Improving the quality of whiting

by John A. Peters, Edward H. Cohen, and Enrico E. Aliberte

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CONTENTS

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Abstract In any food industry, quality is a large factor in price; and price is a large factor in profits.

At present, the whiting industry is in an unfavorable economic position. This report suggests how the industry can strengthen itself by improving handling methods both on the vessel and at the shore plant. These changes will increase not only the efficiency of operations, but also the quality of the product.

INTRODUCTION

Need For The Research

The whiting industry had its start in New England during the 1840's; but until the early 1900's, most of the whiting was used as bait to catch dogfish.

In 1917, the first hot fish shops opened in East St. Louis, Ill. Their popularity increased rapidly and 5 years later, a wholesale firm in St. Louis introduced whiting to this trade. The physical attributes, the plentiful supply, and the low price made whiting more desirable than other available species for fried fish, so the whiting industry grew rapidly. Landings in New England, which comprise 95 percent of the whiting landed in this country, rose from 7 million pounds in 1924 to 170 million pounds in 1957.

Technological developments in refrigeration, packaging, and distribution enabled the industry to supply whiting to markets all over the country. At present, whiting is used not only for human consumption, but also for mink food, pet food, and fish meal (Fritz, 1960).

Accompanying the rapid increase in landings of whiting has been a mushrooming of numerous problems that plague the industry. These problems stem partly from the nature of whiting itself, which unless handled with greater than ordinary care, rapidly loses its initial delicious taste. Furthermore, the headed and gutted form in which most whiting is offered for sale limits demand. Convenient products are capturing an increasingly larger share of the consumer's food dollar, and to many prospective purchasers, headed and gutted whiting does not fit into that category. This combination of factors has resulted in an economically depressed whiting industry, and both fishermen and processors have appealed to the Bureau of Commercial Fisheries for assistance.

Objectives of Project

Accordingly, a research project, "Improving the Quality of Whiting," was started at the Bureau's Technological Laboratory, Gloucester, Mass. The project was designed to aid the industry by (1) focusing

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attention on previous work on improving the handling of whiting aboard the vessel, (2a) investigating methods of handling used in the plant and (2b) making recommendations for improving both the efficiency in processing and the quality of product, and (3) developing new products to expand the market for whiting.

Purpose of Report

The third part of the project--developing new products--has not yet been completed, so it will be reported later. The first two, however, are done. We believe that the findings, if put into practice, will significantly improve the economic status of the industry. The purpose of this paper therefore is to report these findings.

The principal subjects discussed are (1) handling of whiting aboard fishing vessels and (2) handling in the processing plants.

HANDLING WHITING ABOARD VESSELS

Loss of quality begins as soon as fish are caught. It is essential, therefore, that any program directed toward improving quality begin aboard the vessel. The Commonwealth of Massachusetts and the State of Maine, both under contract with the Bureau of Commercial Fisheries, have investigated handling practices in use aboard New England fishing vessels and the effect of these practices on the quality of the fish landed.

Under these contracts, three experienced fishermen made trips aboard vessels, fishing out of ports in Maine and Massachusetts, to determine causes of loss of quality and to instruct crew members on handling procedures to minimize these losses. In addition, inspections were made at the dock to check on the relation of storage practices to the quality of fish landed. In 48 sea trips and 85 dockside inspections, 10 trips were made on whiting vessels, and landings of 14 whiting vessels were inspected.

In the following we report these observations, discuss them, and then give our recommendations.

Observations

Whiting trips were of short duration, ranging from 2 to 5 days with an average of 3.6 days at sea.

About 95 percent of the whiting were landed in the round, so evisceration aboard the vessel was not a particular problem. Washing facilities on many of the vessels, however, were only fair.

Usually, no shelving was used in the storage pens, and hold conditions varied considerably. As judged by cleanliness and condition of paint and pen boards, five vessels were rated good; five, fair; and nine, poor.

Icing practices also varied greatly. On the average, 1 pound of ice was used for each 3.8 pounds of fish. The range, however, extended from 1:1.8 to as high as 1:8.2.

Occasionally, vessels with catches of whiting were tied at the dock for 1 or more days before being unloaded, particularly on weekends.

Discussion

Inadequate washing of whiting prior to storage in the pens results in heavy growth of bacteria on the fish. There is a direct relation between number of bacteria and rate at which the fish spoil. Storage of dirty fish creates trouble that can easily be avoided. Where deck hose pressure and volume of water are low, larger pumps should be installed. Use of small chlorinating units (fig. 1) will improve the quality of fish landed and markedly decrease odor in the holds (Linda and Slavin, 1960).

Whiting is a soft fish particularly susceptible to brusing. Rough handling aboard the vessel, and particularly storage in pens without shelving, results in irreparable loss of quality. Tests by Puncochar and Pottinger (1947) showed that pressure on the fish at the bottom of a pen 4 feet deep was 216 pounds per square foot and in a pen 5 feet deep was 346 pounds per square foot. Extrapolation of these data to the 10- and 12-foot depths found in the unshelved pens of whiting vessels indicates that pressure on fish at the bottom of these pens will be 780 and 850 pounds per square foot, respectively. With pressures of this magnitude, the flesh is badly damaged, and losses in weight of 10 percent or more may result.

