Recover and Evaluate Marketable Products From Cod Trimmings

February 1983

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This information was produced with the funds provided through the Saltonstall-Kennedy program administered by the National Marine Fisheries Service under Cooperative Agreement 81-ABH-00114.

TABLE OF CONTENTS

RECOVER AND EVALUATE MARKETABLE PRODUCTS FROM COD TRIMMINGS

PROJECT REPORT

PROJECT SUMMARY

The Project utilized trimmings from filleting Pacific cod, in particular, J-cut napes, aboard the F/T Arctic Trawler.

The products selected for testing were: standard 16.5 lb. minced fish blocks with emphasis on removing cod worms from flesh and reducing moisture content of minced fish; surimi from napes; nape blocks from trimmed, cleaned nape pieces.

J-cut napes were found to weigh the equivalent of about 33% of the skinless, boneless fillet from which they were derived. The various products produced showed potential for contributing significant revenue to filleting operations--from \$.36 to \$.59 per pound of napes entering the process. This is equivalent to adding \$.12 to \$.20 of revenue per pound of fillets produced.

The Project was successful in employing Japanese surimi making machinery to remove cod worms and moisture from minced flesh. Surimi was produced from cod napes which had an excellent jelly strength at the time of processing, but not following 6 months of storage.

I. SELECTION OF PRODUCTS FOR TESTING

A. Raw Material Source for Test Products

The project utilized trimmings from filleting Pacific cod (Gadus Macrocephalus) aboard the F/T Arctic Trawler. The majority of at sea or land based processing in the North Pacific is expected to concentrate on cod for the foreseeable future thus increasing the yield of saleable products via profitable use of cod fillet trimmings was deemed the project's goal.

Little work was carried out on pollock trimmings. However, most of the project goals, procedures, and products selected could be applicable to pollock filleting operations when it becomes important to do so.

Within the cod fillet trim category, the project focused on napes (belly flaps) which if handled correctly, were seen to have significant yield and added revenue potential. No experimentation was done on cod frames (normally yielding a minced product), heads and viscera (normally for fish meal), or roe. It was felt that these by-products were of much less economic importance than the efficient use of cod napes.

The source of napes for this project were those produced in the normal filleting operations of the Arctic Trawler. A Baader 190 machine for smaller fish produced a bone in, skin on nape as a by-product of its pin-bone cutting capability. A Baader 189 and 99 machine for larger fish any accompanying Baader 51 skinner produced a pin-bone in, skinless fillet from which a hand cut boneless fillet and a corresponding smaller skinless pin-bone in nape was derived. The latest generation of Baader filleting machines, the 184 for smaller fish and the 185 for larger fish will produce a pin-bone fillet only, but in each case the machine will be able to cut along the pin bone without severing the nape from the fillet. The latter step would be done by hand. Thus, rendering the nape from the fillet with the newer Baader machines would be similar to those described for the Baader 189 and 99 filleting machines used on the Arctic Trawler.

Napes from both the 190 machine and those hand cut from 189 or 99 machines fillets weighed approximately 33% of the skinless boneless fillet from which they were derived. In other words, if 1 million pounds of skinless boneless fillets were produced, the total nape weight available for processing of any kind would total 333,000 pounds. This proportion of nape to fillet would not necessarily apply to all filleting methods. Both the 190 machine and the hand cutting of fillets from the 189 or 99 machine in the case of the Arctic Trawler, utilized a J-cut which yields a practically napeless fillet (and a proportionately large nape). A V-cut trimming procedure would yield a proportionately larger fillet (and a smaller nape cut). Although nape yields were not determined for a V-cut, it is estimated that the nape as a percentage of the fillet weight could drop by as much as one-third using that method and the fillet yield would increase accordingly.

The yield difference between a J-cut and V-cut is an important consideration in determining the method of removing the pin-bone since nape material is worth more attached to the fillet (V-cut) than any by-product that can be produced from nape material separated from the fillet (J-cut).

