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A Machine for Heading and Eviscerating Small Fish

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ABSTRACT—A commercial fish eviscerating machine has been modified to automatically head, eviscerate, and thoroughly clean whiting, Merluccius bilinearis, *and similarly shaped species of fish. The unit will process about 60 fish per minute, each weighing between 1/4 and 1-1/2 pounds. The cleaned fish, (butterflied, but with the backbone remaining) can be battered and breaded and deep-fat fried or can be directly processed into minced fish with the use of a meat/bone separator.*

INTRODUCTION

Today when there is a constant demand for nutritious foods that are high in protein, more thought is being given to our natural marine resources. However, with the decrease in landings of the traditional fish species and the increased demand for fishery products, the full use of the underutilized species is essential. The use of the entire fish stock is desirable, both from a conservation view (provided resource management is maintained) and from an economic aspect to expand the fishing season for more productive use of the fisherman's time.

The ever increasing demand for processed fishery products has prompted the fish processing industry to use meat/bone separators and other automatic equipment to increase the edible yield of fish (Miyauchi and Steinberg, 1970). This is especially true with very bony or small fish where it is not economically feasible to remove the bones by hand. This flesh, recovered in minced form, can be frozen into blocks for future use in sticks and portions or it can be made into a variety of products such as fish cakes and salt-cured fish (Mendelsohn, 1974), chowders, heat-processed products, etc. (Anderson and Mendelsohn, 1971), and as an extender in meat dishes (King, 1973). Thus, meat/bone separators, first popular in Japan, are now being installed in the United States and in foreign countries.

The traditional method of preparing fish for processing by a meat/bone separator is to first remove the head with a circular blade positioned on a conveyer line. After the head is cut off, the fish is conveyed to a scaling machine (Fig. 1). Here the fish are tumbled within a metal screen in a heavy spray of water to remove the scales. In the conventional commercial scaling operation, some of the viscera in the belly cavity are also removed. In some processing plants, the loose viscera which remains after the scaling operation are superficially removed by hand. However, the blood along the backbone and the kidney, swimbladder, and other attached small pieces of viscera are not removed.

However, in order to produce high quality products prepared from minced fish flesh collected from a meat/bone separator, the fish must be properly headed, scaled, cleaned, and washed thoroughly. The quality of the minced flesh is judged by the absence of viscera, blood, bone, skin, scales, sound (swim) bladder, and in species such as whiting, *Merluccius bilinearis*, the belly lining (a black membrane lining the visceral cavity).

SURVEY OF CLEANING MACHINES

A survey of gutting and cleaning machines for preparing fish for meat/bone separators was conducted. At the start of this project no commercial machine was available to automatically head and thoroughly clean whiting and similar species. Several machines appeared suitable to meet the gutting and cleaning requirements, but most were very costly and not adaptable to handling mixed species. Not only were different species a problem but also size and range and black belly lining removal. One machine[1] appeared to satisfy most of the requirements. At a preliminary trial it cleaned small freshwater smelt successfully and with modifications appeared suitable for

[1]Model 22, manufactured by LaPine Bros., Inc., Gladstone, Mich. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

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cleaning larger fish. Therefore, this machine was purchased. However, since the start of this project, several new machines have been introduced that may meet the original requirements. We have not checked the efficiencies of these machines for whiting; therefore, no comparisons can be made.

ORIGINAL LAPINE GUTTING MACHINE

As purchased, the LaPine machine was equipped with a V-shaped feeding trough, two spring-loaded rubber belts to hold the fish, a cutting wheel (rotating blade), and two aluminum cleaning wheels (drilled blind holes around periphery and on flat sides (Fig. 2)). The fish were introduced to the gutting machine through the adjustable V-shaped trough up to the point where the belts grabbed the fish to be cleaned. At each station, water could be introduced to clean the blade, wheels, and wash out the visceral cavity.

In using this original machine, commercially headed and scaled whiting were fed to it belly down, and the fish were carried forward between the two spring-loaded rubber belts. The belt speed was set at 43 feet/minute, but with minor gear changes, it could be adjusted upward. While the unit was effective for small whiting, the black belly lining and the kidney in larger whiting were not completely removed. On further processing of the minced flesh into blocks, and other products, this belly lining appeared as black spots, and the pieces of kidney and viscera appeared as colored spots in the frozen product.

MODIFICATIONS MADE TO LAPINE GUTTING MACHINE

To make the original LaPine machine satisfactory for preparing whiting for processing in a meat/bone separator, many modifications were made. Since the machine could only eviscerate fish, an automatic heading unit was designed and installed just prior to the cleaning machine. The heading unit consists of a conveyor with tapered hardwood cleats spaced 3 inches apart (Fig. 3). The distance between cleats is 1 inch at the base and $2^1/_2$ inches at the top. This conveyor leads to a 12-inch diameter rotating stainless steel adjustable blade (Fig. 4) which cuts off the head just behind the gills. Each of the cleats has a section removed so that there is formed a groove along the entire track to allow a spring-loaded plastic tongue to ride along the groove. The plastic tongue acts as a spring to hold down the body of the fish to prevent it from

