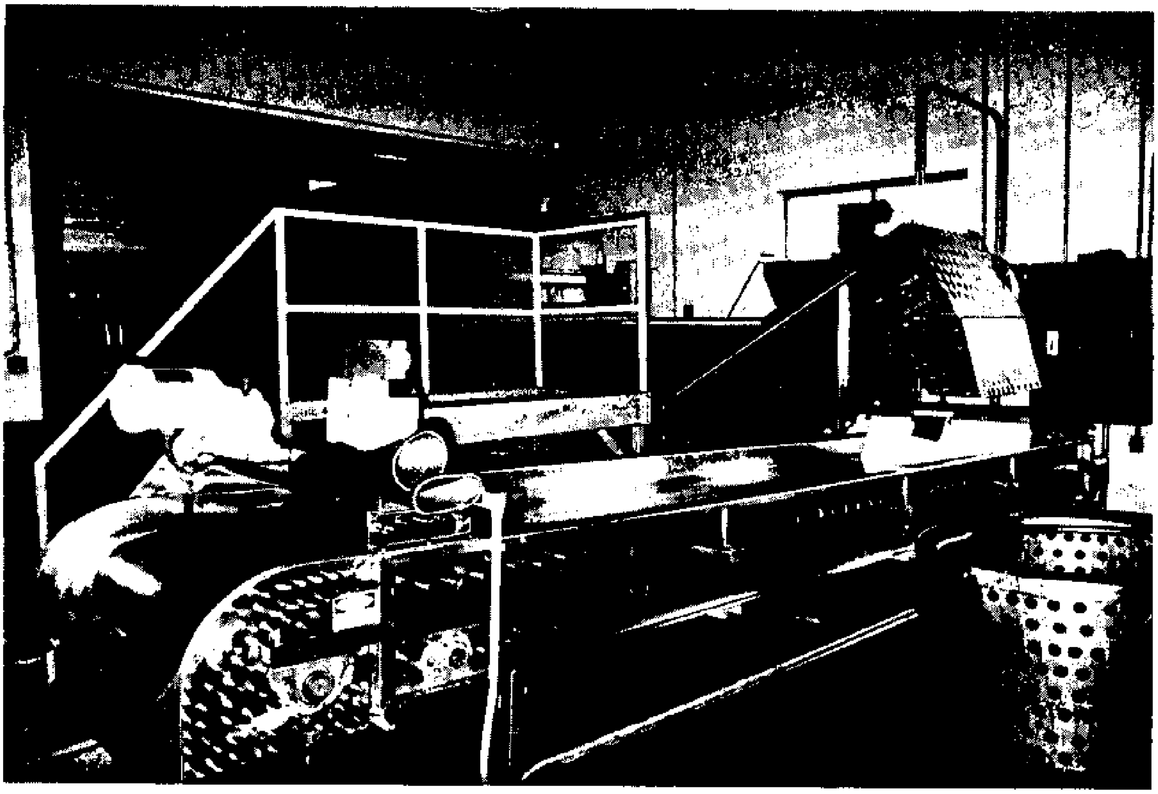

Figure 1. Sixteen-foot Type 304-2B stainless steel inspection and sorting table.