On the Arctic Trawler a J-cut is used on all fillets yielding a proportionately large nape piece from each fillet. For small fish, particularly during strong fishing days, fast, labor free trimming is required which can be achieved with the J-cutting Baader 190 machine. The alternative is a slow laborious handcutting operation. A J-cut is used on the larger fillets since the highest concentration of parasites has been found in the nape area. A J-cut removes most of the affected area and by applying it to all fillets standardizes the appearance and physical characteristics of the pack.

Exhibit 1 illustrates the location of nape material and depicts a J-cut fillet and nape and a V-cut fillet and nape.

The characteristics of napes vary according to the size of fish from which they are derived and the section of nape being considered. Nape size. Sizes of napes according to fish and fillet size are shown below:

Fish Size	Fillet Size[1]	Approximate Nape Size[2]	% of Catch[3]
2.5-5 lbs.	4-8 oz.	1.3-2.6 oz.	15%
5-10 lbs.	8-16 oz.	1.6-5.3 oz.	40%
10-20 lbs.	16-32 oz.	5.3-10.6 oz.	35%
20 lbs.	32+	10.5 oz. +	10%

1/ size gradings of the Arctic Trawler 2/ J-cut 3/ average composition of Arctic Trawler 1980-83. Composition has varied significantly by season and year.

Nape Texture. Exhibit 2 illustrates the various nape sections, each with differing physical characteristics. A "fillet strip" lying on the fillet side of the pin bone is of the same thickness and texture as the fillet meat from which it was derived. It represents from 5-10% by weight of the entire J-cut nape. A "pin bone" strip is essentially fillet type material with short, thick and very sharp pin bones running through it. This strip represents 20-30% of a J-cut nape. The true "belly material" lying on the belly side of the pin bone can be fairly tender in smaller fish (though less tender than corresponding fillet material) to quite tough and pliable in larger fish. The thickness of the true belly material goes from thick along the pin bone to thin throughout most of the nape area. A thin white membrane covers the viscera side of the nape. This membrane can be fairly tough in the case of napes from larger fish. Defects. Parasites (almost exclusively cod worms) constitute the most prevelant form of defect. The incidence of parasites varies greatly according to area fished and fish age. Roughly, the average infestation would be 1 parasite per 2 to 3 napes for small fish and 1 to 2 parasites per nape from larger fish. Pieces of black peritonium normally pulled off the fillet in the gutting process may remain attached to the nape. This thin membrane is easily peeled off. Occasional blood spots, bruises, and ragged edges particularly in napes from larger fish may be encountered. Small napes for the most part are free of these defects.

Napes used for the program were derived from fish within 1-6 hours after being caught. All fish were bled prior to filleting and rendering the nape. Napes from fish not gutted or processed immediately would start to deteriorate (spoil and discolor) and the production of products derived from them would have to take this into account.

B. Selection of Products for Testing

Products selected for testing; 1) were considered to be of significant commercial interest to the developing North Pacific bottomfish industry; 2) did not require substancial new investments in capital equipment and could complement traditional filleting lines; and 3) had established markets.

The test product emphasis changed during the project, as more was learned about markets and the limitations of a basic land based or at-sea filleting plant. Initially, project goals emphasized extruded shellfish substitutes (forms of kamaboko), special blocks for sticks and portions (mixed species blocks and flavored blocks), and prepared entrees and entree ingredients from nape pieces (such as cod kabobs). The final test product program focused on basic fish products which in turn could serve as raw materials for further processing by more specialized production facilities.

The products selected for testing were: Standard 16.5 lb. minced fish blocks with emphasis on removing cod worms from flesh and reducing moisture content of minced fish; surimi from napes; nape blocks from trimmed, cleaned nape pieces.

II. TEST PRODUCTION AND EVALUATION OF SELECTED PRODUCTS

A. Standard 16.5 lbs. Fish Blocks

Prior to the Project, the Arctic Trawler produced approximately 170,000 lbs. of minced cod blocks for test marketing. The market accepted parasite free product at the market price prevailing of from $.40-$.50 per lb. delivered. Two major problems were encountered, however, which made minced block production from cod napes not feasible -- parasites and high moisture content in cod napes.