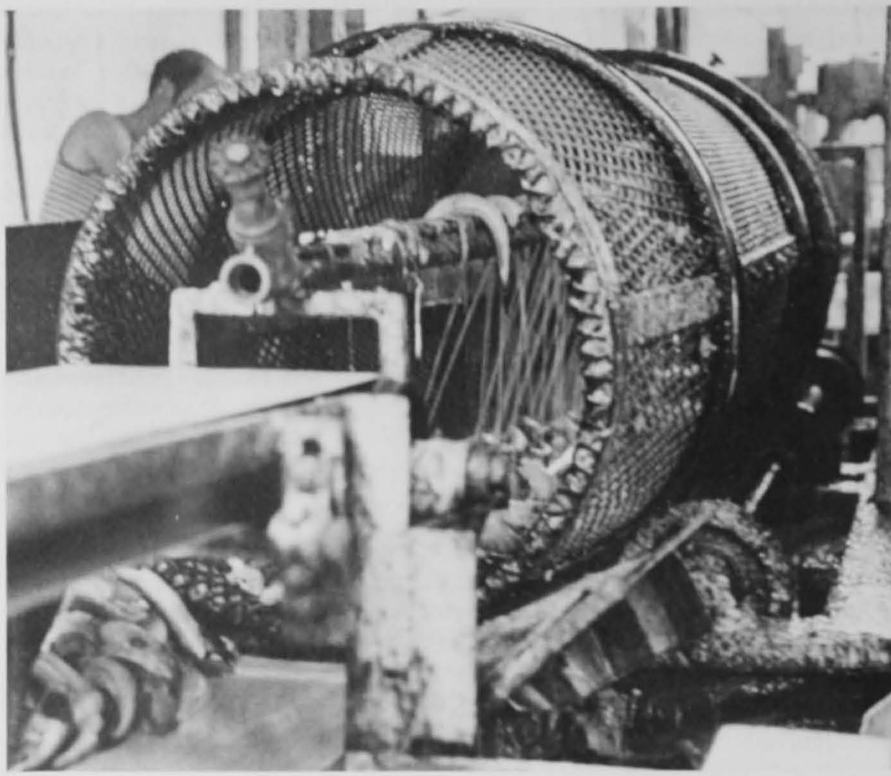

Figure 1.—A conventional rotating scaling machine now in use in the fishing industry.

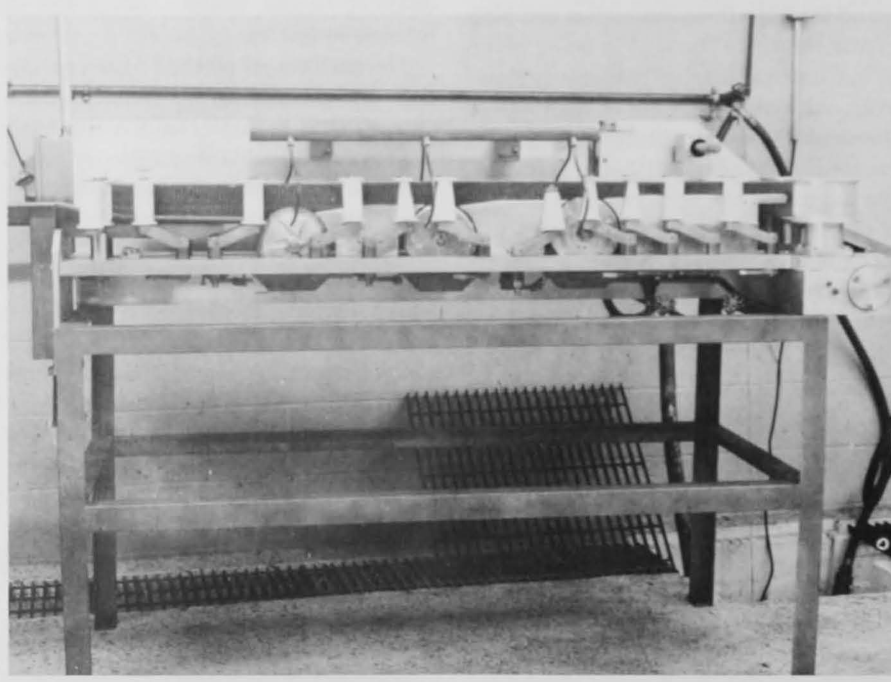

Figure 2.—The original LaPine fish cleaning machine as purchased from the manufacturer.

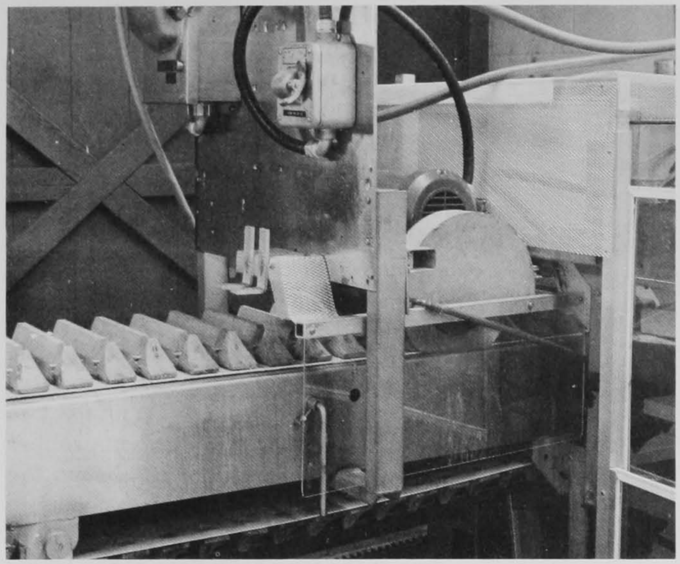

Figure 3.—The cleated conveyor used to bring the fish by the rotating blade to be headed.