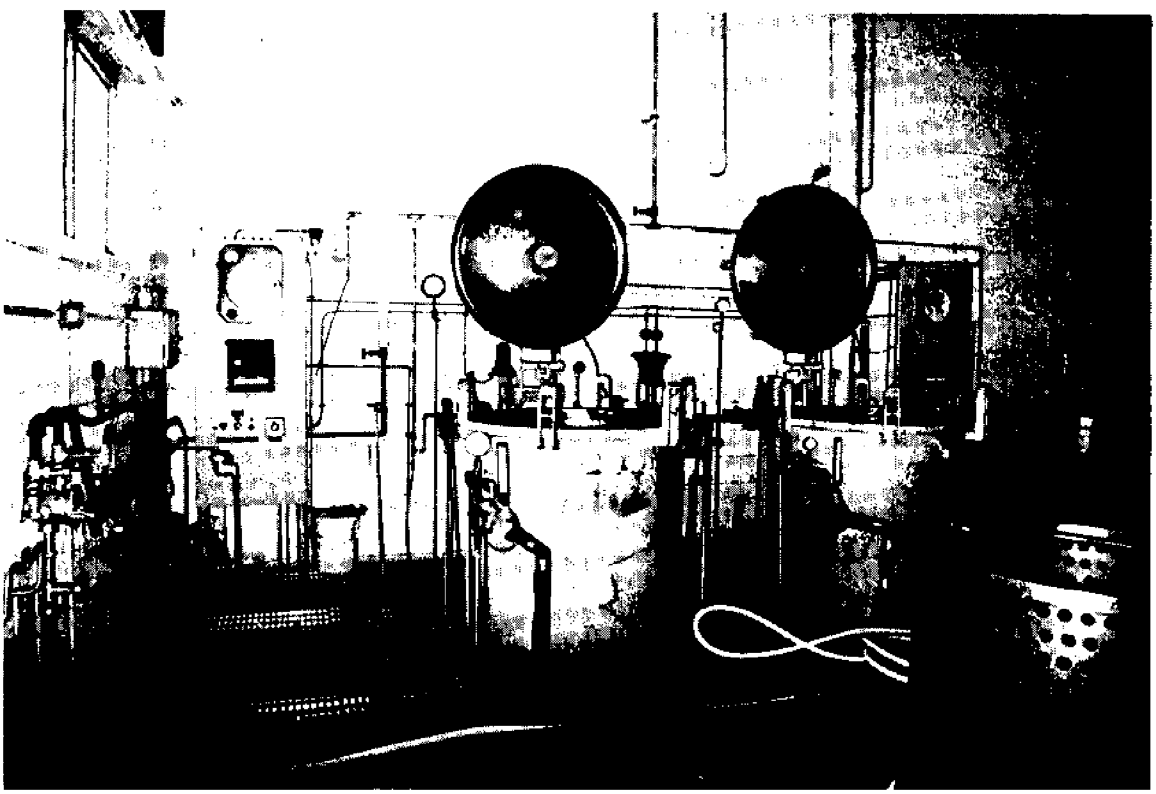

Figure 2. Two special vertical retorts were fabricated of Type 316 stainless steel. Control panel is pictured on left, retort basket at right.

Figure 3. Close-up of retort showing the quick-closure hand wheel.

Figure 4. Close-up of panel controls for semi-automatic operation of retort basket.