One of the most comprehensive reports on proper icing practices aboard the vessel is by MacCallum (1955). He points out that, during the summer, 0.25 pound of ice is

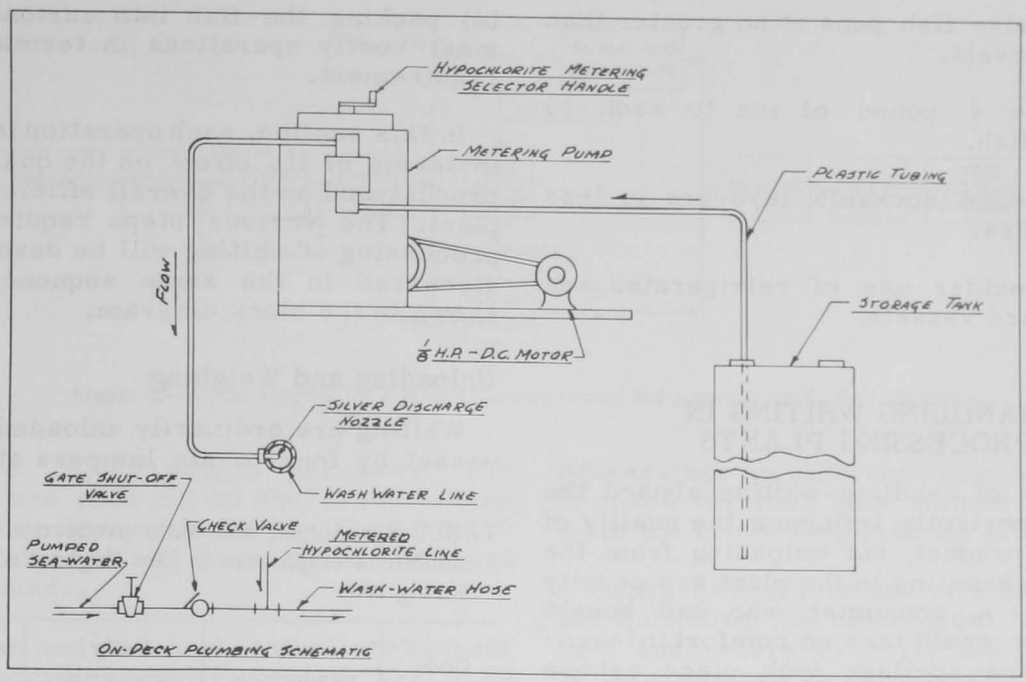

Figure 1.--General layout of sodium-hypochlorite metering installation.

sufficient to cool 1 pound of fish from 55° to 32° F. An additional 0.4 pound is required, however, to keep the fish away from the pen surfaces, to cool the hold and fittings, and to remove heat leaking into the hold. Therefore, a ratio of 1 pound of ice to 1.5 pounds of fish should be used to ensure landing fish of high quality at the end of a 5-day trip in summer. The importance of separating the fish from the pen boards and surfaces is shown in figure 2. A properly iced fish will cool to 32° F. in about 4 hours, compared to the 18 hours or more required for a fish lying against the pen boards.

The technique of storing fish aboard the vessel in sea water refrigerated to 30° F. solves many of the problems due to storage in ice. The loss of quality arising from improper or inadequate icing and the bruising and crushing of the fish from the tremendous weight applied to them can be eliminated by converting present pen sections into refrigerated sea-water tanks. As the tanks are filled, sea water cooled to 30° F. is pumped through the mass of fish. They are cooled rapidly and uniformly to the temperature of the sea water and held at that temperature for the duration of the trip. Tests at our laboratory showed that whiting stored in refrigerated sea water were of much better quality than were those stored in ice for the same length of time (Cohen and Peters, 1963).

It may not be possible to avoid dockside layovers entirely; however, where possible, landings should be scheduled so that the vessel can be unloaded no later than the day following its arrival in port.

Recommendations

Our recommendations for improving the quality of whiting landed are as follows:

1. Wash the fish prior to storage in the hold.

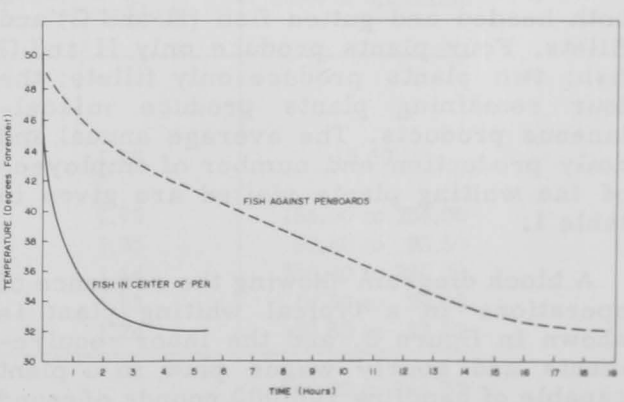

Figure 2.--Cooling rates of fish iced in pens aboard the vessel.

2. Shelve fish pens at no greater than 4-foot intervals.

3. Use 1 pound of ice to each $1\frac{1}{2}$ pounds of fish.

4. Reduce dockside layovers to less than 14 hours.

5. Consider use of refrigerated sea water aboard vessels.

HANDLING WHITING IN PROCESSING PLANTS

Methods of handling whiting aboard the vessel importantly influence the quality of the final product, but unloading from the vessel and handling in the plant are equally important. A consumer who had bought spoiled fish would take no comfort in learning that the spoilage took place ashore rather than at sea.

Economically, handling procedures are of vital concern to plant managers, since, in a highly competitive market, a significant advantage may be gained by a processor with greater efficiency in production.

Two members of the laboratory staff visited 26 whiting plants located in Maine, Massachusetts, and Rhode Island to determine which of the processing steps could be improved in order to increase quality of product and efficiency of operation. During these visits, they observed handling methods from unloading the vessel to shipment of the frozen product, and then discussed these steps with the managers of the plants. The staff members found that the majority of whiting is handled by 14 plants producing both headed and gutted fish (H and G) and fillets. Four plants produce only H and G fish; two plants produce only fillets; the four remaining plants produce miscellaneous products. The average annual and daily production and number of employees of the whiting plants visited are given in table 1.

A block diagram showing the sequence of operations in a typical whiting plant is shown in figure 3, and the labor requirements and hourly wages paid in a plant capable of handling 100,000 pounds of round fish per 8-hour day are shown in table 2. It can be seen that (1) sorting the fish and feeding them into the heading machine and (2) packing the fish into cartons are the most costly operations in terms of labor requirement.

In this section, each operation is analyzed in terms of its effect on the quality of the product and on the overall efficiency of the plant. The various steps required in the processing of whiting will be described and discussed in the same sequence as that shown in the block diagram.

