SURIMI

Some Observations on Trawler Production

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S U R I M I

Some Observations on Trawler Production

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CONTENTS

FIGURE AND TABLES

INTRODUCTION

This report contains observations I made during almost 5 weeks on a foreign fishing vessel, performing the duties of fisheries observer for the National Marine Fisheries Service. From July 22 to August 19, 1985, the vessel's crew processed more than 5,600 metric tons (5,600 t) of pollock, producing about 1,200 t of surimi.

While it wasn't possible to measure most process operations, this report describes them in enough detail to characterize the important aspects of at-sea surimi production. I couldn't collect data on relative production volume of various surimi grades; the ship's captain considered this proprietary information. The data in this report on total production and yield come from the ship's log; however, they seem accurate and valid, as do the haul weights measured and calculated by the joint venture representative (JV rep).

With approval of the ship's captain, I took photographs in the factory while the first officer accompanied me. He approved each photograph before exposure, and he didn't object to photos of the process line from filleters to freezers.

This report is organized into sections dealing with various harvest and production steps. Comments are included to help clarify the operations as I observed them. A final comment section points out details that might be of particular interest to a shore facility.

Out of respect for the confidential nature of such fisheries-observer data, this report doesn't refer to specific vessels, companies, or persons.

OBSERVER FACILITIES AND LOGISTICS

As an observer, I was transported to the processing ship aboard a cargo vessel. That vessel's captain reported that the transfer rate was $6,000 per day, or some $12,000 for my transfer cost. I had no way of judging the accuracy of this statement, but the cargo vessel was reported to be standing by for no purpose other than the transfer. After I was put aboard the processing ship, the cargo vessel was reported to be headed back to its home port.

I was treated well by both officers and crew, and (as called for by the fisheries agreement) I was given private quarters equal to those of the officers. Observers and JV reps took meals with the officers and were given virtually unlimited access to bath and laundry facilities. In general, the galley and quarters were clean and well-maintained.

The crew and officers were hospitable to foreigners on board and businesslike in their dealings. The officers seemed set against having female crew members on board, and female JV reps and observers as well.

The food was plentiful and well prepared. Meals were served at 6 a.m., noon, and 6 p.m. A midnight "snack" for the crew (partly prepared by crewmen themselves) was also available to the observer by request and with advance notice.

Observer sampling schedules were varied, but they normally involved inspecting the catch of cod ends from three trawls per day. Most of the time, it would have been possible to sample every other trawl catch (haul); however, with two catcher boats alternating deliveries, such a schedule would have meant sampling from one boat only.

For this reason, a typical day involved sampling the catch of one boat twice and the other once; thus, I sampled each boat twice over a 2-day period. It would be impractical to increase the sampling to four hauls per day unless the catch was predominantly pollock with few miscellaneous species present.

Sampling took from about 1-1/2 hours on purely pollock hauls to more than 2 hours when there was a heavy incidence of salmon or other prohibited species. Length-frequency measurements of fish added about 1/2 hour to one sample haul, once each day. Data entry took from 30 minutes to 1 hour for each haul, for a daily total of 6 to 9 hours of sampling time.

Each week I prepared a radio message (6 to 8 hours' work) that reported (1) species composition extrapolated to total tonnage landed and (2) quantity of prohibited species for all hauls sampled. Other data collection and miscellaneous duties took several hours each day, but there was usually enough time for personal needs and relaxation.

Sampling itself was usually not difficult labor. Normally, one or more assistants helped to remove the bycatch. At times, however, heavy bycatch incidence required subsampling with baskets. Each full basket weighed about 50 kg (110 lb); along with wet and cramped conditions, this was difficult labor at best. Rain gear and heavy rubber gloves were musts at all times during sampling.

Here are some general observations about the ship and its crew:

<u>Communication</u> between various parts of the ship was good. A telephone system connected the bridge to staterooms and the galley. Loudspeakers communicated on the deck and in the factory. Hand-held radios were used for special applications, such as between the JV rep on deck and the catcher boat when taking a delivery.

When setting up a delivery schedule, the bridge often communicated with the factory to check on the status of a particular haul in process. In this way, deliveries could be timed to dump immediately into a bin, which minimized confusion and maximized fishing time.

Crew facilities and watches. Facilities were generally cramped but adequate. Typical staterooms were set up for two to eight people, and housing assignments were made on the basis of job classification. watches were 6 hours on and 6 hours off.

Crew members had small private "lockers" where they could store food, beverages, and utensils, for use at their convenience. All alcoholic and nonalcoholic beverages (except tea) were brought on board as private stock. A break time with coffee and cookies was usually taken during each shift.

Officer facilities and watches. Facilities for the ship's 10 officers were separate from the crew's. Those on officer status included the captain, the chief officer, and three other deck officers; the chief engineer and three other engineers; the chief and second radio operators; the doctor; the JV rep; and the NMFS observer.

Officers generally had private staterooms and shared a bath. Senior officers ate in the first shift in the officers' galley and were served by a steward. The food was excellent and plentiful. The ship's stores included beverages for the captain and his guests, such as the JV rep and the NMFS observer.

Officers observed the same watch schedule as the crew; the senior officers kept the 6 a.m. to noon watch. The captain normally kept the same watch but was on call 24 hours a day.

Pay. I estimate crew pay to be between $400 to $500 a month. The captain's wages were around $3,000 a month.