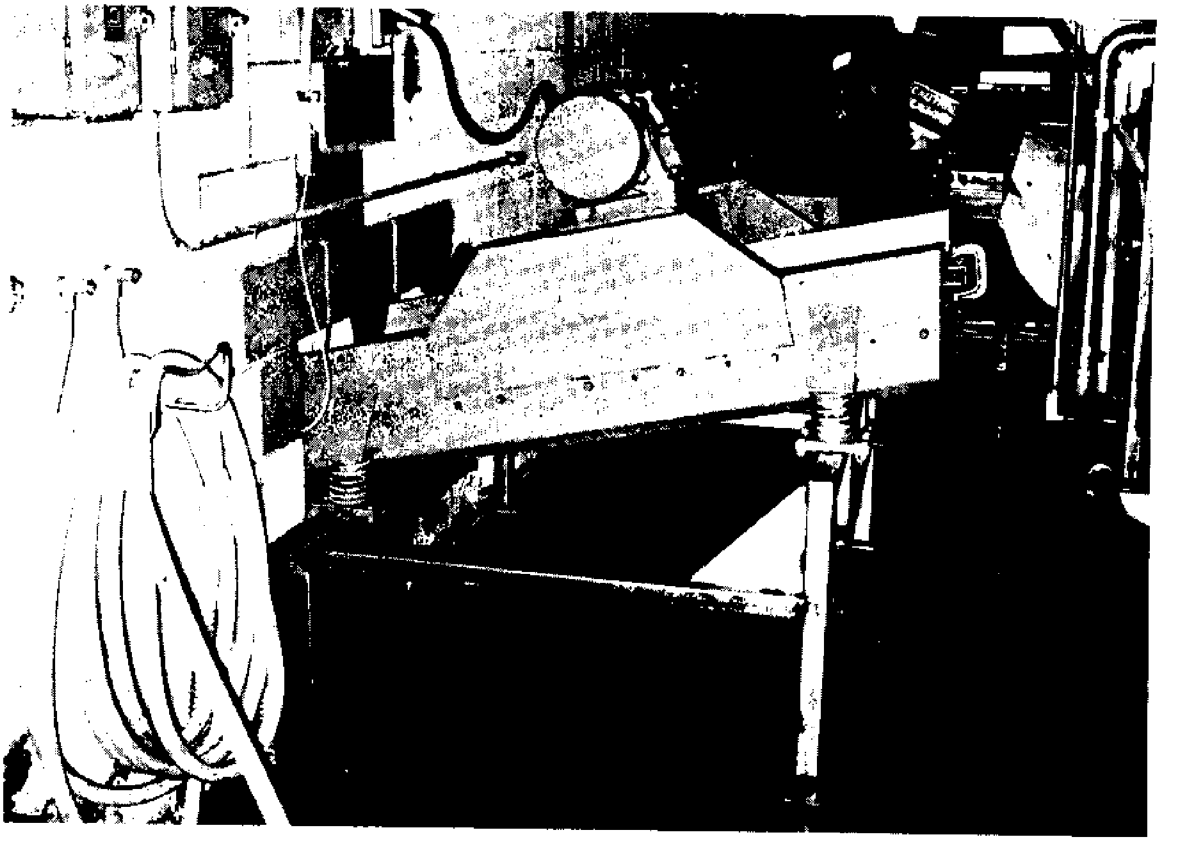

Figure 5. Vibrator used to meter shells to discharge conveyor.

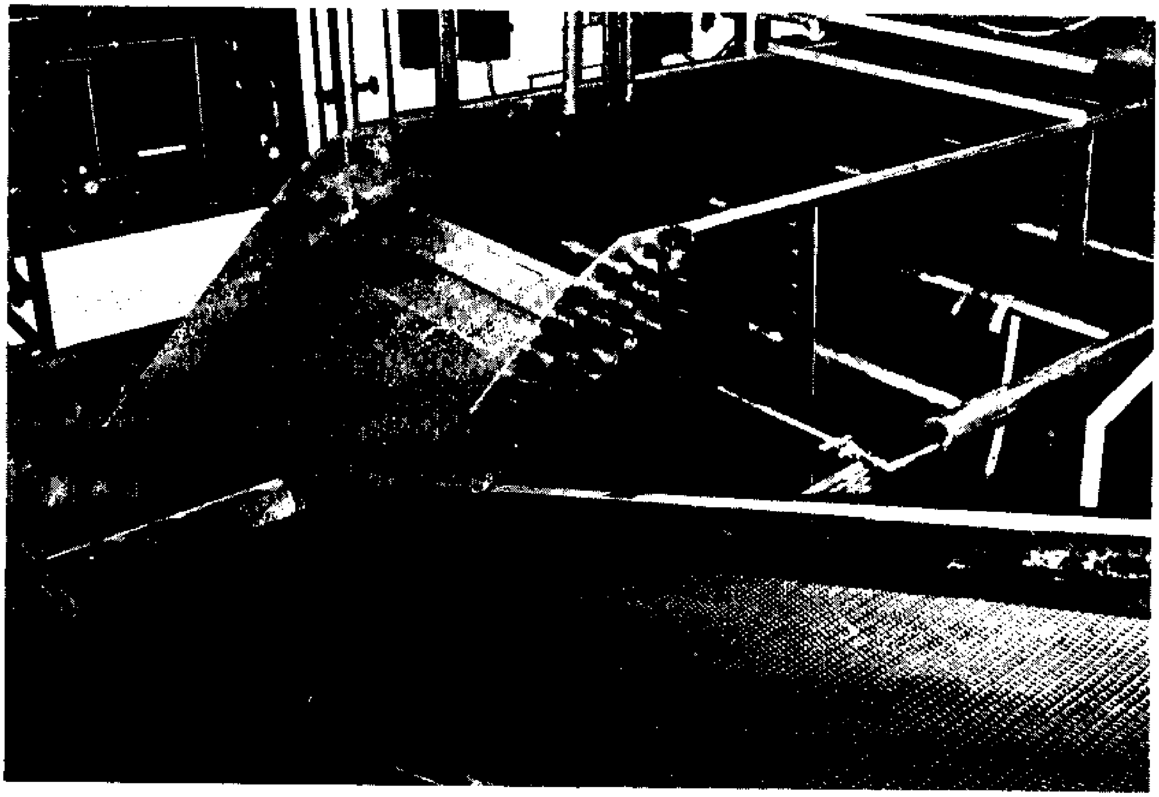

Figure 6. Close-up of brine separation tank with meat transport conveyor in foreground.