Unloading and Weighing

Whiting are ordinarily unloaded from the vessel by four to six lumpers at a rate of

TABLE 1.--Annual and daily production and average number of employees in New England whiting plants during 1961

Code letter	Annual production of whiting	Daily production of whiting	Average number of employees
	Million pounds	*Thousand pounds*	
A	15.00	150	--[1]
B	10.00	100	40
C	10.00	100	45
D	10.00	500	24
E	8.50	140	26
F	8.00	55	32
G	7.00	70	40
H	6.18	34	--[1]
I	5.00	140	80
J	5.00	112	56
K	4.00	100	60
L	4.00	40	--[1]
M	4.00	100	45
N	3.50	100	57
O	2.00	60	40
P	2.00	50	30
Q	1.68	80	60
R	1.50	40	25
S	1.50	15	50
T	1.25	8	0[2]
U	1.25	12	12
V	1.00	30	15
W	0.80	25	45
X	0.30	30	--[1]
Y	0.20	30	21
Z	0.05	8	29

[1] Figures not available.

[2] No processing done at this plant. Whole fish shipped for processing.

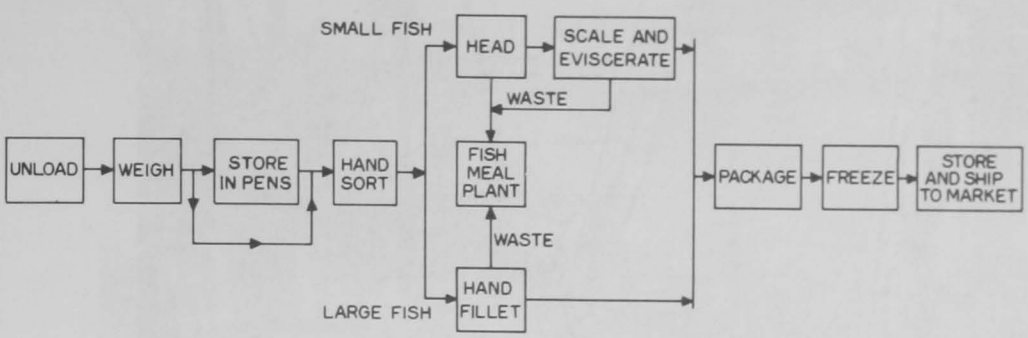

Figure 3.--A flow diagram for a plant producing headed and gutted (H and G) fish and fillets.

20,000 to 25,000 pounds per hour. The lumpers are paid out of the crew's share and receive $15 each for the first 90,000 pounds unloaded and $1 for each additional 10,000 pounds.

The fish and ice are shovelled into baskets of 100-pound capacity, which are then hoisted out of the vessel's hold and swung over to the wharf. In some cases, the fish are dumped into a conveyor that loads them into a truck for weighing and transporting to the plant (figs. 4, 5, and 6).

Where plants have direct access to the wharf, the fish are weighed in the baskets, then dumped into a conveyor that carries them directly to the plant (fig. 7).

No attempt is made to remove the ice from the whiting during unloading because it is supposed to keep the fish cool prior to processing. An allowance of up to 10 percent is made for ice. This amount is deducted from the gross weight of the trip.

Conveyors are in use in some fisheries for unloading the catch from the vessel's hold and, where properly designed, result in less damage to the fish and lower costs than do the other methods of unloading. Owing to the relatively small size of the hatch openings and the large tidal range, it would be difficult, but by no means impossible, to apply this equipment to the whiting fishery. Vacuum-chamber fish pumps such as are used by some West Coast companies for unloading sardines probably could easily be adapted for use with whiting. These machines are reported to (1) have large capacity, (2) result in minimum bruising of the fish, and (3) require only a small amount of water for efficient operation. The impeller pumps used

TABLE 2.--Cost of labor required to process 100,000 pounds of whiting per day [1]

Operation	Employees	Hourly wages per employee	Cost of operation
Transferring fish from pens to conveyor	1	1.95	15.60
Sorting and feeding heading machine	10 to 15	1.95	156.00 to 234.00
Filleting	4 to 6	1.95	62.40 to 93.60
Packing	20 to 25	1.44	230.40 to 288.00
Check weighing	1 to 2	1.85	14.80 to 29.60
Utility men	5 to 6	1.74	69.60 to 83.52
Total			548.80 to 744.32

[1] Cost estimates are based on union wages prevailing during 1961 season.

Figure 4.--Unloading a whiting vessel by means of baskets and a hoist.

Figure 5.--Basket of whiting swung over from vessel to wharf.

Figure 6.--Basket being emptied onto conveyor.

Figure 7.--Conveyor moving the whiting from the wharf to the plant.

for Maine sardines and menhaden could also be used for unloading whiting, but they generally require large volumes of water and their use is prohibited in some ports.

Preprocessing Storage

Whiting may be conveyed directly from the truck or weighing station to the processing line; but frequently they go to storage pens, where they are held for about 3 to 4 hours. Occasionally, the storage period will be as long as 18 hours. The whiting are then transferred from the storage pens to the processing line by conveyor belts or by sluices (figs. 8 and 9).

Temperature and time combined have the greatest influence on the loss of quality in fishery products. Even short exposures at temperatures of 40° F. will decrease the quality markedly. This loss will show up not only in the product as it is being packed, but also during subsequent frozen storage, so it results in a marked reduction of storage life.

During preprocessing storage, excessive temperatures (up to 50° F. or even higher) may occur at several points. In warm weather, the first such point is in the truck being filled on the wharf where the fish are receiving the full heat from the summer sun. The second point is in the storage pens, where great piles of fish often are held for many hours.

The bacterial load present is also of great detriment to the quality of the fish. In general, the higher the bacterial count, the greater is the rate at which the bacteria will lower quality.

The small amount of ice unloaded with the fish is inadequate to keep the fish cooled to 32° F. while in the storage pens. The fish and ice are both covered with slime, which contains myriads of bacteria in an actively growing form. Unless the bacteria are removed from the fish, irreparable loss of quality may occur.