HARVEST

The stern trawler is described in table 1. At 94 m (308 ft), she was the smallest of the fleet and serviced two catcher boats instead of three. The two catcher boats alternated deliveries and were usually scheduled 3-1/2 hours apart. The crew of the mother ship could accommodate 35- to 45-t hauls around the clock on this schedule (13 t/h maximum). The highest day's production was about 296 t of pollock from 300 t of landings (12.3 t/h of pollock). The daily average production for 28 fishing days was about 200 t, for an average rate of 8.3 t/h.

The ship's crew of 64 was divided into two shifts, working 6 hours on and 6 hours off. All crew worked in the factory, although 16 on each shift were identified as fishing crew. When a catch was landed, seven crew members left the factory to handle the cod-end exchange. During cargo transfer, the factory would usually stop operations.

With 7 hours between catcher-boat deliveries (minus about 1 hour for setting and retrieving nets), each boat could tow for as much as 6 hours. At times, this tow length was necessary--and delivered fish that were 0 to 6 hours old.

During good fishing, a typical tow length for a full cod end (45 t) was about 2 hours. This, of course, resulted in a more uniform landed fish age of 4 to 6 hours. Some tows were as short as 20 minutes, with 30 to 45 minutes for set and retrieval. In any case, it was typical to deliver a haul that contained preand postrigor fish as well as fish in rigor.

The incidental catch was typically less than .5 t per haul. I observed a true cod incidental catch of about .25% in over 10,000 t of landings. Fishing strategy varied from boat to boat, but most schools of pollock were found in 60 to 80 fathoms of water and 0 to 20 fathoms off the bottom.

Fishing hard on the bottom was common, with a bycatch of flatfish occasionally becoming significant and forcing a move to new grounds. The herring bycatch occasionally reached 10% or higher. Anything over 1% caused problems in the factory. Catches of salmon and halibut were minimal during the cruise. I observed less than 150 salmon in sampled hauls, which comprised about 45% of total landings. (Complete species composition data for total landings for the area is available from the NMFS Observer Program in Seattle.)

The typical catcher boat was 100 to 125 ft long and had a crew of three or four plus the skipper. With a price of $93/t ($0.0423/lb), the maximum daily gross earnings were about $14,500 per catcher boat from 155 t landed. In actual practice, the landings were less than maximum; discards and small fish reduced ex-vessel value.

During a 29-day period in July and August, the ship operated at slightly over 61% of maximum production. Cargo transfers, mechanical problems on catcher boats, lack of fish, and weather accounted for most of the reduced production. Total discarded fish was about .7%. The value of true cod was slightly less than $80 per day per boat.

Although the vessel I was aboard was the smallest of the fleet of mother ships, its two catcher boats had a greater delivery potential than those of the other mother ships. To help even out the season catch, catcher boats rotated, so they fished for all the mother ships at one time or another.

The weather on the fishing grounds, 50 to 100 miles offshore between Dutch Harbor and Unimak Island, was mild in July and August. The skies were generally overcast with winds of 10 to 20 kn, although on many days it was calm. We encountered rough seas on only two occasions, and then winds were less than 45 kn.

One accident marred the season when the F/V Sea Dancer sank with the loss of one life. A Coast Guard airplane and perhaps 20 ships searched the area for 1 to 2 days, without success.

The catcher boats were well-equipped with fish location and navigation equipment. The mother ships also searched for fish while servicing the catcher boats. With a cruising speed of 12 kn and 3-1/2 hour deliveries, the mother ship could search large areas between deliveries. Catcher boats normally fished close to the mother ship. Mechanical failures weren't common, but such things as loss of steering, broken hydraulics on winches, and inoperable fish finders did occur.

A particularly bothersome problem for one boat was the malfunction of the net monitor used to indicate the quantity of fish in the net. Retrieving a net to look at catch might take an hour away from fishing. But not knowing when the net was full meant the boat might tow far longer than necessary, resulting in wasted fuel and time.

Radio communication between ships was good most of the time. VHF was used between mother ships, with day codes a common device to keep catch and location secret. Communication between catcher boats and the mother ship was on VHF or citizens band, also using code sheets. Some catcher boats used scramblers.

Long range communication from the mother ships to home port or to the Coast Guard in Kodiak, Alaska, was frequent and of good quality. Most catcher boats had good quality, single-sideband marine radios for long range communication. At least one catcher boat had satellite telephone, which provided expensive but excellent communication to any telephone in the world.

SURIMI PROCESSING

Description of the process line

Figure 1 gives a general scheme of the surimi process line. Table 2 is an equipment list. Table 3 summarizes production data from July 22 to August 19.

The process line is generally elevated above a wooden process deck, with catwalks about 2 to 3 ft above the deck. Most waste water is discharged to the deck, and ultimately overboard, through two or more large scuppers. Trash chutes are located port and starboard, convenient to the bins and conveyor belts.

The process line consists of the following elements:

Storage bins

Three storage bins are situated aft and just forward of the stern ramp. The port, center, and starboard bins contain 39, 47.4, and 39.5 cubic meters, respectively. With the port and starboard bins open and fish piled in compounds above them, the two side bins contain up to 52.6 and 53.5 cubic meters, respectively. With a density of .94 t/cubic meter, the total holding capacity is over 144 t. An additional haul can be stored on deck in the cod end, for a total storage capacity of about 190 t. Storage bins were connected to seawater sprays.

Transfer belts

A series of transfer belts route fish from any bin through the washer/scaler to the filleters or into the center bin. The first conveyor belt downstream from the bins was made of wire mesh for dewatering fish from the bin.

Washer/scaler

This horizontal cylinder, about 30 ft long and 4 ft in diameter, had flat tumbling surfaces with seawater sprays inside. It rotated at about 10 rpm.