Figure 7. Tumble food freezer utilizes CO_2 gas to freeze product.

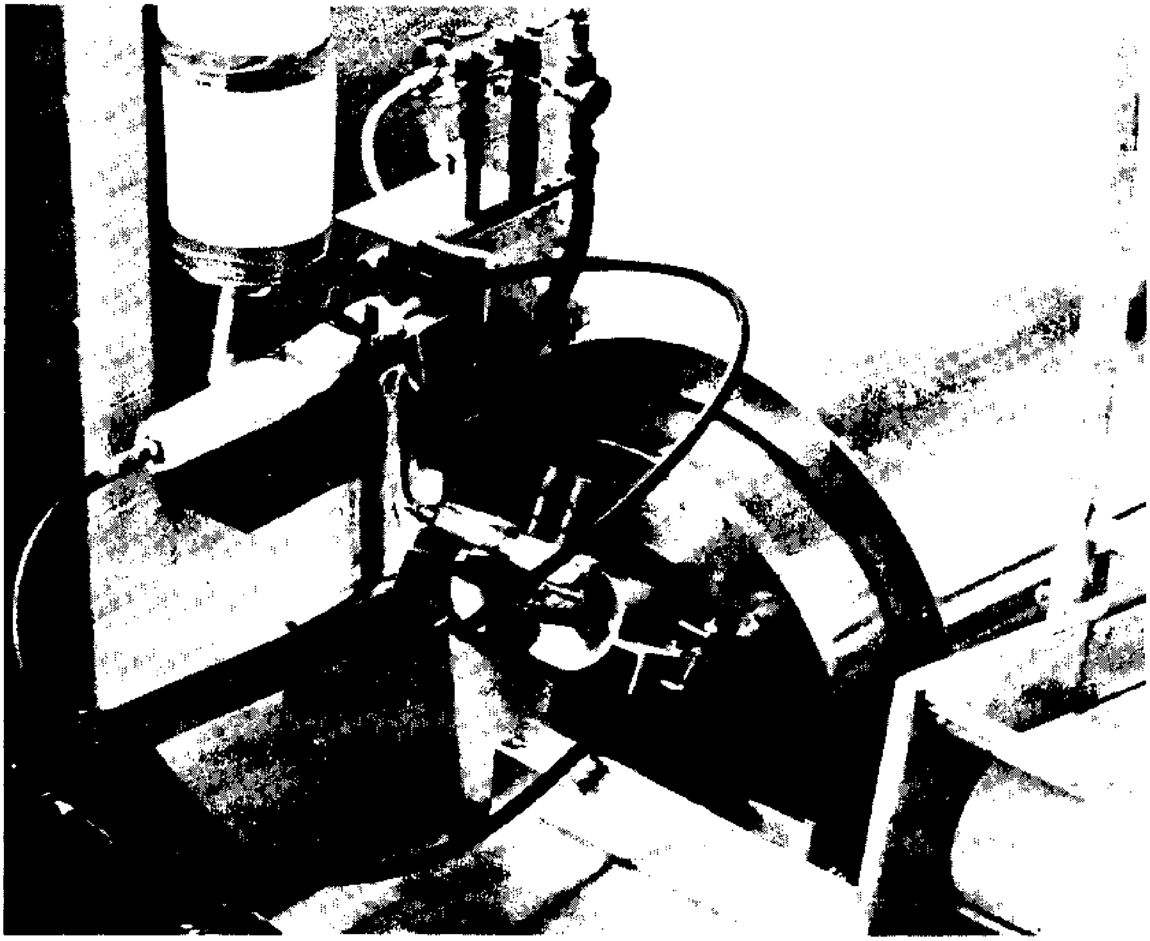

Figure 8. Close-up of CO_2 nozzles at the entry point into tumble freezer.