Cod worms. The incidence of parasites in cod flesh is apparently on the increase worldwide and is related to the growing sea mammal populations (due to conservation programs) which serve as hosts during a certain state of the parasite lifecycle. The predominant parasite in North Pacific cod is commonly referred to as a cod worm (nematode) and is light to dark brown in color, ½ to 1 inch long, and found in the cod flesh in a thin coil averaging about ¼ inch in diameter. Cod worms tend to be more concentrated in the nape area.

The removal of parasites by hand utilizing a knife or tweezers seems a prohibitively expensive procedure in the case of minced fish since the final product has a relatively low price. The first mincing done on the Arctic Trawler was carried out on a Baader 594 machine with a 3mm. mesh through which flesh was squeezed in the deboning process. It was found that cod worms were able to pass through this mesh, making the minced product not saleable. This was corrected to some extent by passing already minced fish a second time through the Baader mincer, but using a 1.5 mm. mesh. Whole cod worms were not in evidence after passing the flesh through the finer mesh; however, worm segments were. Also, the Baader meat bone separator was not designed to handle minced fish flesh and did not perform this strictly straining function efficiently.

A device was found which did separate cod worms from fish flesh - a Bibun meat strainer (produced by Bibun Machine Construction Co. Ltd. of Japan) commonly used in the surimi making process. See Exhibit 3. The Bibun device receives minced flesh and transports it via a screw housed in a cylindrical perforated housing. The least dense fish material moves to the outside of the screw and through the straining holes in the cylinder. More dense material continues along the screw and exits through a nozzle at the end of the machine. The tougher, more dense cod worms, any remaining bones, and darker more dense flesh are thus separated from the desired cod flesh. The resulting minced product is free of parasites and parasite particles, dark flesh, bones, and skin.

Moisture. Excessive moisture was encountered in very fresh minced North Pacific cod flesh utilizing the normal mincing procedure. The standard block carton had to be filled above capacity to reach 16.5 lbs. of meterial. This excess volume was squeezed out in the plate freezing process.

It has not been determined whether this excessive moisture is a peculiarity of North Pacific cod (as compared to North Atlantic cod) or a special problem of at-sea processing where fish is very fresh and had no chance to drip or dry during storage on ice or in a prior freezing and thrawing process.

As a solution to the excessive moisture problem, a Bibun continuous dehydrator was utilized (see Exhibit 3). This device, which was developed for making surimi, transports minced flesh via a screw housed in a perforated cylinder and squeezes moisture out in the process. Through proper use of the machines, the moisture content of the exiting minced flesh can be regulated.

The three machines finally used in the production of minced cod blocks for the project are commonly used in the production of surimi and thus are discussed in some detail in the increasing volume of literature on that product. For references to literature about surimi production see Exhibit 4. However, a few factors related to each machine and their use in producing minced fish are included here.

Mincing. A Baader or Bibun mincing machine can be adjusted to control the force of the belt pressing fish flesh against a perforated drum through which flesh separated from bone passes. Yield, and to some extent product quality, is determined by the machine setting. A relatively high pressure setting which forces the maximum amount of flesh through the mesh could produce an acceptable minced fish product, whereas a lower pressure setting would be required for an acceptable surimi product. On the other hand, a high pressure setting is more difficult to control Fish material must be fed to the machine more carefully or a back-up of fish material against the drum often occurs.

Skin on cod or pollock nape material (such as is derived directly from the 190 filleting machine) can produce acceptable minced flesh without skinning if the material is placed skin down on the in-feed belt and the pressure setting of the belt is relatively low. If handled this way the skin side of the fish material will not be forced through the mesh. However, the time saved by not skinning material prior to mincing should be compared to the yield loss and extra hours required to operate the mincer with skin-on product.