Filleters

Six Toyo 708N filleters were positioned in parallel along the feed belt. These filleters produced a relatively clean butterfly cut with some belly-wall membrane left attached. The line contained takeout conveyors for trash fish and offal. Fillets were transferred to the deboners by a series of wire mesh and rubber belts.

Deboners

Three deboners of unknown manufacture measured about 18 inches in diameter and 18 inches long, with a cylinder hole size of 2 to 3 mm. Deboners were normally crewed by one or two feeders. The feed belt had a provision for diverting fillets into a holding box of perhaps 3 cubic meters capacity.

First wash

This consisted of two tanks in series. The first was approximately 3 ft high by 4 ft in diameter; the second was slightly taller, about 4 ft high. Both tanks had conical bottoms and were equipped with axial-blade agitators that rotated at about 5 rpm. The inlets were on the top of each tank, and the outflow pipes were on the bottom. The piping was connected in such a way that the crew could probably bypass the second tank if they didn't need it.

First screening

The first screens were a parallel set of three, each about 15 ft long and 2-1/2 ft in diameter. No interior wash sprays were evident. A high-pressure seawater hose was available for exterior cleaning. The three screens delivered to a single pump through a common chute, which had 10 to 15 cu ft of storage capacity. The pump appeared to be a twin-lobe design.

Second wash

This system employed a set of four tanks, each approximately 4 feet in diameter by 4 ft high. The tanks were fed by a single distribution system and seemed to be piped in parallel. Series operation may have been possible.

Second screening

This was accomplished by a set of four screens in parallel. Three were approximately 15 ft long by 2-1/2 ft in diameter; the fourth was somewhat smaller--perhaps 2 ft in diameter. All screens discharged into the same hopper. No spray wash was evident. A high-pressure seawater hose was used to prevent screen blinding.

Refiners

The first step in the refining process employed a set of two refiners, each approximately 2-1/2 ft long by 18 inches in diameter. The next two steps used single refiners of similar size, operated in series with the first set. At this point, the product flow was split into four streams (grades 1, 2, 3, and meal).

Refiner surge storage

A device in each refiner line appeared to allow for temporary storage, to even out the flow. These boxes were connected to the pumps, which moved the reject material from the refiners to the next downstream step. The storage boxes had horizontally-rotating paddles that kept the material in motion and fed it to a single inlet/outlet.

These storage boxes were about 3 ft long by 2 ft in cross section. An additional storage box of unknown purpose was located adjacent to the last refiner.

Presses

Press #1 had twin screws approximately 20 ft long and 2 ft in diameter. The press appeared to be used primarily for #1 grade surimi. Press #2 had a single screw about 15 ft long and 2 ft in diameter; it appeared to be used primarily for #2 grade. For #3 grade, the presses were twin over-and-under, parallel-mounted screws about 1-1/2 ft in diameter.

Mixers

Three refrigerated mixers were located one to each line. The mixers in lines #1 and #2 had bowls 3-1/2 to 4 ft in diameter. The smaller mixer in line #3 was about 3 ft in diameter. The dough-hook-type mixing devices seemed to be rotating horizontally. The refrigeration was most likely direct freon. I saw no evidence of weighing devices for batches. The chemicals were preweighed. The batch mixing time was not recorded.

Fillers

Each line was equipped with a twin-screw filler and a weighing scale. A roller conveyor took bagged product (in pans) to the freezer. One operator handled each filler and scales.

Freezer

Front-loading, horizontal-plate freezers were arranged in two rows, almost the entire width of the ship. The total capacity was at least enough to handle 70 t of finished product per day.

Operation of the process line

Raw product storage

Port and starboard storage bins were used to store unrefrigerated fish. Fish were settled and packed into the bins, and seawater was injected through a simple piping system near the top of the tanks. Fish in excess of the bin capacity were dumped in the compounds above the bins on deck. The maximum fish depth was 9 to 10 ft.

After the fish had settled for an hour or more, a ship's officer and the JV rep together measured their height. The JV rep and the officer would agree on the measurement and then calculate the weight of the fish, using a calibration chart for each bin. The volume from the calibration chart was then multiplied by .94 t/cubic meter (the agreed-on density).

At a convenient time after measuring the haul--usually 3 to 4 hours after it was received--the haul was transferred to the center bin, to prepare for processing. This transfer seemed to be done primarily to provide an opportunity for sampling by both the observer and the factory. Most incidental catch was separated out during the transfer, which took place at the rate of about 10 t/h.

Factory sampling was primarily concerned with the size of pollock, the amount of discard, and the amount of usable bycatch, which was mostly true cod. Observer sampling was concerned with total species composition (to the nearest .1 kg), prohibited species, and daily length frequency of pollock. True cod were retained at a price about three times that of pollock.

The percentage of pollock under 20 cm long was estimated and applied to a formula that reduced the price to "meal fish." The small pollock were retained for meal. Prohibited species were discarded along with sharks, skates, herring, smelt, jellyfish, sculpins, and most other species. Some flatfish were kept for meal.

During the transfer operation, the fish were put through a descaler and a seawater wash. The fish were sometimes still in rigor after 3 or 4 hours in the side bins. Fish in storage remained at about seawater temperature (8 to 9 degrees C in July and August).

Washer/scaler

Most fish were washed at least twice--first, during the transfer to the center bin; later, as the fish were sent to the filleters. In practice, however, some fish were washed and descaled many times because the feed belts to the filleters operated in a continuous loop that passed through the washer. Several tons of fish were transferred to the feed belt loop, where they remained until being removed to a filleter feed chute. The main bin takeout conveyor was made of wire mesh for dewatering. The main feed belt loop consisted of two rubber conveyors with rubber cleats.