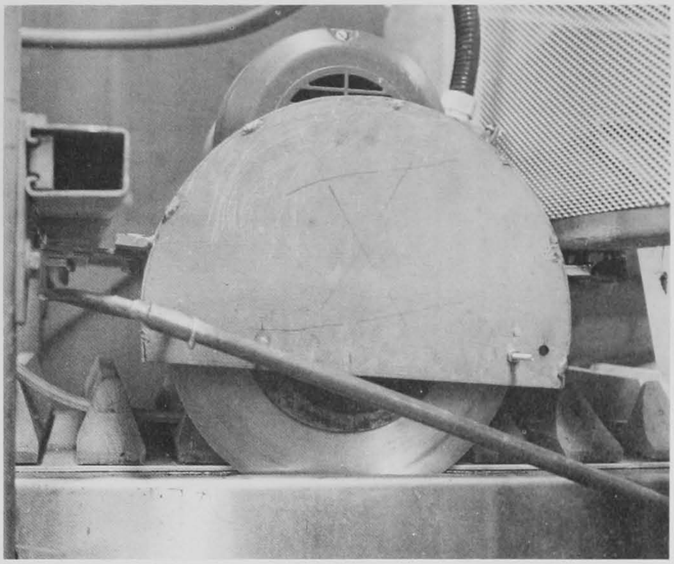

Figure 4.—The rotating blade for heading the fish.

rolling as it is being headed. Keeping the fish upright until it is gripped by the carrier belts of the gutting and cleaning machine is essential for successful evisceration.

After the fish are headed, the cleated conveyor carries them to the entrance of the gutting and cleaning machine. At this point, a transfer device pulls them out of the conveyor and deposits them between the belts of the gutting machine. The transfer device consists of two sprockets and a chain on which is mounted a pair of spring-loaded striker arms, each equipped with a pair of sharp spikes (Fig. 5). A striker arm stops directly above the conveyor and as a fish passes under, the striker is released and drives the spikes into the back of the fish. The spikes on the chain conveyor drag the fish out of the cleat conveyor and into the entrance of the spring-loaded carrier belts of the gutting machine. This chain conveyor is equipped with a variable speed drive which allows it to be run at the highest speed at which operators can load the cleated conveyor.

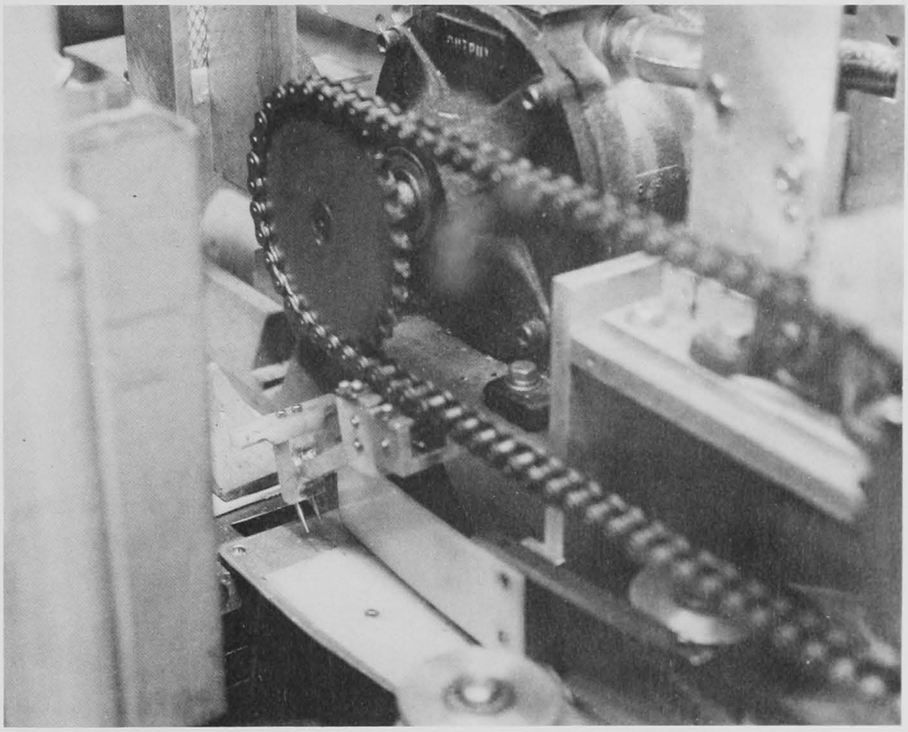

Figure 5.—The device for transferring the fish from the header to the cleaning machine.

Between the heading machine and cleaning machine there is an adjustable trough or slide which controls the depth of cut made by the slitting knife. This is positioned by an air-operated cylinder and can be manually adjusted, depending on the size of the fish to be cleaned. The machine will clean whiting varying in size from about 8 to 14 inches with no adjustment; however, if all the fish in a given lot are small (about 8 inches), the inlet trough can be adjusted upward specifically for these fish and adjusted down for larger fish. This adjustment makes it possible to obtain maximum yield.