Washing and brushing the in-feed belt proved to be necessary to keep the mincer operating efficiently (it kept fish material from slipping on the belt). A stiff fiber brush and water spray device which continuously kept the belt clean was installed and proved very effective. Such a device is not offered with the standard Baader or Bibun mincer.

With a relatively low pressure setting and clean (free of skin and viscera) fish material, the mincing machine did not require a full time operator. Material was fed by conveyer into a hopper and passed automatically to the mincing machine in-feed belt.

Dewatering. Removing moisture from fish flesh using a screw press involves more than a mechanical process. For instance, slowing the speed of the screw and increasing the pressure of the flesh against the perforated drum did not necessarily force more water out of the minced flesh. Moisture is bound in the fish flesh and often must be released by other than mechanical force. In the surimi making process, minced fish flesh is treated to achieve a desired pH (around 7 or neutral) and washed prior to dehydrating. This process releases water molecules and soluable proteins which are then readily squeezed out with a press. Successful dewatering was achieved without a true washing step being incorporated by feeding minced flesh into the screw press with a stream of fresh water. The fresh water acted as a neutralizing and release agent as the flesh passed through the screw press. Thus, successful dewatering took place only by adding water to fish flesh and increasing the speed (reducing pressure) of the screw--the opposite of what would be expected.

The moisture content desired in the final product was that which allowed for 16.5 lbs. of minced flesh in a standard block carton and frame. This occurred at a moisture level of about 84% (compared to close to 90% prior to dewatering).

The addition of fresh water to fish flesh in the dewatering process may produce a desireable washing action which prolongs the shelf life of minced fish blocks and products derived from them. Minced flesh deteriorates more rapidly during processing and in frozen storage than the material from which it was derived. A proper washing cycle, as in the surimi process, removes soluable proteins and inorganic salts which accompany spoilage in fish flesh. Likewise fresh water added to minced flesh in the dewatering process caused a milky colored spray of liquid to be thrown off of the flesh passing through the screw press indicating that soluable proteins were being removed. No controlled test on shelf life with and without this simple washing method was carried out, however.

Straining. By changing the nozzle opening on the Bibun strainer, the quality of the strained material can be controlled. A small opening causes more of the dense material (less desireable color and texture as well as dense material like parasites) to be incorporated in the finished product. A first grade surimi product must be very white and requires that the nozzle opening be large and the accompanying yield low. For acceptable quality minced fish blocks, a greater range of material could be incorporated in the final product with an accompanying yield increase. In the case of the minced block material tested, a setting was used to achieve a yield of about 75% on the first fraction (a very white, clean material on the first pass through the strainer), 15% second fraction (material that had not passed through the strainer screen the first time but passed through the second time), and 10% flesh which was discarded because it was darker, and had worm particles and flesh from the more dense fat layers.

Minced cod flesh pushed through a strainer with a 1.5 mm. mesh produces a product with non standard physical properties. The more typical minced fish product on the market has been separated through a 3 to 5 mm mesh and more of the natural fiber strength of the fish muscle is intact. However, all minced product produced aboard the Arctic Trawler has been sold at the prevailing market price for minced cod blocks. Comments by block buyers and a government laboratory that tested the product indicated that the texture was acceptable, but slightly spongy. Color (due to the white muscle of the original material, dehydrating and straining) was described as good to exceptional. Since the minced blocks produced were derived from very fresh fish and washed to some extent, it is possible that the fish sticks made from these blocks for the test programs were benefiting from a gelling action during cooking making them firmer and less prone to falling apart. A less optimum quality of raw material might produce a mushy, unacceptable product if put through the same process.

Yield figures, from nape to minced block, are summarized in Exhibit 5 and compared to those for surimi. Roughly, 100 lbs. of napes should yield 70 lbs. of good quality (color and moisture content acceptable) minced flesh.

Estimated production volumes for the smallest mincing, dehydrating, and straining machines available are shown in Exhibit 6. A very small line could produce about 1.5 metric tons of finished product per 8 hours. This corresponds to an output of 6.5 metric tons of skinless boneless fillets from which the raw material for mincing would be derived. A small line would require about 3 workers from mincing to packing.