We recommend therefore that whiting be thoroughly washed and de-iced as they are unloaded from the vessel and re-iced carefully as they go into storage pens. Only by thorough washing can the bacteria-laden slime and the intestinal contents squeezed out of the fish during storage on the vessel be removed. Re-icing with clean ice in the proportions of at least 1 part ice to 4 parts of fish will help to cool the fish during preprocessing storage and reduce the loss of quality that occurs during this period.

Figure 8.--Storage pens are used to hold the fish until they are processed.

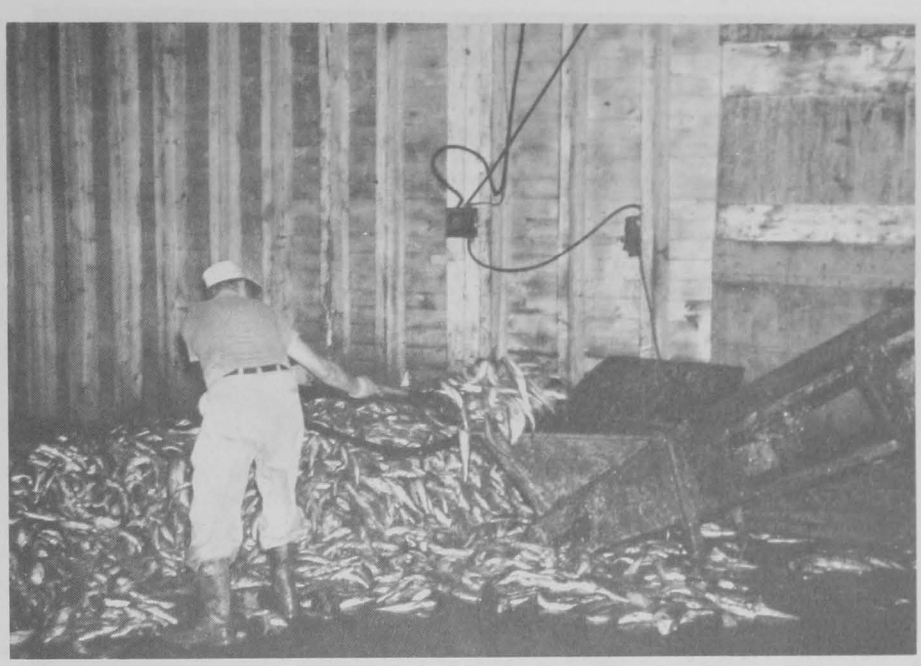

Figure 9.--Whiting are shoveled from storage pens onto conveyors and then carried to the heading machine.

The loss of quality during storage of whiting in pens at the shore plant can be eliminated, as it can on the vessel, through proper use of refrigerated sea water at 30° F. Instead of relying on the inadequate amount of ice unloaded with the fish, the processor can obtain positive and rapid cooling through use of a refrigerated sea-water system.

Handling Small and Large Whiting

The next step in handling whiting depends on their size. They are sorted into two size groups--small and large.

Small whiting.--The small whiting are first headed and then are descaled and eviscerated.

1. Heading.--The heading machine used in the whiting industry is made up of a conveyor belt having parallel wooden blocks on its surface in which the fish are placed and are carried to a rotating knife blade that cuts off the heads (fig. 10). A common arrangement is to have two belts and two knives mounted on the same frame (fig. 11). The machine is adjusted to cut the average size whiting just behind the pectoral fins. Whiting that are smaller than average will have some of the edible portion removed in the heading operation, whereas the larger fish require trimming to remove the fins.

Normally, 10 to 15 workers are needed at a two-belt heading machine to sort out the undersized and oversized fish and to keep the belts loaded with whiting in the size range desired for heading and gutting. The undersized fish are carried by conveyor belt to the waste or gurry collection point. Here, a truck (fig. 12) may take heads, viscera, filleting-line waste, and undersized fish to the dehydration plant. Alternately, large steel hoppers are used to collect the waste. They are emptied periodically into a dump truck, and the waste is transported to the dehydration plant.

Oversized fish are carried to the filleting line in boxes or by conveyor belt.

Sorting the whiting into sizes and feeding the conveyor to the heading machine costs the processor from $20 to $30 per hour. Sorting machines are available that can sort whiting into any desired size category and thereby reduce labor requirements at the heading machine by at least half. In addition, more precise control of sizes will permit the adjustment of the heading machines to yield a maximum amount of edible fish with a minimum amount of trimming.

2. Scaling and eviscerating.--From the heading machine, whiting are conveyed to a rotating, expanded-mesh cylinder, where the scales and part of the viscera