The carrier belts hold the fish in line as they travel over the rotary slitting knife (Fig. 6). This 6-inch diameter stainless steel knife cuts deep into the belly of the fish up to the backbone. As with the heading wheel, this wheel has a stream of water to wash it and keep it clean. Above this blade there is a plastic hold-down arm to keep the fish from riding up while being slit. The fish

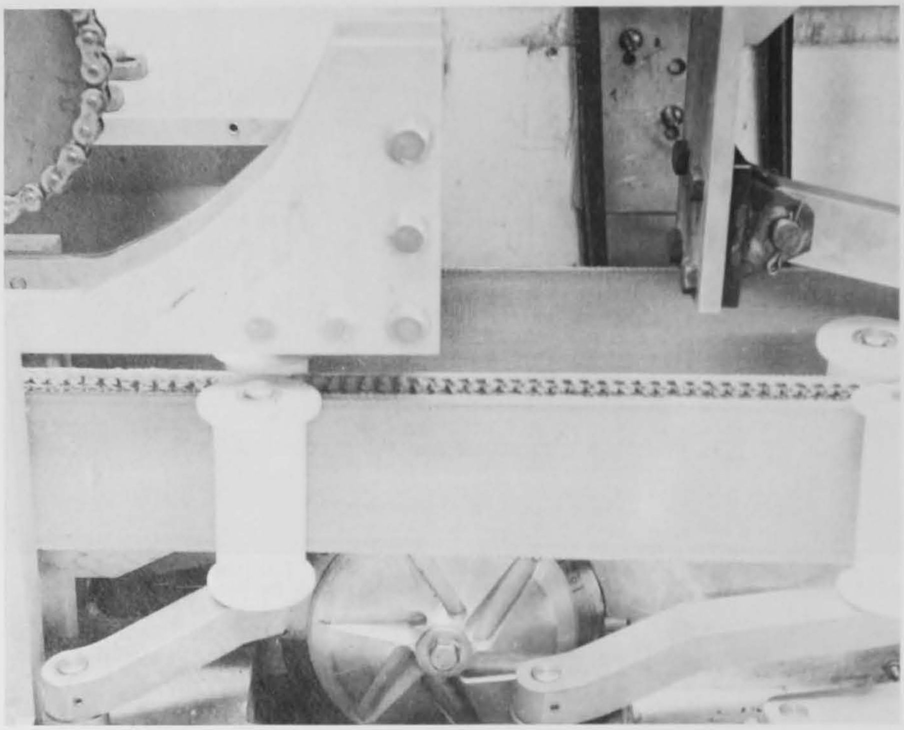

Figure 6.—The belly slitting blade to open the fish for cleaning.

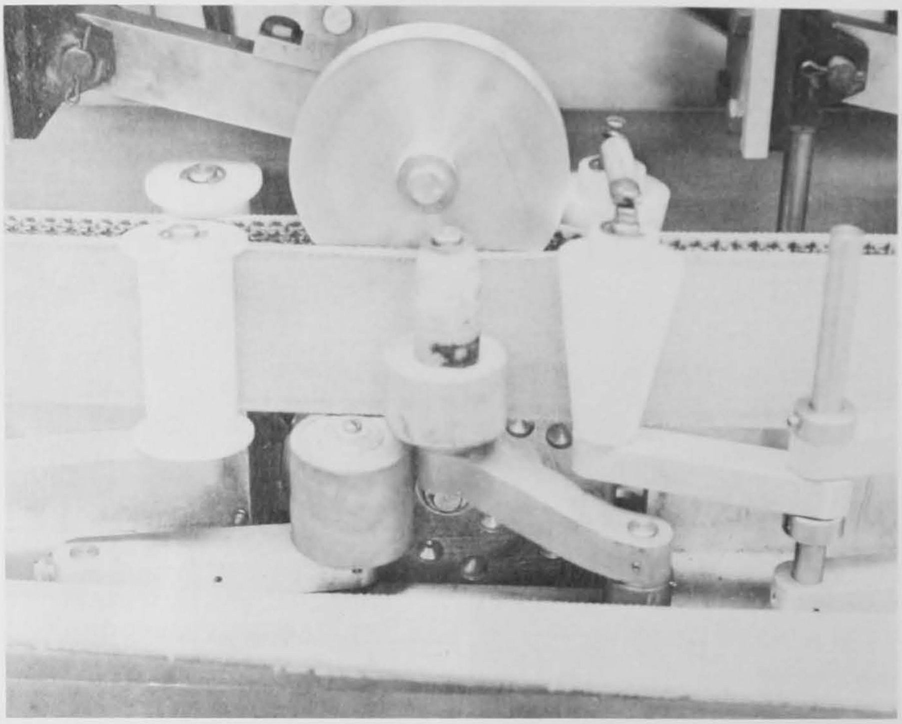

Figure 7.—The section of the modified machine showing the aluminum cleaning wheel with the fish hold-down roller and soft rubber wheels to press the inside of the fish against the cleaning wheel.

now pass over a smooth aluminum bar, used as a guide between the rubber belts, to the first cleaning station. At this point, the fish pass over a 6-inch diameter aluminum cleaning wheel or disc with a rounded periphery that has blind drilled holes along the outside edge and along the flat sides (Fig. 7). These cleaning wheels were part of the original gutting machine. The pattern of holes is arranged to overlap each other for complete cleaning of the inside of the fish. Running water is used to keep this wheel clean.

In the original machine, the 3-inch rubber belts were only wide enough to hold the outsides of the small fish against the cleaning wheel. With the larger whiting, the longer belly flaps hung below the 3-inch belts and the lower portion of the belly flaps were not adequately cleaned. Therefore, two air pressure controlled soft rubber wheels were installed just below the rubber belt (Fig. 7). One was placed on each side of the machine to hold the tips of the long belly flaps of the larger fish against the cleaning wheel. With these secondary holding wheels the insides of both small and large fish can now be effectively cleaned.

Another smooth aluminum bar, between the rubber belts, guides the fish to the second cleaning wheel. In the original machine, this 6-inch aluminum cleaning wheel was similar to the first cleaning wheel. However, in the modified unit, a cleaning wheel designed especially for herring, which is tapered at the top to fit more closely into the belly cavity of the fish, was installed. This modified wheel also has blind holes drilled around the periphery, drilled slots on the outer tapered edge, and sharp blind holes along the flat sides. It is also washed with water. As with the first cleaning wheel, the 3-inch belt would not hold the entire body of the larger fish against the wheel. Therefore, another set of air pressure controlled soft rubber wheels were installed just below the rubber belts to hold the long belly flaps in the larger fish against the cleaning wheels.