If the cost of labor was \$7.50 per hour per person, the direct labor cost invested in the minced product would be about \$.05 per lb.

The market for minced blocks is a very small part of the much larger fillet block business (10% in 1982). In 1982 only about 31 million pounds of minced blocks from all species were imported. The U.S. production is negligible. See Exhibit 7.

Minced cod blocks are priced at \$.35-\$.50 per pound delivered, the price varying by season and general market conditions. Breaded fish sticks are derived from these blocks and sold in retail stores as generic fish sticks and under well known labels with other frozen fish fillet and portion items. The most important feature of minced fish stick products is price--they must be cheap. The blocks from which they are derived must be cheap as well. There is little or no reward for a minced fish block which is an improvement over the norm in terms of meat quality, package, or distribution.

Currently, a joint government industry commission is carrying out a program to evaluate and recommend processing and labeling requirements for mixed minced and fillet blocks (often referred to as laminated fish blocks even though such blocks are mixed, not laminated). Up to 20% minced flesh mixed in with fillets in a standard 16.5 lb. block may be sold in the U.S. under the new standard. This type of block is currently produced and sold in Europe. A small quantity of fillet blocks with 20%

minced fish added was produced aboard the Arctic Trawler and tested by the NMFS's Northwest and Alaska Fisheries Center in Seattle. In a controlled evaluation, the panel found no significant visual, flavor, texture, or overall difference between a portion prepared from all fillets and one with 20% minced added.

Similiar results have been obtained elsewhere. If it continues to be shown that up to 20% good quality minced fish can be added to a fillet block with no drop in quality, the value of minced fish should be increased. Cod fillet blocks trade at the $1.05 to $1.20 per pound level, more than double the price of minced fish blocks. The key to the value allowed for any minced fish component of a mixed block will be the labeling requirements for the final finished product. If the word minced must be featured in the label, the product may be downgraded in terms of value, and the price of the minced fish component of the product downgraded as well.

For further information on the evaluation of and recommendations concerning mixed fish block processing and labeling, contact the:

Northeast Fisheries Center
Gloucester Laboratory
Emerson Avenue
Gloucester, MA 01930

B. Surimi from Cod Napes

With invaluable assistance from Billy Thrash of Nichibei Fisheries, Inc., the only U.S. surimi producer, approximately 750 lbs. of surimi was produced from cod napes. The surimi was produced following a number of days of testing to determine acceptable washing and dehydrating methods specifically for cod napes from the Arctic Trawler filleting operations.

The surimi produced tested very high (high gel strength) on board the vessel utilizing standard test procedures but did not test high following 6 months of storage. Thus, no final conclusions have been reached as to the suitability of cod napes for surimi. Some preliminary opinions have been formed, however: 1) fresh cod napes appear to have excellent natural gelling properties; 2) the procedures used in the first tests would have to be modified probably in the area of washing (two washes rather than one) and/or improved blending of sugars and phosphates which help retain gelling properties of fish protein in frozen storage; 3) there is the possibility that napes are not suitable for surimi due to their proximity to the viscera and a resultingly high enzyme level which can not be economically removed in any standard wash procedure.

Of great benefit was the application of surimi making procedures to the production of minced fish flesh in particular and the understanding of fish flesh chemistry in general.

The method employed for making surimi was the same as that described in the well distributed "First Surimi Processing Manual" by Billy Thrash. Napes were minced, washed, dehydrated, strained, mixed with sugar and sorbital, and packed and frozen. Equipment used is shown below:

ARCTIC TRAWLER
EXPERIMENTAL PRODUCTION LINE
FOR SURIMI

OPERATION	EQUIPMENT	CAPACITY
Mincing	Baader 694 Approx. $13,000	Rated: Approx. 500 kg./hr. input ($\pm$ 30 8 oz. belly flaps/min.)
Washing	50 gallon plastic bucket	
Dehydrating	Bibun S.R. 1000 Approx. $12,500	Variable. Our experience $\pm$ 250 kg./hr.
Straining	Bibun Sum 420 Approx. $12,000	Rated: 1000 kg./hr. input (input must include recycled 2nd & 3rd fraction)
Mixing	By hand in plastic tote	
Packing and Freezing	Block cartons Horizontal plate Freezers	

Section IIA. of this report describes important features of the mincing, dehydrating, and straining processes used in the production of surimi. Other special features of the experimental surimi process used are discussed here.