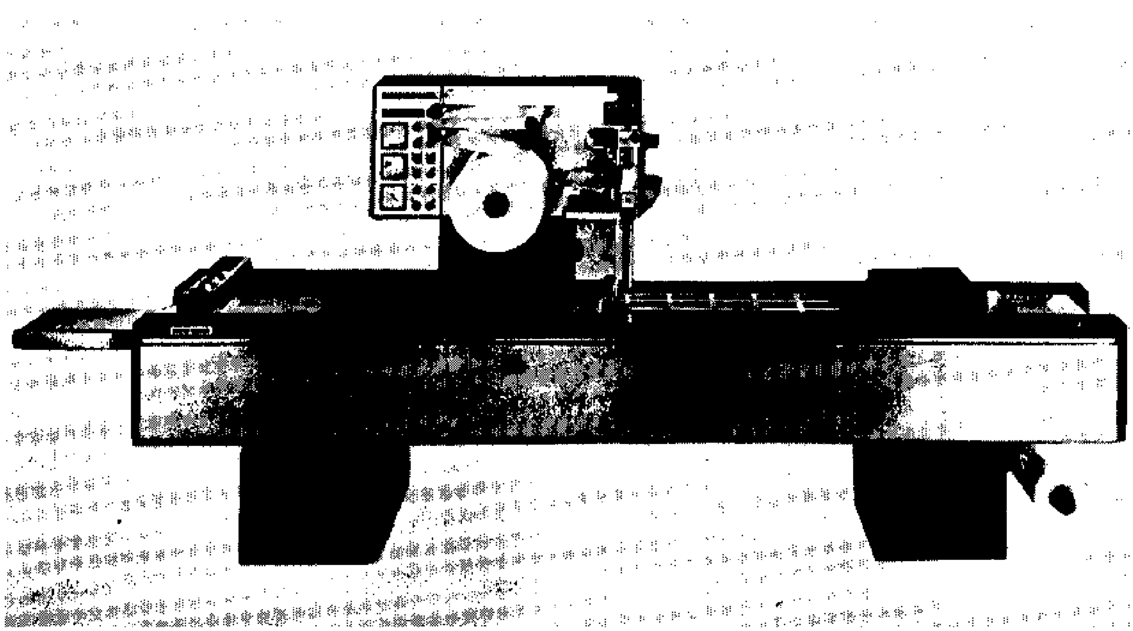

Figure 9. Vacuum packaging machine modified to package seafood products with liquid.

Evaluation

There were two basic objectives in this undertaking. The first was to select food-processing machinery that would handle more than one seafood species, thus enabling operation and production of marketable seafood products on a year-round basis. The second was to evaluate the equipment for application in the seafood-processing industry.

The project was truly a team effort by the Rhode Island firm and the URI Marine Advisory Service, and all phases of the project—i.e., species selection, processing line design, production sales—must be considered in the evaluation. However, it must be emphasized that the evaluation of each piece of processing equipment on its own merits is of paramount importance. Each component functioned as an individual part of the process. Final evaluation, however, must not be solely on what each component can do alone but also on the support and strength it lends to the whole processing unit. As such, some performed better than others, although all are technologically sound pieces of equipment. The following evaluation, therefore, discusses the success of each component's use in the multi-purpose seafood-processing concept.

Component #1
Conveyorized Inspection and Sorting Table

This component performed exactly as expected. There were no problems encountered in the operation and performance of the table. It was found, however, that in operations with certain shellfish species there was some damage to the product. The cause was the height of the component that fed the conveyor. The receiving end of the conveyor was modified in order to alleviate this problem. In future applications, care should be taken to minimize product damage during product transfer from one component to another.

The variable speed motor allowed precise quality control inspection of all species without sacrificing time or creating a bottleneck in the processing line.

Component #2
Stainless Steel Retorts, Controls, Baskets and Hoist

This component functioned extremely well as a total unit. It had been used previously in single-species applications in the seafood industry, and there was some question as to its performance with multiple species. The experimental trials demonstrated that there was no need for concern, since this component performed efficiently in cooking all the species of seafood used in this project. As discussed previously, time and temperature could be modified to control the degree of cooking, thus affecting yields and determining a partially or fully cooked product.

The retorts were modified to open and close at a faster rate in order to provide a much smoother operation of the entire process. Proper training of the retort operator is also important because he has to maintain the flow of the line. Once the controls are preset, the retort operator only loads and unloads the retorts and starts the cooking process. Charts provide a complete record of each cycle performed.

The intense heat generated by these cookers could not be handled by the exhaust vents originally installed. Much larger fans were required to maintain an acceptable working temperature in the building.

The potential for use of these retorts in canning seafood products is very real, and modifications of operating procedures could well accommodate a small canning operation. This use, however, was not evaluated during the project.

Component #3
Meat-Shell Separators

As stated previously, the inclined vibrator initially used to release the meat from the shells did not work satisfactorily at all. However, the vibrating action produced was sufficient for metering the separated shells onto the discharge conveyor. In this capacity, it did an outstanding job.