In the original machine, as the larger fish passed over the cleaning wheels, they were forced above the rubber holding belts and were not cleaned properly. To keep the fish in position on the cleaning wheels, two pressure-controlled, free-rolling, hold-down wheels were installed above the cleaning discs. These grooved wheels hold the fish against the disc for complete cleaning (Fig. 7).

From the second cleaning wheel the fish pass over another aluminum bar and onto the final washing and cleanup conveyor. The fish ride on one belt and are held down from above by two belts (Fig. 8). The fish are held by the V-belts to a point on the machine where the belly flaps are spread out almost horizontally (Fig. 9). A stream of water is spashed on the surface of the spreader as a lubricant to keep the belly flaps from dragging. With the belly flaps spread wide open, they now pass over a spirally grooved, tapered, rotating aluminum wheel. The fish are held down on this rotating wheel by a spring-loaded wheel on top (Fig. 9). This cleaning wheel removes the last traces of black belly lining and any viscera that were not removed by the two previous cleaning wheels. The cleaned fish are now conveyed to the meat/bone separator for further processing.

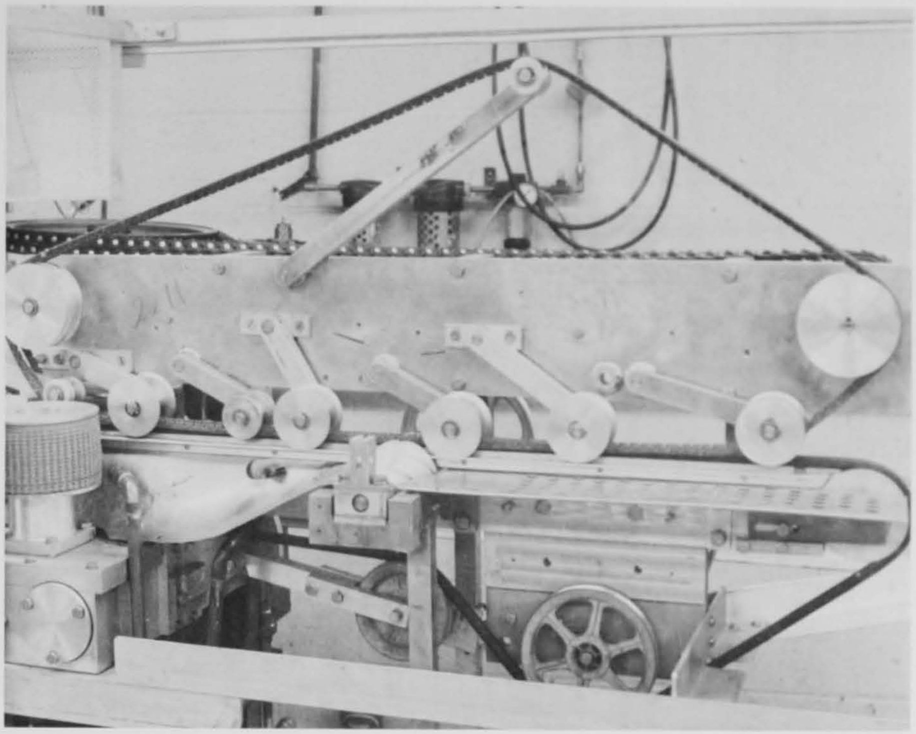

Figure 8.—The conveyor which brings the fish to their final washing and cleaning.

COLLECTION OF MINCED FISH FLESH

As the fish leave the cleaning machine (belly down), they are made to flip over on their backs (belly up and fully exposed) onto a conveyor (Fig. 10) leading to the meat/bone separator. This offers an inspection point to assess the cleaning effectiveness of the eviscerator. An inspection of the fish is made, and any uncleaned fish are removed from the line. The completely cleaned fish are then conveyed directly into the meat/bone separator[2].

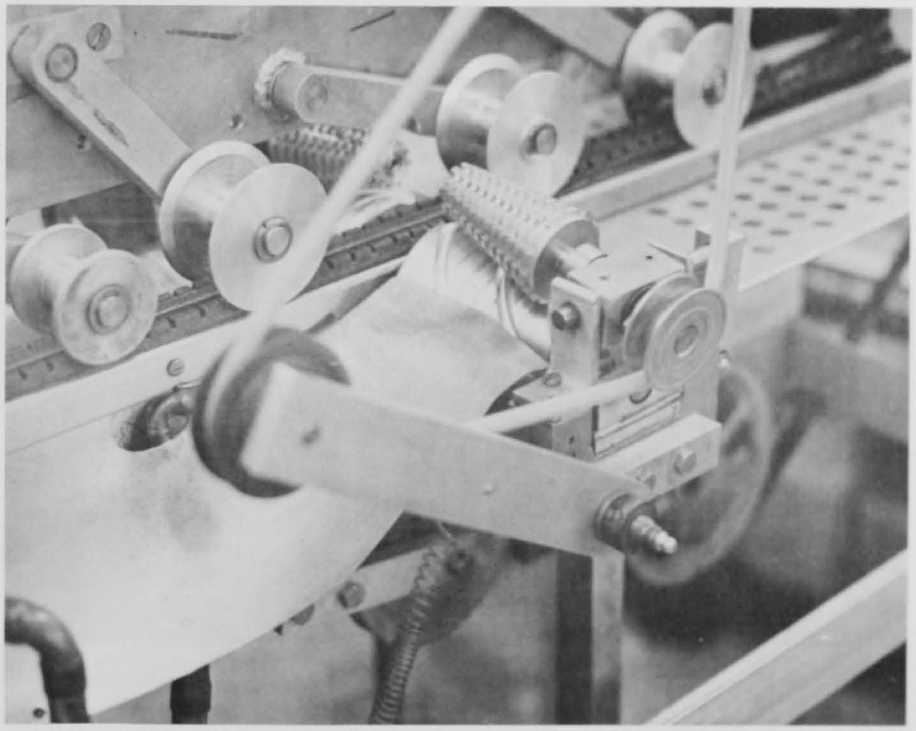

Figure 9.—The device which gives the fish their final washing and cleaning.