Raw Material. Surimi from pre-rigor and post rigor cod napes was produced with no differences being observed. Japanese surimi producers reportedly let pollock pass through rigor prior to processing. Cod napes frozen up to 48 hours then thawed yielded acceptable surimi but not of the quality of surimi from fresh fish material. It was not possible to test the suitability of frozen (for more than a few days), iced, or RSW preserved fish for surimi. It is reported that gelling properties are destroyed by all of these methods of preservation. There also may be important differences in the suitability of fish flesh according to seasons and given a high incidence of parasites. It was not possible to test these variables.

The surimi produced utilized cod napes immediately following catch, filleting, and trimming (within 1 to 6 hours after being caught).

Washing. Successful washing removes blood from the flesh and more important, removes substances in the flesh which impedè the gel forming ability of proteins which make up the fish flesh. See Exhibit 8 for a short explanation of the chemical factors related to gelling strength, the criteria by which surimi is judged.

Good immediate results were achieved by first treating fresh water (produced by vessel water makers) with sufficient baking soda to raise the pH of a mixture of 1 part minced cod flesh to 3 parts water to 7. The mixture was stirred and left to soak for about 2 minutes. As the minced flesh began to settle, the liquid remaining at the top containing soluable proteins, fats, and blood, was poured off. The remaining washed flesh was poured through a screen to remove excess water. One wash appeared to be sufficient to achieve the desired results. Fish flesh prior to washing had a pH close to 6. When placed in fresh water that was not treated, the minced flesh did not settle in the solution, thus blood and fats could not be skimmed off. A low pH also caused the minced flesh to become slightly grainy (cooked in the acid bath). A long soak (more than 2 or 3 minutes) caused the fish flesh to slip in the dehydrator to the point where dewatering was not possible. Thus, determining an acceptable washing procedure appears to be the most critical problem in formulating a production system for any given raw material. Washing is critical to retaining gel strength, obtaining good color, and making dewatering possible. Wash requirements are also critical to process economics. A requirement for multiple washing could be prohibitively expensive in terms of fresh water needs, time, and machinery.

<u>Dehydrating</u>. Surimi should be around 80% moisture content, drier than an acceptable minced product.

<u>Straining</u>. The strainer nozzle was set so approximately 75% of the dewatered material which entered the machine passed through the strainer

mesh (the most valuable first fraction). The second pass through yielding an additional 15% (the less valuable second fraction). The remaining material was discarded.

Mixing. Strained material was mixed by hand with 4% (by weight) sugar and 4% sorbital prior to freezing. Machine blending would have produced improved results.

Packing and Freezing. Surimi was hand packed in block cartons, about 15 pounds per carton. In a surimi production line, product is ejected from the mixer into packages automatically. Cartons were frozen in horizontal plate freezers.

The estimated yield for surimi from napes (less than 60%) is shown in Exhibit 5 and is compared to the yield (over 70%) for minced fish. Also shown is the $ return per pound of nape material utilized at hypothetical market prices. Given a lower yield yet a higher product value, surimi from trimmings ($.59 revenue per pound of napes used given a $1.00 per pound market price for first fraction surimi) appears to be a better alternative than minced blocks ($.36 revenue per pound of napes used given a $.50 per pound market price). *At the early 1984 market prices for these products (20-25% lower than those used in the example); the relationship still holds.

Potential surimi output given the experimental machines used for the Project is calculated in Exhibit 6. It would be possible to produce

1 to 1.5 metric tons per 8 hours with 4 to 5 workers operating this small $50,000 production line.