The brine separation tank worked just as predicted, with excellent results in separating the meats from the shells. The only problem encountered was that the drag-link conveyor at the bottom of the tank had to be modified to handle the load. Once it was reinforced, no more problems occurred.

Component #4
Tunnel Freezer

This component, though used successfully in single-species applications in the seafood industry, did not work well in the multipurpose concept. Its performance depended largely on the degree of moisture in the processed product. The unit was originally designed by the manufacturer to handle a relatively dry product.

Besides the maintenance of proper moisture level in the product, the loading of the tunnel in this particular application presented some problems. It was felt that to operate this component properly and obtain an efficiently frozen product, moisture levels had to be closely controlled at entry. Additionally, when whole fish or shellfish were put through the tunnel, they were properly frozen, but there was damage to the appendages of some species.

This component could be used in some specific seafood applications with excellent and efficient results.

Component #5
Packaging Machine

The packaging machine proved to be the most sophisticated machine of all the project components to operate. Initial trials were quite rewarding; however, some problems were evident. The hope was that with some modification the machine could operate within the prescribed criteria.

Problems were encountered at the very outset with erratic machine performance. The machine initially was not set up properly, and the adjustments necessary to assure reliable performance were never made. Loading the machine presented the biggest problem. Because of moisture, product frailty, and varying product weights, automatic filling of the machine could not be easily accomplished. Manual loading was necessary, which interrupted the flow of the processing line. These problems hampered full evaluation of various product package configurations.

Changing between species also presented problems, and these were anticipated; however, our modifications were not successful in correcting them. Microbiological problems were minimized, since strict sanitary controls were observed and all product was either prefrozen, packaged and stored at 0°F, or packaged fresh and immediately frozen for storage at 0°F.

This machine does have potential in the seafood industry; as in Europe, this machine would function extremely well in a specific single-seafood application.

In summary, it is safe to say that the theory of multi-purpose processing is a workable concept and well within the realm of practicality. There are still problem areas, especially in the loading of different seafood species into processing equipment, as evidenced by the trials with the tunnel freezer and packaging machine.

In the past we have seen new processing equipment introduced into the seafood industry only to fall short of the mark and receive negative feedback, eliminating any future trials. Though each failure has its own specific cause and degree, often the problem has been the lack of supporting equipment and the technology necessary for the equipment to perform as designed. Again, the whole process must be evaluated as a unit and not on the basis of individual components alone.

In any future applications of multispecies processing, the initial planning stages should produce a set of criteria for each piece of equipment which could be used in the selection of that equipment. If the criteria are not specifically known or if there is no equipment which meets the requirements, the situation can best be overcome by building flexibility into the component. Flexibility might help alleviate or conquer any unforeseen problems. This flexibility may also be necessary in the future as economics and United States fisheries policies change with time.

Appendix A

List of manufacturers who provided leased equipment and technical assistance:

A. K. Robbins and Company, Inc.
261 Fifth Avenue
New York, NY 10016

Conveyorized Inspection and Sorting Table
Chain Hoist
Stainless Steel Retorts, Controls, Baskets and Hoist
Meat-Shell Separator and Vibrator

AIRCO Industrial Gases
P.O. Box 285
King of Prussia, PA 19406

Tunnel Freezer

Robert Reiser and Co., Inc.
253 Summer Street
Boston, MA 02210

Packaging Machine

Appendix B

Due to the complexity of this project, conducted by the Marine Advisory Service in cooperation with industry, the assistance of legal counsel was required. Both parties were advised and found it advantageous to have a written legal cooperative agreement specifying the services each party would provide.

Below are listed the general categories included within the agreement for this particular undertaking between the University of Rhode Island Marine Advisory Service and Amoriggi Seafoods.

1. Purpose of the agreement
2. Equipment involved, location of the equipment, vendors supplying equipment
3. Time period for the agreement
4. Authorities involved
5. Construction, installation and limits of the processing line and facility
6. General obligations
   a. what each party provides
   b. who may use equipment
   c. protection against loaning or transferring equipment
   d. method and content of information dissemination
   e. disposition of experimental product
   f. demonstration requirements
   g. protection of proprietary rights
   h. insurance
7. Miscellaneous
   a. amending criteria
8. Agreement administrators