Filleters

Any bycatch of true cod that remained after the sampling and center-bin transfer was removed from the filleter feed chute by the fillet machine feeder and placed on a small takeout conveyor that served all six machines. Each machine (Toyo 708N) was crewed by one feeder and sometimes one helper, who oriented fish for feeding by placing them with the head away and belly right. The machine took fish as fast as they were presented, about 120 fish a minute with the feeder alone and more than 200 a minute with a helper.

The machines operated with few malfunctions. A seawater hose at each machine was used occasionally to rinse scales from the cutter blades.

The size of the pollock had a significant effect on the overall yield as the heading knife on the machines wasn't adjustable. The head cut was approximately 10 cm, which would cut a 20-cm fish in half. Some of the machine plugs were undoubtedly caused by undersized fish.

Head and viscera were carried away from the fillet machines by a series of screw conveyors to the meal holding tank. Fillets were removed by wire mesh conveyor.

Deboners

Three deboners of typical horizontal, perforated-drum design were installed in parallel. They were crewed by one feeder, sometimes by two. The fillets were placed skin side up on the feed belt, which then presented the fillet meat side to the deboner cylinder. A box and chute arrangement before the second and third deboners acted as a flow control buffer by allowing the fillets to be stored.

The deboner's cylinders appeared to have 2- to 3-mm perforations and were operated with enough tension to leave little meat on the skin. No water appeared to be necessary to remove the deboned flesh from the cylinder to a screw conveyor, which delivered it to the first of two wash tanks installed in series. There appeared to be no buffer storage between the deboners and the first wash tank.

First wash

It wasn't possible to measure the water-to-meat ratio of washing operations, but it seemed very low. At times, there was so little water that the mixture showed almost no fluidity. By the time the mixture got to the second of the two series-mounted wash tanks, it was fluid but probably less than 1 to 1.

There seemed to be no way to put deboned meat directly into the second tank, so they must have been mounted in series. However, it's possible that the piping was connected to bypass the second tank if desired. The pumping system wasn't visible, nor were many of the pipes.

The fresh wash water was refrigerated in a prechill tank to perhaps as low as 7 to 13 degrees C (45 to 55 degrees F). The only visible source of freshwater was a spray manifold at the top of the first tank. The water seemed to be in the 5- to 10-gpm range, which would indicate a water-to-meat ratio of .6 to 1.2 (assuming a round weight production of 45 t each 3 hours and a 15% yield). This rough estimate fits with visual observations of the mixture's fluidity in the second tank.

Rotation of the horizontal mixing blades on the vertical agitator shafts in both tanks was about 5 rpm. The blades were angled to direct flow down toward the outlet rather than upward. There was no apparent vertical mixing in the first tank and very little in the second. The flow was first in, first out. Neither tank seemed to have provisions for decanting floating particles and oil.

First screening

The first set of three horizontal screens was connected in parallel and rotated at about 10 rpm. The screen size was hard to judge, but it seemed to be less than 1 mm. No provision was made for water wash inside the screens, nor were there sprays on the outside to reduce blinding. Occasionally, a hand-operated, high-pressure seawater hose was used to clean the screens.

An exit chute collected the product from all three screens and directed it into a single pump. The pump appeared to be of a twin-lobe design with a 4-inch spiral flex hose. The pump feed (exit chute) had 10 to 15 cu ft of surge flow storage, which might hold as much as 10 minutes of production, depending on moisture content, yield, and production rate. At times, the collection chute backed up into the screens themselves, providing considerable surge storage.

The meat coming from the first wash seemed to have some pink color left in it. The moisture content was quite high, as would be expected.

Second wash

The second set of tanks was difficult to observe, but the tanks appeared to be much like those of the first (and about the same size). Four tanks were fed by a single distribution chute, indicating that they operated in parallel. However, a piping arrangement could have been present to connect one or more tanks in series.

It wasn't possible to measure the wash time or the water/meat ratio, but it seems likely that with twice the total tank volume of the first wash, the second wash used about twice the water/meat ratio or about twice the dwell time. It's most likely that the water/meat ratio was twice that of the first wash, between 1.2 and 2.4.

Although these are rough estimates, they demonstrate that the water consumption was probably typical of what is reported in the literature. Adding the first and second washes gives an estimated total water consumption ratio of 1.8 to 3.6--which is equivalent to 15 to 30 gpm, or 22,000 to 44,000 gallons per day.

Second screening

This set of four horizontal-rotating, parallel screens operated in the same way as the first. One screen was smaller than the other three (for no apparent reason), but it may have been fitted retroactively. The color of the meat at this point was much lighter than after the first screening.

The collection hopper/chute and pump were similar to those in the first set of screens.

Refiners

These operated in series, in three steps. Three grades of surimi were possible, in addition to reject material from the last refiner (this probably went to the meal plant, but it was impossible to tell with any certainty how the piping was arranged).

<u>The first step</u> employed two refiners in parallel, which produced the first grade of product. It appeared that this product stream was at least two-thirds of the total.

<u>In step two,</u> the reject from these two parallel refiners was pumped into a second single refiner of similar size. This refiner removed the second grade of surimi.

<u>In step three,</u> the reject went to the third refiner, which separated the third grade and rejected mostly skin, scales, ligaments, and other materials suitable for meal.