RESULTS AND DISCUSSION

An overall view of the automatic fish header and eviscerator is seen in Figure 11. The number of fish that can be headed and cleaned is now around 60 fish per minute but could be increased by adding an orienter to align the fish automatically for heading just behind the gills. The limiting factor at present is the feeding of the fish into the cleat conveyor. It takes two people to properly feed 60 whiting per minute into the machine. Figure 12 shows a comparison between a whiting cleaned by the modified LaPine machine and a whiting headed and dressed in the conventional manner. The fish processed by the LaPine machine (on the right of Fig. 12) is thoroughly cleaned of all the viscera, blood, and black belly lining, while the conventionally processed fish (in the center of Fig. 12) contains blood, kidney, viscera, and black belly lining. The thorough cleaning and washing also reduces the number of bacteria that is normally present in high concentration in the visceral cavity. Products made from the fully cleaned fish retain their quality longer,

[2] Model 15 Bibun meat/bone separator.

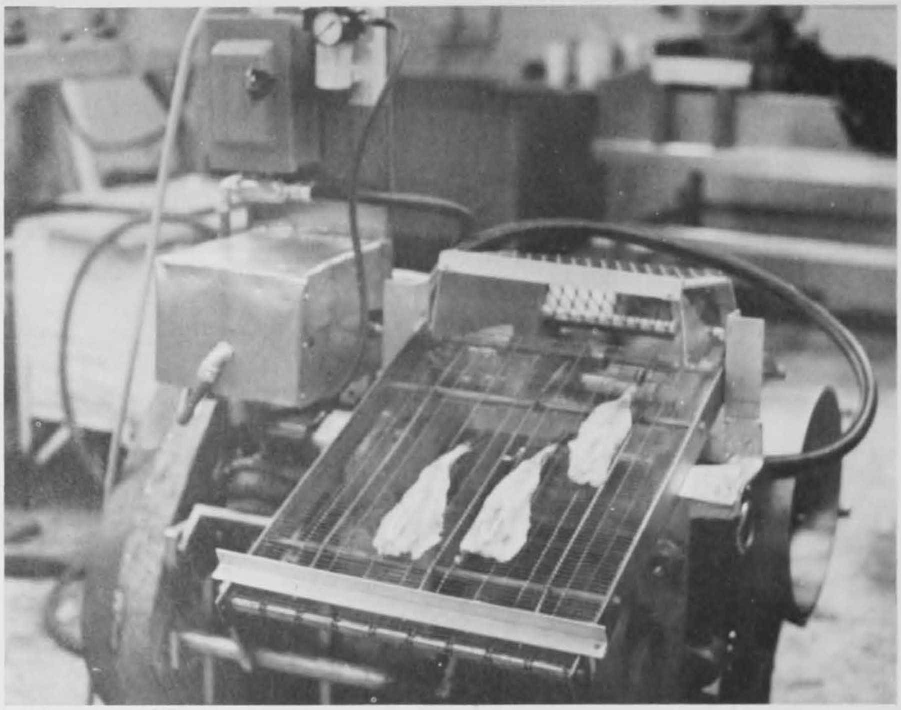

Figure 10.—The cleaned fish as they enter the meat/bone separator.

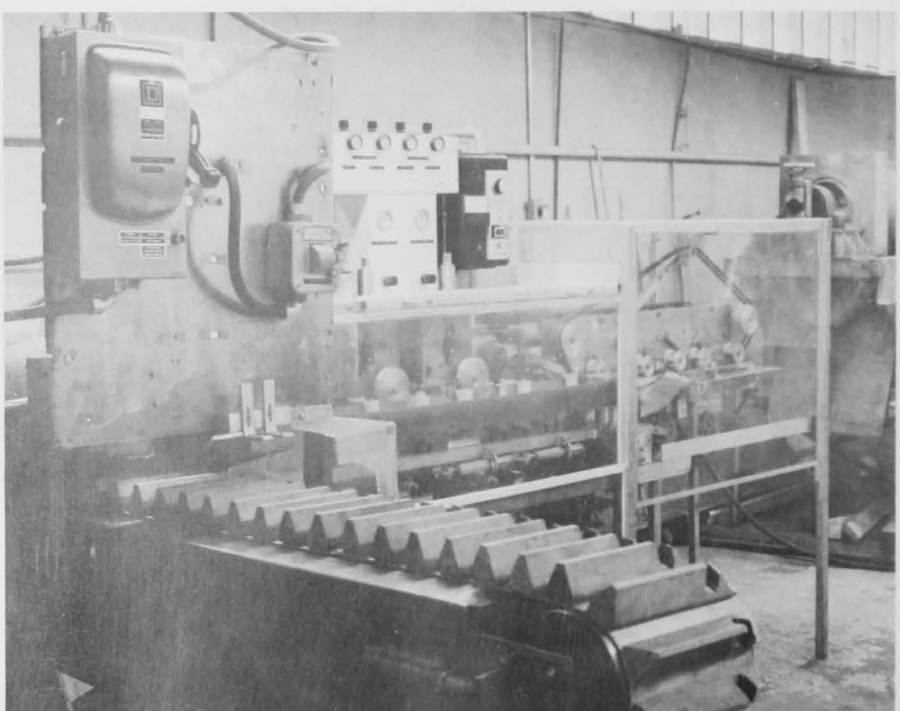

Figure 11.—An overall view of the automatic LaPine heading and cleaning machine.