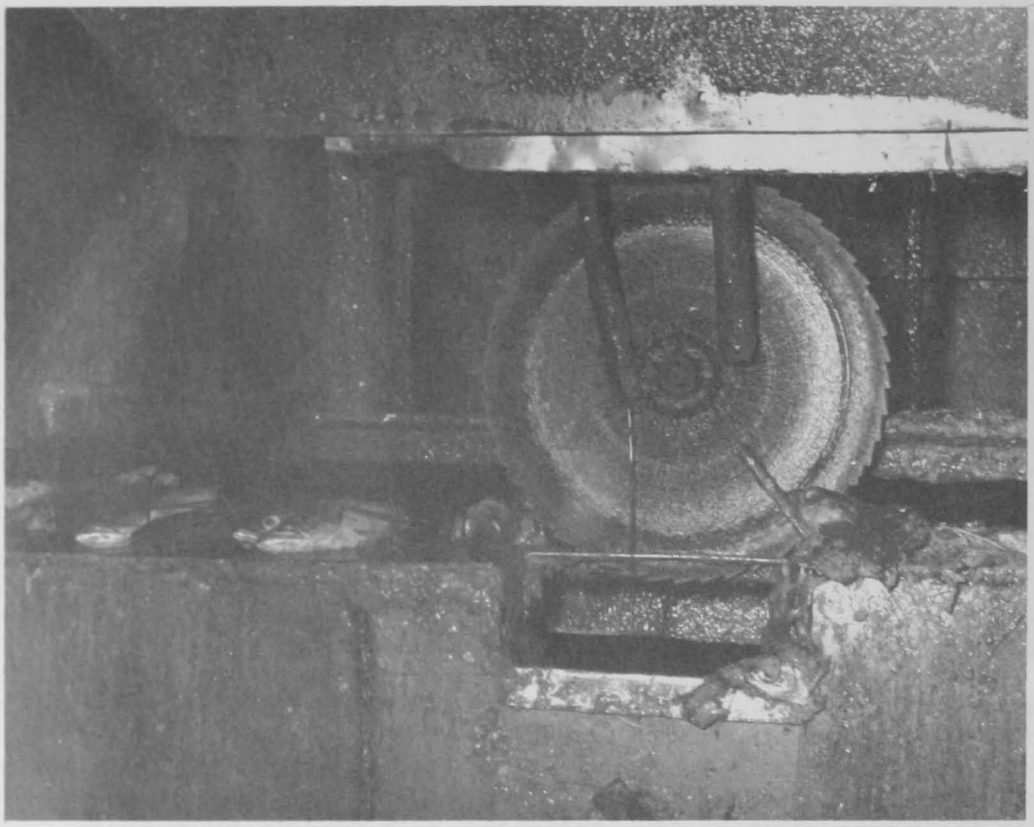

Figure 10.--Worker placing whiting into position for heading. Circular Knife Blade on Whiting Heading Machine.

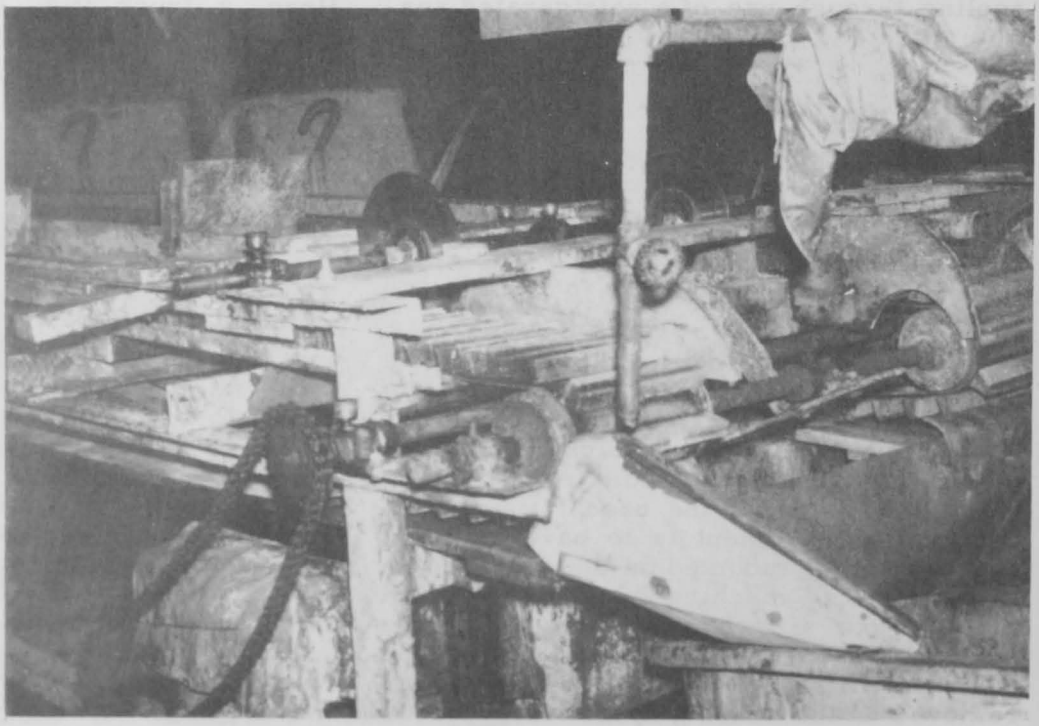

Figure 11.--Close up of a double heading machine.

Figure 12.--A conveyor drops the gurry into a truck for shipment to the dehydration plant.

are removed and the fish are washed by sprays of water (fig. 13).

For a truly headed and gutted or dressed pack of whiting, the remaining viscera are removed at the packing table. This operation may be performed by a separate group of employees or by the packers as they place the fish in the boxes. Whiting packed simply as headed or cleaned receive no additional evisceration.

Present scaling machines appear to do an adequate job of removing the scales from the headed whiting, but complete evisceration is now a hand operation. Machines are available, however, that can remove 100 percent of the viscera from whiting. The machines may be obtained as single eviscerating units or as integrated combinations of heading, gutting, and washing machines. Output and labor requirements vary, depending on the type of machine used, from 8,400 fish per hour with one employee to 15,000 fish per hour with three employees. Thus, with one or two of these machines and a sorting machine as described above, the average whiting plant could produce a headed and completely eviscerated product at a labor saving of $15,000 to $25,000 per year. Estimated equipment costs are $7,000 to $15,000 for the sorting machine and about $15,000 for the combination heading, gutting, and washing machine.

Large whiting.--The large whiting sorted out at the heading machine are filleted by hand (fig. 14), and the fillets are washed in water or a brine solution usually of 10° salinometer concentration. The washed fillets are then packed in 1-, 5-, or 10-pound waxed paperboard cartons and frozen and stored, using essentially the same procedure as is used for packing the H and G fish.

At present, only the large whiting, which occur in the catch in relatively small quantities, are filleted. Filleting of the small whiting by hand is impractical because of the expense involved.

We know of no filleting machine proved by practical trial to be capable of handling the small whiting in a large-scale operation. Manufacturers, however, have indicated that they have machines capable of adaptation or machines in the final stages of development that will fillet small whiting with sufficient speed and yield to make this operation profitable.

The production of fillets from small whiting for use in new products offers the greatest hope for expansion of the whiting industry.