The reject material from each step could be pumped to a holding tank rather than directly to the next step. These small tanks seemed to have two functions: (1) to even out the production flow and (2) to allow the crew to shut down the refiners if they couldn't keep them full. The actual operating strategy wasn't obvious. Pumping appeared to be arranged so that the holding tanks could be filled or emptied with a single connecting hose.

The washed meat going into the first refiner step was quite wet. The first product stream was very white and had little fibrous texture. The second step sometimes produced a slightly grayish product, but it often produced material almost as white as the first refiner. When this occurred, the combined production of the first two refiners appeared to be over 90% of the total.

The product of the third refiner had a definite gray (sometimes brownish) color. The flow to this refiner wasn't usually continuous; it seemed to occur sporadically, as enough material accumulated in the holding box between it and the second step refiner.

Holding boxes

The plumbing and function of these three devices wasn't completely clear; judging from the color and texture of the material in them, they were piped between each set of refiners and between the last refiner and the meal plant. They appeared to accumulate reject material from the refiners and to allow a more even loading of the second and third refiner steps.

The boxes seemed to have only a single inlet/outlet, suggesting they were connected to a pump that was switched manually. The boxes didn't appear to be refrigerated, although their screwlike mixer blades were constantly revolving. The motion of the mixer blades may have been simply to keep the material presented to the inlet/outlet hole for pumpout.

Presses

Three sets of presses seemed to be matched to the three refiner steps and to the three grades of surimi being packed on the three separate parallel lines. The largest press was in the top quality line, as would be expected. The second press was a twin-screw model that seemed to operate as a single unit. The third set of presses consisted of two small, separate units mounted over and under. They were loaded in sequence as needed.

I don't know their compression ratio. They didn't appear to be refrigerated or designed for disassembly and sanitation, nor did they appear to be cleaned except for an occasional surface rinse with seawater.

Mixing and packaging

Each set of presses fed surimi into mixing bowls through screw augers. There didn't appear to be any way of weighing the amount of material in the bowls, so they were probably filled by volume. The chemicals were preweighed in plastic bags, which were stacked next to the mixer.

The bowls and mixer shrouds of all three mixers were refrigerated. When they operated for some time, they became heavily coated with ice, indicating that their jacket temperatures were well below freezing. Judging from the piping arrangement, they were probably refrigerated directly rather than with a secondary refrigerant.

Colored bags (holding 10 kg of surimi apiece) were filled with typical twin-screw fillers and placed on trays for weighing. The operator adjusted the final weight and sent the tray into the freezer on roller conveyors.

All three lines packaged surimi simultaneously, using different bag colors to identify the various grades.

It appeared that orange, yellow, and green bags were used for #1, #2, and #3 grade surimi, respectively. A special #1 grade (perhaps to indicate different sugar content) was packaged in blue. However, the production lines seemed to have considerable flexibility and may have produced more than one grade of product. In one instance, both #1 and #2 lines seemed to be using blue bags. I couldn't confirm the use of color for grade identification.

Freezing and casing

The freezers, located in one of the cold-storage holds on the factory level, were of typical horizontal-plate design. I couldn't determine their actual capacity, but the system seemed capable of handling the full factory production. This means they could handle about 830 10-kg trays per 3-hour freezing cycle.

After freezing, the trays were transferred to a casing line on a roller conveyor. The trays were then emptied, and the surimi was boxed. The boxes were glued, coded, and conveyed to a lower storage level. A crew of five or six could empty and box about 30 cases a minute.

Miscellaneous operation points

Several items are worthy of mention.

Pumps. The pumps that moved wet product between washers, screens, refiners, and presses seemed to be twin-lobe gear pumps, but specific details weren't available. The pumps didn't appear to be reciprocating, centrifugal, screw, or rubber-vane types.

Freshwater didn't seem to be in short supply. At no time were restrictions placed on domestic use of water (including drinking water, laundry, and showers). Even though the overall production rate was less than 60% of maximum, we experienced a number of consecutive days of production at maximum capacity without apparent water shortage. Seawater was used in the production line for all operations except meat washing.

Freshwater on the ship wasn't deemed potable unless it had been specially filtered. The problem appeared to be rust in the tanks or pipes.

Seawater was piped to all parts of the ship, and it was used for all purposes except where potable water was necessary, such as surimi washing and domestic use. Large quantities of seawater were routinely used in the factory for washing fish and transporting waste materials overboard. Seawater in a high-pressure system was used to clean screens, to reduce blinding.

Power. All factory machinery was electrically driven. It appeared that 440-V was common in the factory, while voltages of about 100 and 200 were common in domestic use.

Nematodes. Few were evident in the filleted fish. Five or six casual inspections of pollock fillets from the machinery failed to turn up even one. I made no attempt to correlate nematode incidence to the location of fishing grounds. Casual observation of true cod fillets also didn't indicate the presence of more than a few nematodes.

Comment

The primary quality that seemed to distinguish the surimi line on this mother ship was flexibility in handling semibatch production. Although the process line was capable of sustained daily production of more than 300 t, there were many times when production was less than maximum. On the average, however, after 10,000 t of production, only about 60% of maximum was achieved. Production flow surge storage was provided at critical points in the line, and most operations were controlled manually.

Each of the 32 crew members per shift seemed able to handle most job assignments. When a new cod end of fish was landed on the deck (every 3 or 4 hours), the crew would leave the factory, and production would adjust to a new situation that might last 30 minutes to an hour.

FISHMEAL AND MISCELLANEOUS SPECIES PROCESSING

No detailed information on the meal line was available. In general, the meal line handled the pollock offal and a few miscellaneous flatfish. The joint venture contract set a different price for bycatch, including small pollock used for meal. Table 3 includes production data for meal and oil.