have a better appearance, and extended storage stability. It is even more important to remove all the viscera, including blood and kidney (where the bacteria reside) for use in minced products. The mincing process increases the surface area of the flesh, making it more susceptible to bacterial spoilage and, in fatty fish, to development of rancidity.

The efficiency of the modified LaPine cleaning machine was determined using whiting of various sizes. The settings on the LaPine machine were held constant during the experiment, except for the inlet feeder. For the lots of whiting containing small fish (between 8 and 10 inches) or large fish (16 inches or longer), the inlet feed was adjusted to compensate for the size. The

Table 1.—Cleaning efficiency[1] of the modified LaPine machine.

Whiting length (inches)	Cleaning efficiency[2] (percent)
8-10	94
10-12	100
12-13	97
14-16	90
16	80

[1] Complete removal of head and viscera.
[2] Average results from duplicate experiments.

cleaning efficiency results from two duplicate experiments are shown in Table 1. As can be seen from this table, the cleaning efficiency is highest for whiting between 10 and 14 inches, which is within the range in which most of the whiting fall that are landed in this area. Several attempts were made to clean whiting weighing over 2 pounds that were found in the lot of fish measuring over 16 inches. Although these fish were headed properly, they would not transfer from the heading conveyor to the cleaning machine. The pins in the transfer conveyor would not set deep enough into the back of the very large fish to pull them from the cleat conveyor to the cleaning machine. These fish just passed by the cleaning machine and fell off the heading conveyor. Therefore, with the machine set for cleaning whiting between 10 and 14 inches, the fish going into the machine should be limited in length to about 16 inches and in weight to about $1\frac{1}{2}$ pounds. Modifications to the machine can be made to handle the very large whiting, but this would reduce the efficiency of the machine to clean the smaller fish.

Recovery yields after each phase of the process were also determined. The results from each size lot are shown in Table 2. A composite of the results from the various sizes of fish is given in the last two columns of this table.

As seen in Table 1, all the whiting between 10 and 14 inches were almost fully cleaned and the larger (longer) the fish, the lower the efficiency. This is fortunate, for most of the whiting landed locally measure between 10 and 14 inches, although there may be some smaller and some larger fish in the catch. Also, in Table 2, the highest yields were obtained from fish weighing between 1/2 and 1 pound. These fish are again within the 10 to 14 inch range, which constitutes the bulk of the whiting landed. To show the relationship between the length and weight of whiting, an average length-to-weight ratio was determined using whiting between 10 and 14 inches. The composite value (35 fish) found is that a whiting 11.6 inches long weighs 0.6 pounds. This ratio is not always constant and depends mainly on whether the fish are feeding.

CONCLUSIONS AND RECOMMENDATIONS

The modified LaPine machine will head and completely clean the bulk of the whiting landed (10-14 inches in length) without changing the operating conditions signficantly. Minor adjustments to the modified LaPine machine controls can be made to handle batches of smaller and larger fish for more efficiency.

The fish that have passed through the modified LaPine machine can be used directly as a frozen, raw, or fried product or put through the meat/bone separator. In either case, the fish are completely cleaned and can be processed directly into high-quality products.

To further automate the heading and cleaning operation, several pieces of auxiliary equipment are needed to complete the processing line. Since the unit works well with whiting up to 16 inches in length, a divergent slot grader could be used to sort the fish into three size categories—smaller than 8 inches, 8 to 16 inches, and larger than 16 inches. The machine works best when the controls are set for the middle range of 10 to 14 inches. For more complete cleaning of the other sizes of fish, the controls can be readjusted for the smaller fish and again for the larger fish. These changes can be engineered to automatically respond to the various sizes of fish.

All the fish that are run through the machine should be scaled to keep the scales from getting into the mince or into the batter and breaded fried products. Therefore, a scaler should be part of the auxiliary equipment.

The speed at which the machine can be run is now limited by the hand loading and positioning of the fish in the slots of the feed conveyor. The fish are positioned to sever the heads just behind the gills. The conveyor speed is approximately 60 fish per minute, set at this rate by the capability of two workers to properly feed the conveyor. By using an automatic orientor to position the fish for heading, the production rate could probably be increased to 75 fish per minute. This would reduce hand labor costs and increase the efficiency of the operation.