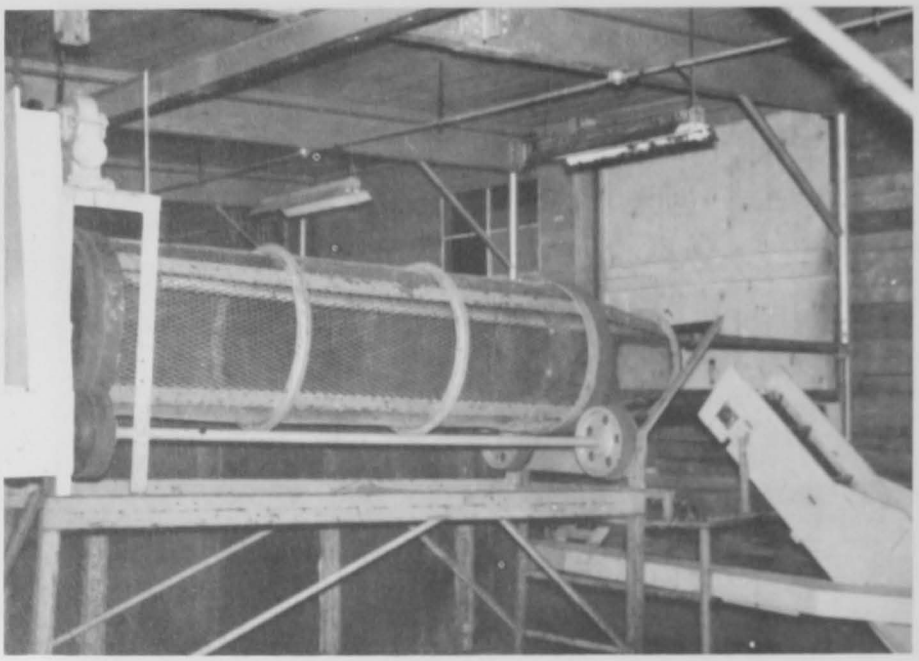

Figure 13.--A typical scaling machine that is used by the whiting industry.

Packing and Freezing Headed and Gutted Whiting

The number of employees engaged in the packing operation varies from 10 to 16, depending on the size of the plant and whether the packers are required to complete the removal of the viscera. Whiting are packed in $1\frac{1}{2}$-, 5-, or 10-pound cartons.

On the packing line for $1\frac{1}{2}$-pound cartons, the packers remove the fish from a conveyor in the center of the bench, fill the waxed paperboard cartons, check the weight on "over-under" scales (fig. 15), and put the carton on another conveyor leading to the overwrapping machine (fig. 16). After the cartons have been overwrapped, they are placed in metal trays, which are then stacked on pallets. When the pallet is loaded, it is taken by fork lift or handtruck to the plate freezer (fig. 17). Seven of the plants visited have their own plate freezers. The others accumulate several pallet loads of packages before the pallets are trucked to a public cold storage warehouse for freezing.

Two basic methods are used for packing the 5- and 10-pound-size cartons. In one method, the fish are weighed into lots of appropriate size by one or two weighers. The weighed fish are dumped into a waxed,

Figure 14.--An experienced filleter cutting large whiting.

paperboard carton and conveyed to the packers, who arrange the fish neatly in the carton. In the other method, the fish are filled into the cartons to the approximate net weight by the packers, and the cartons are conveyed to the weighing station, where the weight is checked and adjusted if necessary (fig. 18). The filled and weighed cartons are then stacked on pallets or are put into racks. In general, the 5- and 10-pound cartons are frozen in public cold storage warehouses by means of shelf coil or blast freezers.

Automatic carton filling machines are in use in some industries, and certain types could possibly be adapted for packaging whiting. Costs, both initial and maintenance, are high and would rule out the use of such equipment in most plants. The use, however, of sorting equipment would provide greater uniformity of sizes at the packing table and thereby speed up the operation.

The time between packing and freezing the whiting often is excessive. Frequently 5- and 10-pound cartons become water soaked and tear easily. During the summer months, the fish are exposed to the high temperatures found in the plants, and both workmanship and edibility of products are lost rapidly. In present plants, every effort should be made to speed the flow of product from the packing table to the

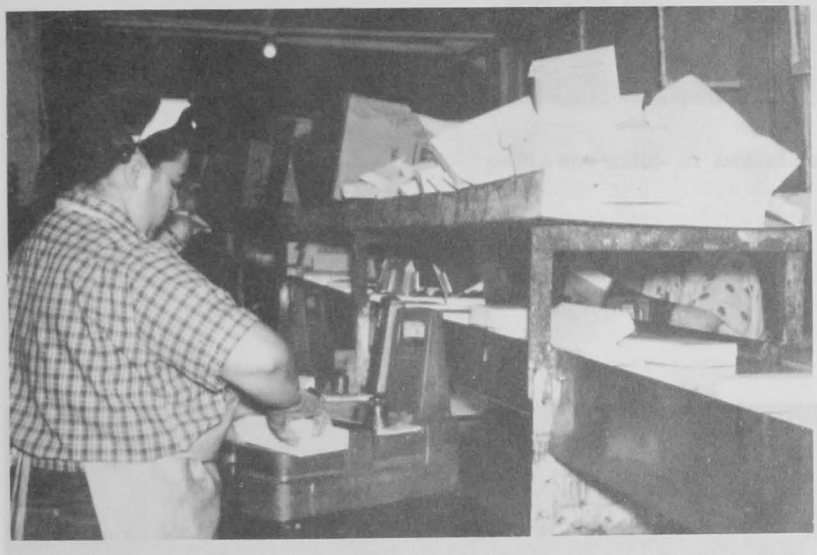

Figure 15.--A packer is using an "over-under" scale to check the weight of 1½-pound boxes.