The market for surimi today is the Japanese kamoboko industry which produces approximately 1 million tons of kamoboko products per year. The raw material for much of this supply is Alaska pollock converted into surimi by Japanese factory ships. The U.S. market for surimi based products has expanded tremendously in the last few years. In particular, one form of kamoboko, artificial crab legs made from pollock surimi, reportedly has a 15 million pound market in the U.S. alone. It is anticipated that a kamaboko type industry will develop in the U.S. to produce surimi based shellfish products and other structured protein foods.

As a U.S. industry develops, marketing of a broad range of surimi products will become more feasible and reliable grade and price information available. Currently, price information is difficult to obtain in part because price is determined by the jelly strength of the product being sold. For the revenue estimates used in this Project, a $1.00 per pound price was used for first fraction, good quality surimi from cod, and $.80 for second fraction surimi.

C. Nape Blocks from Trimmed, Cleaned Nape Pieces

A limited number of standard blocks utilizing trimmed nape pieces were produced for the Project. A critical factor in producing nape blocks is the labor time required to render a product suitable for packing. The market price obtainable for nape block is also important. The market for nape blocks is limited and, as is the case for minced products, nape blocks are considered a second grade product and must be inexpensive to be attractive. Yet, breaded portions from nape blocks produced aboard the Arctic Trawler were tested by a taste panel and compared very favorably with standard fillet block portions.

It should be noted that a standard fillet block can contain up to 10% nape material. Incorporating nape material into a fillet block is the best use of the raw material providing that blocks are produced and the nape material is of good quality. Fillet block prices are above $1.00 per lb., considerably higher than the price per pound for alternative nape products.

Special production factors related to nape block production are discussed below:

Raw Material. Nape material from both small and large fish was tested. The nape from small fillets was found to be more tender than that from large fillets and when steamed, was difficult to distinguish from fillet meat in terms of texture, color, and flavor.

Nape meat from larger fillets on the other hand was found to be tougher and more pliable than fillet material, and slightly darker in color.

Rendering. A complete rendering required three steps. First, the fillet material outside the pinbone was trimmed away in one cut. Second, the bellyflap was sliced away from the pinbone. Third, cod worms, bloodspots, and black peritoneum, if any, were trimmed away. The latter was achieved easily by inserting the point of a knife under the edge of the black membrane, and peeling it away from the nape.

It took an average of one hour for one relatively inexperienced trimmer to completely render 90 pounds of skinless napes from large fish with the following yields being realized (see Exhibit 9 for illustrations):

Fillet trim	5-10%
Pin bone strip	20-30%
True nape	60-75%

Both the fillet trim and true nape material could be used for nape blocks. Theoretically, from 65 to 85% of the total nape piece could be packed in the form of nape blocks. However, in the larger fish, napes often required a significant amount of trimming due to parasites, ragged edges, blood spots, etc. Thus, only 50% recovery of acceptable nape material for blocks was achieved regularly. The remaining 50% was minced. The extra work required to render clean nape material for nape blocks would cost $.17 per lb. of clean nape material at an example labor cost of $7.50 per hour. Eliminating one of the cuts, the fillet trim cut, would reduce the yield of nape material to about 40% but require about 2/3 of the trimming time, thus reducing the cost per pound of finished material to about $.12 per pound.

A simple mechanical device for making the nape cuts is illustrated in Exhibit 10. A machine such as shown could eliminate much of the tedious hand trimming required to render napes.

Napes from smaller fish would have to be recovered at the filleting machine, put through a skinning machine, then rendered. Due to the small size of these napes it seems that it would be feasible to make only the cut which severs the pinbone away from the belly flap. The clean, boneless nape yield should be 60%, higher than the yield on the same cut from larger napes since the nape material from smaller fish has less defects.

The rendering cost per lb. of clean small nape material would be equivalent to that for large napes (about $.12 per pound at a labor cost of $7.50 per hour). Cutting time would be increased due to more handling required from small pieces, but defect trimming time would be decreased.