An exploratory cost survey of the

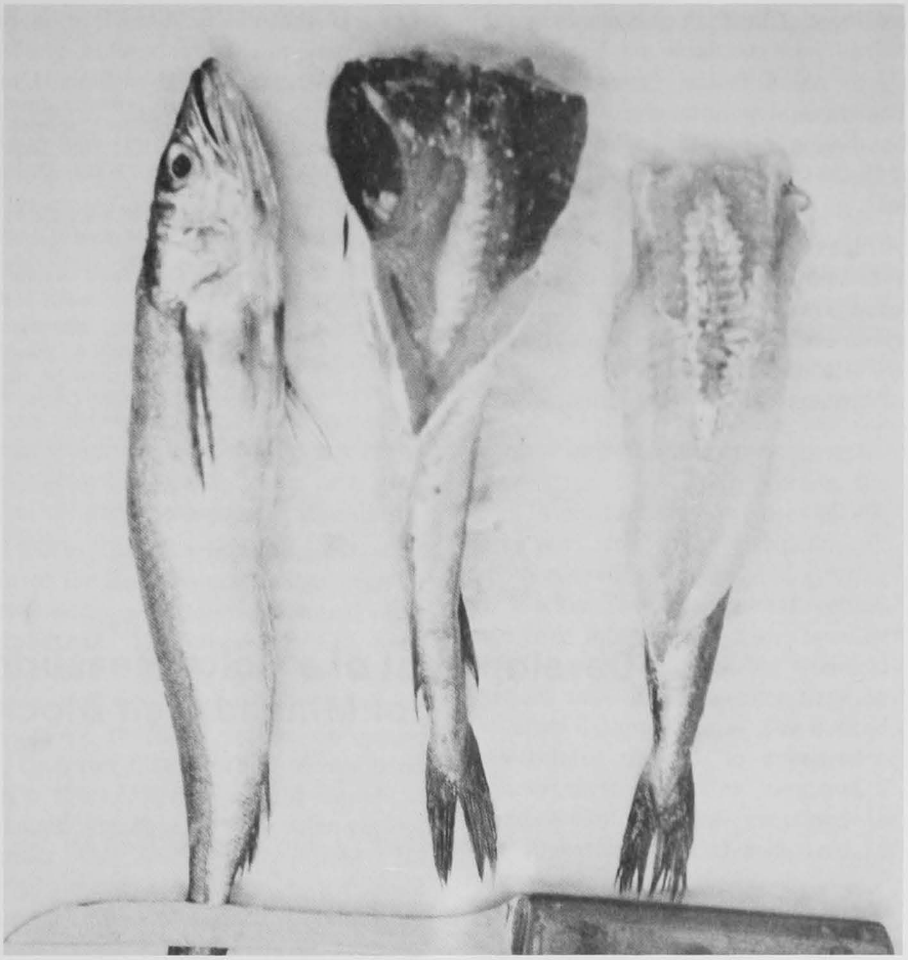

Figure 12.—A comparison of whiting cleaned by the conventional commercial method and by the automatic LaPine machine.

Table 2.—Recoveries[1] from each phase of the process.

	Percent yield by weight of fish				Average recovery (%)	
	Up to ½ lb	½-¾ lb	¾-1 lb	Over 1 lb	Whole fish	Headed fish
Whole whiting	100 %	100 %	100 %	100 %	100 %	—
Headed fish	70.0	70.5	70.4	68.5	69.9	100%
Cleaned fish (completely eviscerated)	49.8	52.5	53.7	51.1	51.9	74.3
Minced fish (collected from Bibun meat/bone separator)	43.4	47.8	50.3	40.0	45.4	65.0

[1]Average results from duplicate experiments.

commercial heading and cleaning machines now available on the market shows them to be very expensive. Preliminary estimates of the cost for building a modified LaPine machine indicate that its selling price should be less.

Plans are underway to test the modified machine under commercial conditions. The unit will be put into a commercial fish processing plant where its efficiency, throughput, and quality of product will be determined.

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MFR PAPER 1234

Development of a Color Measuring System for Minced Fish Blocks

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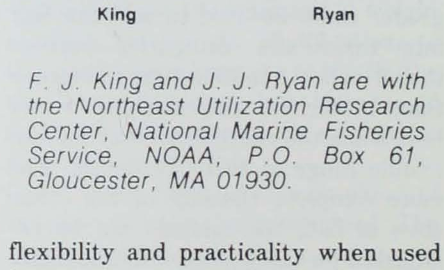
ABSTRACT—The present interim grade standard for minced fish blocks has three categories of color styles, but it does not include a method for classifying a given block into one of these categories. This report describes a system for color classification. It is based on a reflectance spectrophotometer and Munsell neutral value standards. A set of color pictures is included to visualize what is measured by these Munsell "shades-of-gray" standards.



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The proposed Interim Standards for Grades of Frozen Minced Fish Blocks contain three color classifications: "white", "light", and "dark" (National Marine Fisheries Service, 1975). This is the first seafood grading standard which classifies color into styles. Previous seafood grading standards have included color only as a visual indication of deterioration in quality from the normal appearance of a product. In contrast to other graded seafoods, the normal appearance of freshly prepared minced fish blocks can vary widely. These blocks can be made from virtually all species, ranging from white flesh such as cod to dark flesh such as herring, or from a mixture of species. For some product applications, such as fish sticks or portions, a white appearance is desirable (King, 1973a). For other applications such as mixtures with ground beef, a dark appearance is appropriate (King, 1973b).

Such considerations led to classifying styles of color in the Proposed Interim Standards for Grades of Frozen Minced Fish Blocks. The present document (National Marine Fisheries Service, 1975) states that "color standards will be developed and incorporated in the final regulations." Since its publication, we have examined several methodologies for color classification. They are described in this report.

In present buyer-seller contracts, the appearance (color) of minced fish blocks is determined by mutual agreement, such as by limiting the source material which can be used or by using color photographs or chips. These methods have obvious advantages of flexibility and practicality when used by small groups. Their advantages become difficulties when considering them for a proposed U.S. standard. For example, the proposed interim standards of grades of frozen minced fish blocks is meant to include all source materials from which minced fish blocks might be derived. Color photographs have their disadvantages, such as fading and difficulty of duplicating or replacing an original with a