The meal plant was fed by a large holding tank, about 10 ft by 20 ft by 5 feet deep. The meal plant itself consisted of two parallel lines; each line contained:

- o furnace,
- o cooker (type and number unknown),
- o stickwater centrifuge (two horizontal centrifuges about 4 ft long),
- o driers (two rotary indirect heated driers about 3 ft in diameter),
- o oil separator centrifuges (two vertical bowls about 2-1/2 ft in diameter),
- o bone separator with vibrating screen, and
- o bagging machine set up with automatic batch weigher.

The meal plant was located on the deck below the surimi factory and appeared to be run by a crew of two. Effluent from the starboard side of the ship appeared to be stickwater, so no recovery was apparent. The stickwater effluent didn't appear to be hot, so it's likely that a heat-recovery system was in use.

QUALITY CONTROL

This surimi trawler had a well-equipped laboratory and ran quality checks on previous days' frozen product. However, very little in process quality control was in evidence. One of the few checks was on pollock size. In this case, a 50-kg sample of pollock would be checked for undersized fish.

If the lab found too many fish under 20 cm, the JV rep was called to doublecheck and agree to an adjustment. The small fish were classed as "meal grade," and the haul value was adjusted downward accordingly.

A factory crewman, trained by the company to do quality-control checks, occasionally checked pollock-length frequencies for the parent company. He also checked the factory temperature and other points throughout the ship, including seawater and ambient temperatures. It appeared that this information was for the home office, not for hourly process control.

The quality-control lab was set up to conduct shear, punch, colorimeter, and particle tests. A standard test was performed using precooked sausages, and the results were recorded at least daily. Some test score data were collected for the three grades of surimi, but these haven't yet been correlated with known test procedures.

SANITATION

There was no routine washdown of the surimi processing equipment and factory facilities. The equipment wasn't designed for cleaning access, and it wasn't cleaned. Occasionally, equipment was rinsed with seawater. This rinse usually occurred when the line was shut down for one or more watches, which sometimes meant several weeks between rinses.

I observed some putrid fish hanging on conveyor belt sides and at other locations. I also noticed some washed and refined meat that was old enough to have developed a surface crust and brown color, in a chute connected to a surge storage box immediately following the third step refiner. And I often saw putrid fish in the main fillet machine intake, although I didn't know its fate in the filleter (it could have been diverted to the meal plant). In any case, it's reasonable to expect that with temperatures of

10 to 13 degrees C (50 to 55 degrees F) in the factory, the bacteria count of the finished product would be quite high.

Also of note in the factory were some hose connections used for washed meat transport. These hoses were plastic and contained liquids and solids trapped under anaerobic conditions. I didn't make any reliable observations on the periodic use of these hoses; therefore, I don't know the duration of the condition.

CARGO TRANSFERS

Four or five cargo transfers were made during one 4-week period. Some transfers were extensive, involving offloading surimi, frozen fish, and meal as well as taking on supplies. Other transfers were simply to take on small quantities of supplies.

In each case, the cargo ship was tied on the starboard side of the mother ship, using an assortment of heavy rubber dolphins to absorb the shock when the vessels bumped together. During extensive transfers, the mother ship stopped taking deliveries from the catcher boats so that all fish were processed before transfer. In one case, this was accomplished during an 8-hour run to the transfer site in the lee of an island. Deliveries were made and processing continued when the transfer didn't require the entire crew.

POTENTIAL APPLICATIONS TO SHORE FACILITIES

Some observations may be of value about the shipboard operations I observed and their potential for shore facilities, particularly the Alaska Pacific Seafood/Alaska Fisheries Development Foundation (APS/AFDF) demonstration plant in Kodiak, Alaska.

<u>Yields.</u> Factory trawler surimi yields of 25% are reported to be typical of independent trawlers. The significantly lower yield of 21.4% I observed from this ship's factory production records (see table 3) may be caused by the characteristics of a joint venture. The mother ship yield was calculated by dividing the surimi produced by the pollock processed, just as it should be on independent trawlers. However, this trawler was using fillet machines that couldn't be adjusted easily for small fish; this lowered fillet efficiency and, ultimately, the overall yield. As an independent trawler, it could possibly have discharged small fish, thereby maximizing yield and minimizing the apparent catch (reported as surimi produced divided by 25% yield).

Three factors make it difficult to understate the estimated catch by manipulating yield data: (1) the joint venture's need to measure each haul accurately; (2) the mother ship's contractual obligation to account for all fish delivered; and (3) the advent of 100% observer coverage. Lower yield estimates would seem be an advantage to the mother ship if the price of fish should be based to some degree on yield.

Evening out the flow. The various devices and procedures employed to even out flow were very useful in a situation that demanded many changes in production rate. The APS/AFDF plant in Kodiak might benefit from similar modifications, particularly in rate-sensitive operations like washing, refining, and pressing. Two examples would be using surge-storage devices and using several machines in series or parallel instead of one large machine.

Use of freshwater. Much less freshwater for washing meat was used on the processing vessel than in the APS/AFDF shore plant. One obvious reason is the restricted availability of freshwater on the ship, but note these two points:

(1) No water was used inside the screens, and blinding was controlled by infrequent use of seawater on the outside of the screen. The use of water in this manner should be evaluated in relation to the loss of yield it causes.

(2) The amount of water used in one or more washes, and the timing of those washes, needs to be carefully evaluated under controlled conditions, including laboratory analysis of those chemical factors that indicate washing efficiency.