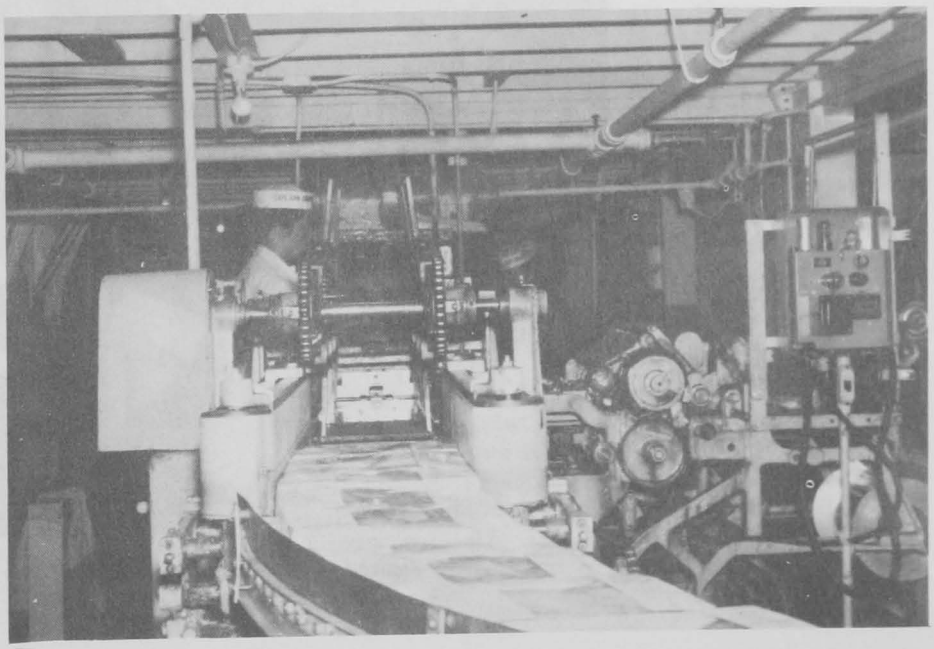

Figure 16.--Cartons of H and G whiting being overwrapped by automatic machine.

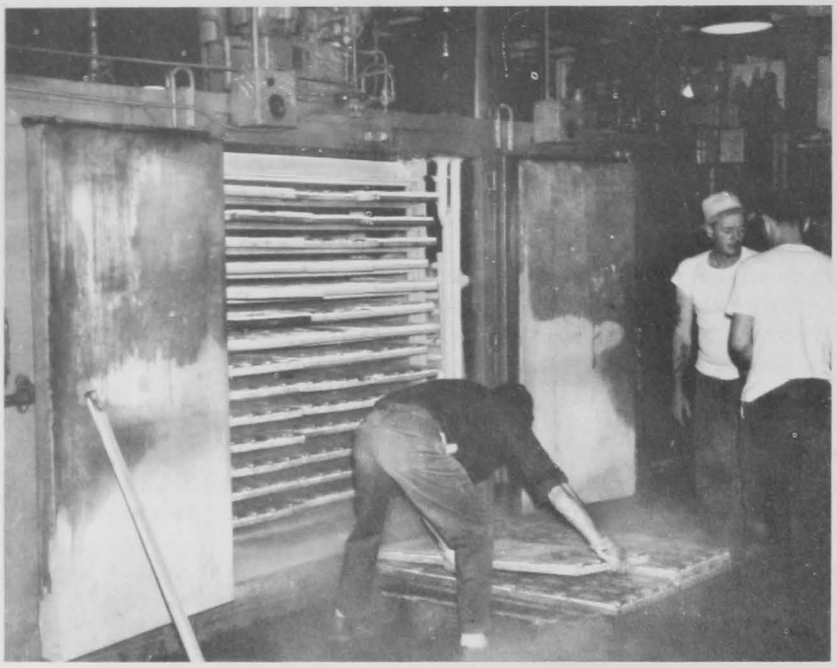

Figure 17.--Workers are placing trays of 1½-pound cartons of whiting into a plate freezer.

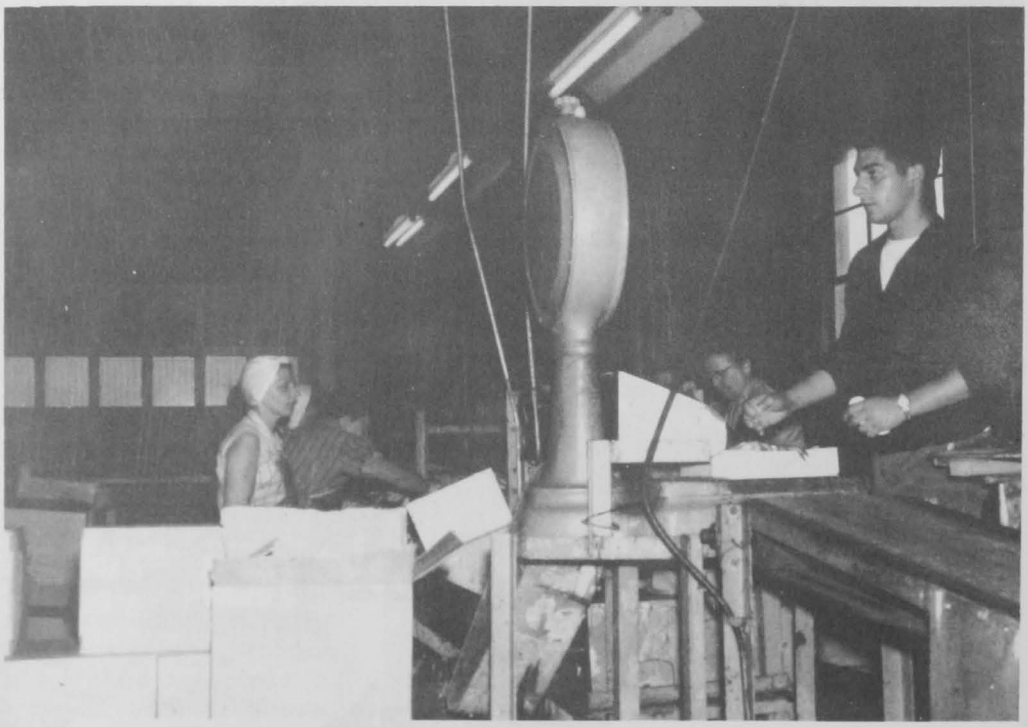

Figure 18.--Packers check-weighing boxes of 5's and 10's.

freezer. Pallets should not be loaded so highly that pressure on the bottom layers damages both the package and the product. In any plans for new or expanded freezing facilities, consideration should be given to automatic plate freezers or conveyorized blast or sharp freezers.

With this equipment, the packaged whiting could be moved without delay from the packaging line to the freezer, and the loss in quality would be arrested.

Storage of Frozen Product

The frozen product is packed in corrugated master cartons and held for sale and shipment to market. The holding period varies greatly. It may be as long as 12 months.

Recommendations

The analysis of handling methods in whiting plants shows that many operations are inefficient and that they result in excessive costs and in poor quality. Our recommendations for increasing efficiency and improving quality are as follows:

1. Use conveyors or vacuum-chamber fish pumps for unloading.

2. Thoroughly de-ice, wash, and re-ice the fish in the storage pens and, preferably, replace the storage pens with refrigerated sea-water tanks.

3. Use sorting machines.

4. Use improved models of heading and gutting machines.

5. Decrease time interval from packing to freezing.

6. Use automatic filleting machines for small whiting.

Sources of supply for the various items of new equipment discussed in this report may be obtained by writing to:

U.S. Department of the Interior
Technological Laboratory
Bureau of Commercial Fisheries
Emerson Avenue
Gloucester, Mass.

SUMMARY

The whiting fishery has shown spectacular growth in the last four decades. Problems in handling this delicate fish also have grown and become more important as the demands of the market and competition from other products have increased. To help solve these problems, the Bureau of Commercial Fisheries Technological Laboratory in Gloucester has studied all phases of the whiting industry.

This research has shown that the quality problems currently plaguing the industry begin at sea and can be corrected by employing improved sanitary and icing practices. Use of refrigerated sea water rather than ice will eliminate much of the uncertain results and tedious labor involved in icing the fish and will result in the landing of whiting of better quality.

At the shore plant, storage conditions can also be improved through the use of refrigerated sea water. In addition, use of modern machinery for sorting, heading, and eviscerating the fish not only would improve product quality but would also reduce costs and improve the processors' position in a highly competitive market.

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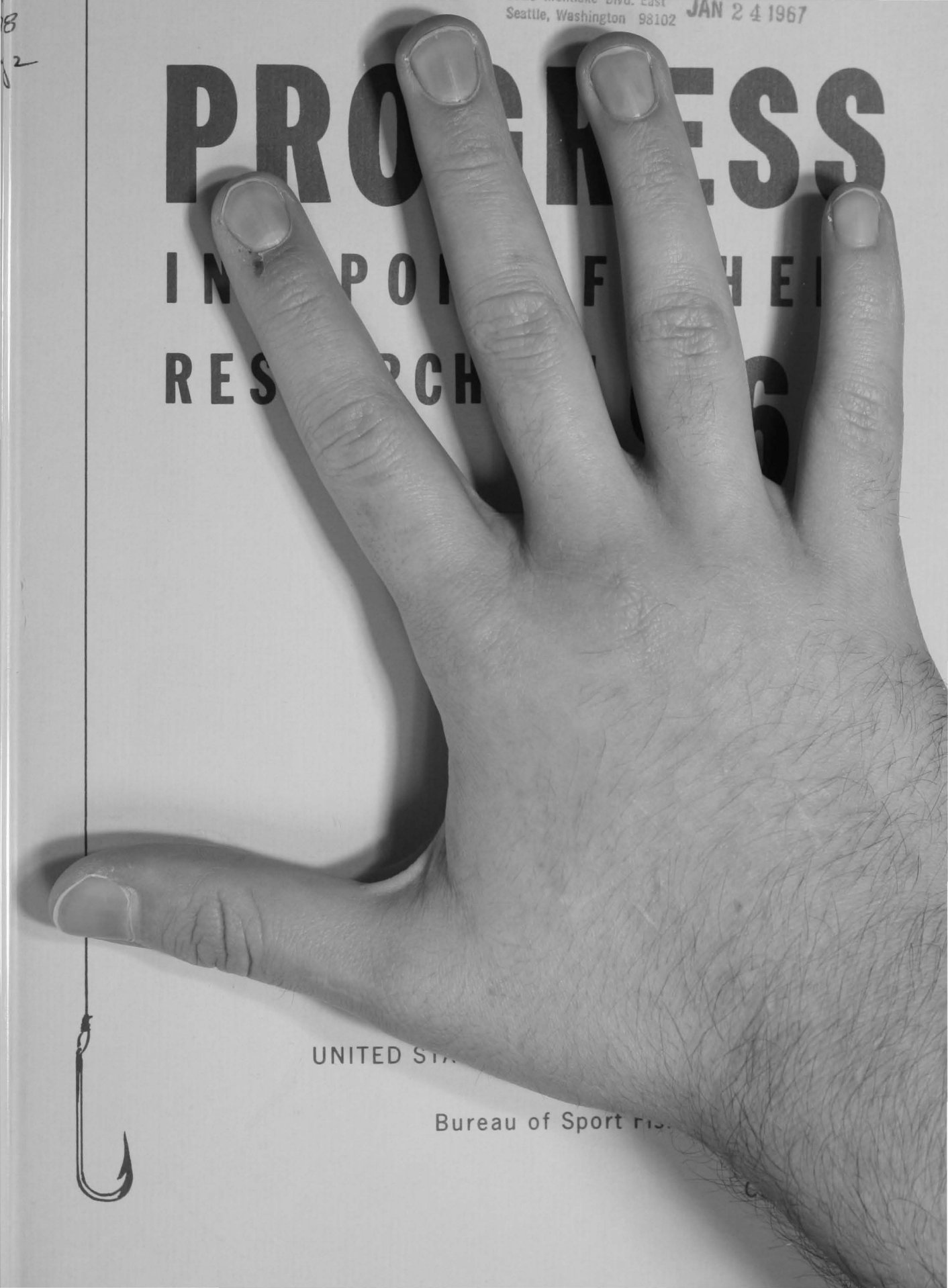

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