Temperature control. The temperature of the surimi at various processing steps on this mother ship was controlled by refrigerating the wash water and the mixer bowls. If surimi temperature is really critical to producing a top-quality product, shore plants should consider similar techniques.

Sanitation. There was no apparent effort to maintain the minimum standards of sanitation that will be required of U.S.-operated shore plants or trawlers. It's not in the scope of this report to discuss either the relative merits of such standards or the presence or absence of health hazards in plants that don't maintain those standards. It's worth noting, however, that factories that maintain such standards will incur significant costs, which will put them at an obvious competitive disadvantage with factories that don't.

Fillets or surimi? The freezing of fillets—other than some high value bycatch—would be difficult on a surimi trawler because of limitations in crew, space, and freezer capacity. But such limitations shouldn't concern most shore plants; they might gain significant economic advantage by high-grading fillets from the surimi line. Significantly higher yield can be obtained from fillets compared to surimi, and profits may be higher per round weight ton. Combination frozen fillet/surimi production may offer advantages that offset the mother ship's advantages of mobility, closeness to the grounds, and inexpensive disposal of liquid waste.

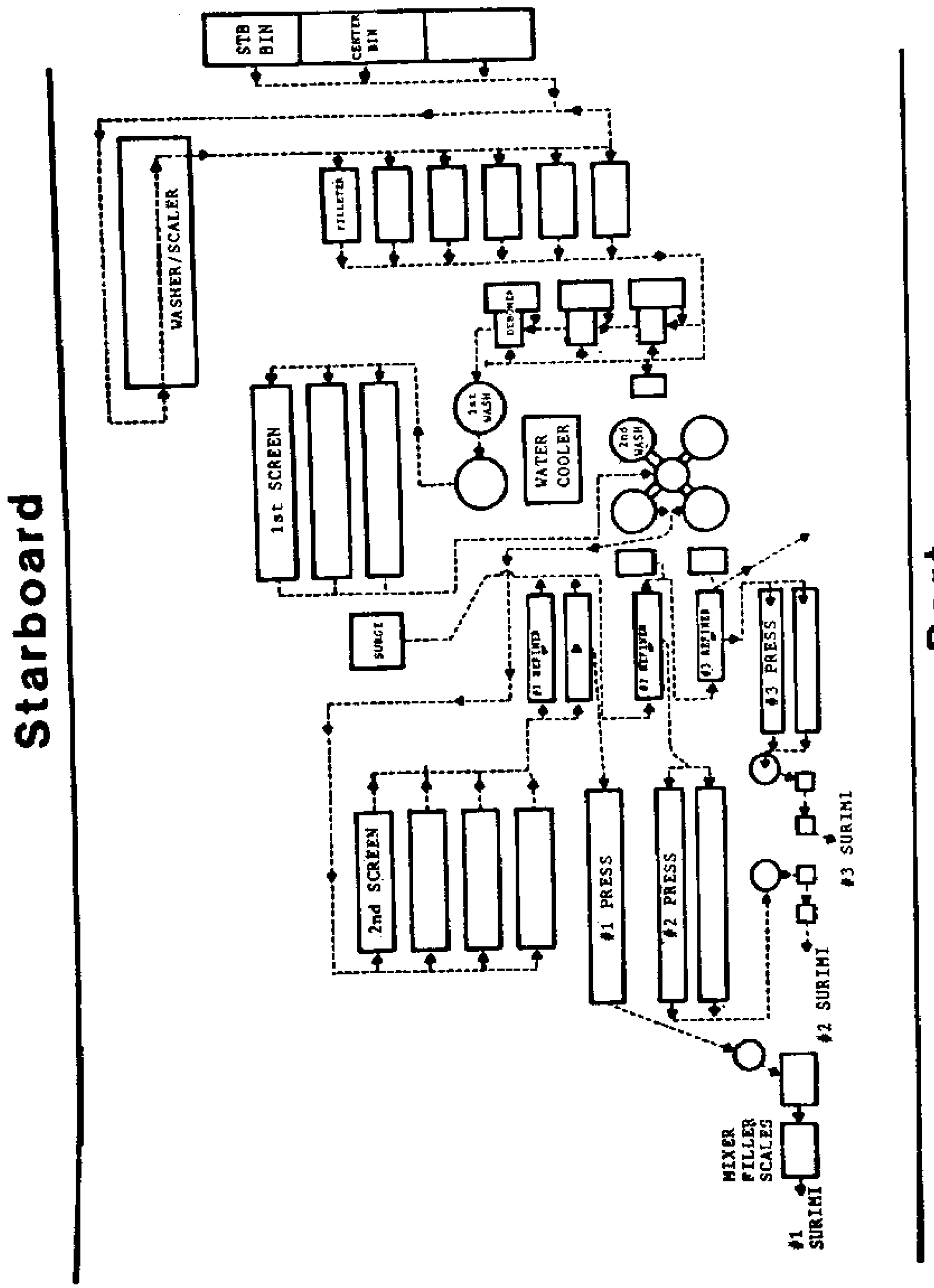

Figure 1.--Process line layout

Table 1.--Vessel data

Vessel type	stern trawler--surimi
Length	94 m
Width	16 m
Draft	6.76 m
Gross tonnage	4049.69 t
Net tonnage	2207.07 t
Engine type	Hitachi B & W
Horsepower	4400
Year commissioned	November 1968
Number of officers	10
Number of fishing crew	32
Number of processing crew	32
Total ship complement	74
Foreign guests	2

Table 2.--Equipment list

Item	No.	Size	Crew
Surimi line			
Toyo 708N filleter	6	150+ fish/min 120 fish/min	2 feeders 1 feeder
Storage bins	3	port 52.6 cubic meters center 47.2 cubic meters starboard 53.5 cubic meters total 144.1 t at .94 t/cubic meter	
Deboners	3	18 in long X 18 in OD	1-2 feeders
First wash tanks	2	first, 3 ft X 4 ft diam second, 4 ft X 4 ft diam	
First screens	3	15 ft long X 2-1/2 ft diam	
Second wash tanks	4	4 ft high X 4 ft diam	
Second screens	4	3 @ 15 ft long X 2-1/2 ft diam 1 @ 15 ft long X 2 ft diam	
First refiner	2	2-1/2 ft long X 18 inches diam	
Second refiner	1	2 1/2 ft long x 18 inches diam	
Third refiner	1	2 1/2 ft long x 18 inches diam	
Presses	5	1 @ 15 ft long x 2 ft diam 2 @ 20 ft long x 2 ft diam 2 @ 15 ft long x 1-1/2 diam	
Mixers (refrigerated)	3	2 @ 3-1/2 ft bowl 1 @ 3 ft bowl	
Fishmeal plant			
Furnace	2		
Driers	4	about 3 ft diam	
Centrifuges	4	2 horizontal about 4 ft long 2 vertical bowl about 2-1/2 ft diam	

Table 3.--Production data

Date	Deliveries				Products					Yield (%)		
	Pollock total	P Cod total	Discard total	Grand total	Surimi	Froz.	Meal	Oil	Total	Surimi	Meal	Oil
1	206.5	0.6	0.1	207.2	46.3	0.2	12.9	2.3	61.7	22.4	6.2	1.1
2	235.4	0.4	0.0	235.8	53.0	0.2	15.3	2.8	71.3	22.5	6.5	1.2
3	239.8	1.0	0.0	240.8	53.3	0.3	16.5	3.2	73.3	22.2	6.9	1.3
4	230.8	0.6	0.1	231.5	50.2	0.3	17.7	3.3	71.5	21.8	7.6	1.4
5	235.6	0.3	0.2	236.9	51.3	0.1	17.7	3.0	72.1	21.8	7.5	1.3
6	172.7	0.2	0.1	173.0	36.9	0.0	12.9	2.4	52.2	21.4	7.5	1.4
7	162.9	0.0	0.3	164.2	34.6	0.0	12.3	2.3	49.2	21.2	7.5	1.4
8	273.9	0.4	0.0	274.3	56.4	0.2	20.7	3.7	81.0	20.6	7.5	1.4
9	285.5	0.6	0.2	286.3	63.0	0.2	22.2	3.8	89.2	22.1	7.8	1.3
10	152.0	0.2	0.1	152.3	33.9	0.1	13.2	2.3	49.5	22.3	8.7	1.5
11	No Fishing											
12	74.5	0.3	2.5	77.3	14.2	0.1	3.9	0.9	19.1	19.1	5.0	1.2
13	185.7	0.7	1.5	187.9	38.4	0.3	14.4	2.7	55.8	20.7	7.7	1.5
14	252.6	2.0	6.1	260.7	53.7	0.7	21.3	4.1	79.8	21.3	8.2	1.6
15	117.5	0.9	0.4	118.8	26.0	0.3	9.0	1.9	37.2	22.1	7.6	1.6
16	110.9	0.4	0.7	112.0	20.2	0.2	5.8	1.4	27.6	18.2	5.2	1.3
17	84.4	0.5	0.5	85.4	20.7	0.2	8.9	1.0	30.8	24.5	10.4	1.2
18	58.6	0.1	0.4	59.5	12.9	0.0	4.5	0.9	18.3	22.0	7.6	1.5
19	244.6	1.2	0.1	246.6	54.2	0.5	18.6	3.6	76.9	22.2	7.5	1.5
20	264.7	2.2	2.3	269.8	59.0	0.8	20.4	3.7	83.9	22.3	7.6	1.4
21	295.9	1.3	3.0	300.4	67.5	0.4	23.7	3.8	95.4	22.8	7.9	1.3
22	101.6	0.2	1.2	103.1	22.2	0.1	7.2	1.3	30.8	21.9	7.0	1.3
23	202.0	0.3	0.9	203.2	45.0	0.1	15.3	2.8	63.2	22.3	7.5	1.4
24	132.1	0.1	1.2	133.4	31.5	0.1	8.7	1.7	42.0	23.8	6.5	1.3
25	161.9	0.3	5.1	167.3	36.2	0.1	13.2	2.7	52.2	22.4	7.9	1.7
26	262.5	0.4	13.2	276.1	61.3	0.1	21.6	4.6	87.6	23.4	7.8	1.8
27	275.2	0.3	9.4	284.9	65.3	0.2	22.5	4.6	92.6	23.7	7.9	1.7
28	277.0	0.4	6.6	284.0	66.3	0.1	21.6	4.8	92.8	23.9	7.6	1.7
29	218.1	0.2	16.8	235.1	52.2	0.1	17.6	3.6	73.5	23.9	7.5	1.7
accum	5514.9	16.1	73.0	5607.8	1225.7	6.0	419.6	79.2	1730.5	22.2	7.5	1.4
to date	10244.3	24.2	75.0	10346.4	2216.2	9.0	737.9	130.1	3093.2	21.6	7.1	1.3

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This publication was prepared by Kenneth S. Hilderbrand, Jr., Extension seafood processing specialist, Oregon State University. Trade-name products and services are mentioned as illustrations only, and this mention does not suggest that the OSU Extension Service either endorses such products and services or intends any discrimination against products and services not mentioned.

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