Packing and Freezing. Nape material was packed in standard 16.5 lb. cartons and frames skin side in and frozen in horizontal plate freezers.

Exhibit 10 presents a comparison of the alternative rendering methods applied to small and large napes, and the revenue per lb. of skinless napes entering the process. A net revenue of about \$.50 per lb. of napes, net of an estimated labor cost to render them, appears possible. This is above a comparable return per pound estimate shown in Exhibit 5 for mincing (\$.36 revenue less about \$.05 labor) close to the return produced by surimi (\$.59 less about \$.075 labor). At the early 1984 prices for minced and surimi products (lower than shown in Exhibit 5) nape blocks have a higher return than the minced and surimi alternatives.

The market for nape blocks forms a small segment of the fillet block market. Around 150 million lbs. of cod fillet blocks have been imported (and imports constitute close to 100% of the supply of U.S. consumption) in each of the last two years. Very little price and volume information is talked about in the nape block trade. However, there is reportedly a nape block market particularly with institutions seeking the lease expansive fish protein portion available and the general price level cited is \$.75 per pound with prices being quite volatile. Also, nape blocks with up to 20% minced included are reported to be exported by East Coast cod packers to European markets.

Various alternative uses of nape material were considered. Small skinned and rendered napes having flesh characteristics close to those of fillets were packed and compared to regular fillets from fish caught and processed under similar conditions. They were found to be slightly less tender than the fillet meat but very comparable in all other respects. The small 2-4 oz. pieces could be a valuable retail or institution item if packaged and merchandized correctly.

Whole napes, not trimmed, were frozen in blocks and sold to a small fish and chips chain which rendered the product, utilizing the resulting clean nape material for deep frying. Buyers for this type of product appear to be limited, however.

III. EVALUATING THE POTENTIAL RETURN FOR TEST PRODUCTS AND OTHER ALTERNATIVES

Selecting the product to produce from cod trimmings also is dependent upon the type of processing operation being considered - is the fish purchased by a land based or floating processor, or caught by a catcher/processor.

For a processing operation which purchases its raw material, a key to maximizing the return is yield from the product purchased. The more saleable product squeezed out of the raw material the better, so long as there is a margin between the revenue added and the variable cost of producing that revenue as each additional product is produced.

Providing space and labor are available, the purchasing processor should derive the maximum yield from the purchased fish with products which produce the highest total return. Two directions could be taken:

1. V-cut fillets as nape material stays with fillet and sells at the fillet price (a V-cut fillet would normally sell for less than a J-cut fillet).

   If some large nape material is trimmed away in the V-cut operation, clean and add to fillet blocks being produced (up to 10% allowed) thus nape material sells at fillet block prices.

Mince material from V-cut and if regulations permit (see pg. 14) add to fillet block thus potentially allowing mince material to sell at fillet block prices.

With remaining minced material, make minced blocks.

or

2. J-cut fillets or J-cut and portion into loins, center cuts, and tails (all relatively high value products).

   Trim the relatively high volume of napes and produce nape blocks.

   Mince nape trim material and produce minced blocks.

In a fishing-processor operation, the key to maximum return is squeezing as much revenue as possible out of the catch. This may or may not entail maximizing yield from the various species of fish caught.

The following table presents a list of alternative production possibilities rated according to their revenue potential per labor hour. Given the example product prices and pounds produced per man hour, revenues would be maximized by processing first, the incidental catch (black cod and pollock), then cod trimmings if time permits.

SURPLUS TIME ALTERNATIVES

CATCHER-PROCESSOR OPERATION

Product	Assumed Price/Lb.	Assumed Lbs. Produced Per Man Hour	Added Revenue Per Man Hour
H&G Black Cod	.90	125	$113
Pollock Fillets	1.10	80	88
Black Cod Fillets	1.00	80	80
Nape Blocks	.75	90	68
Minced Blocks	.50	115	58

Exhibit 1 and 2

J-cut and V-cut napes

Location and Sections

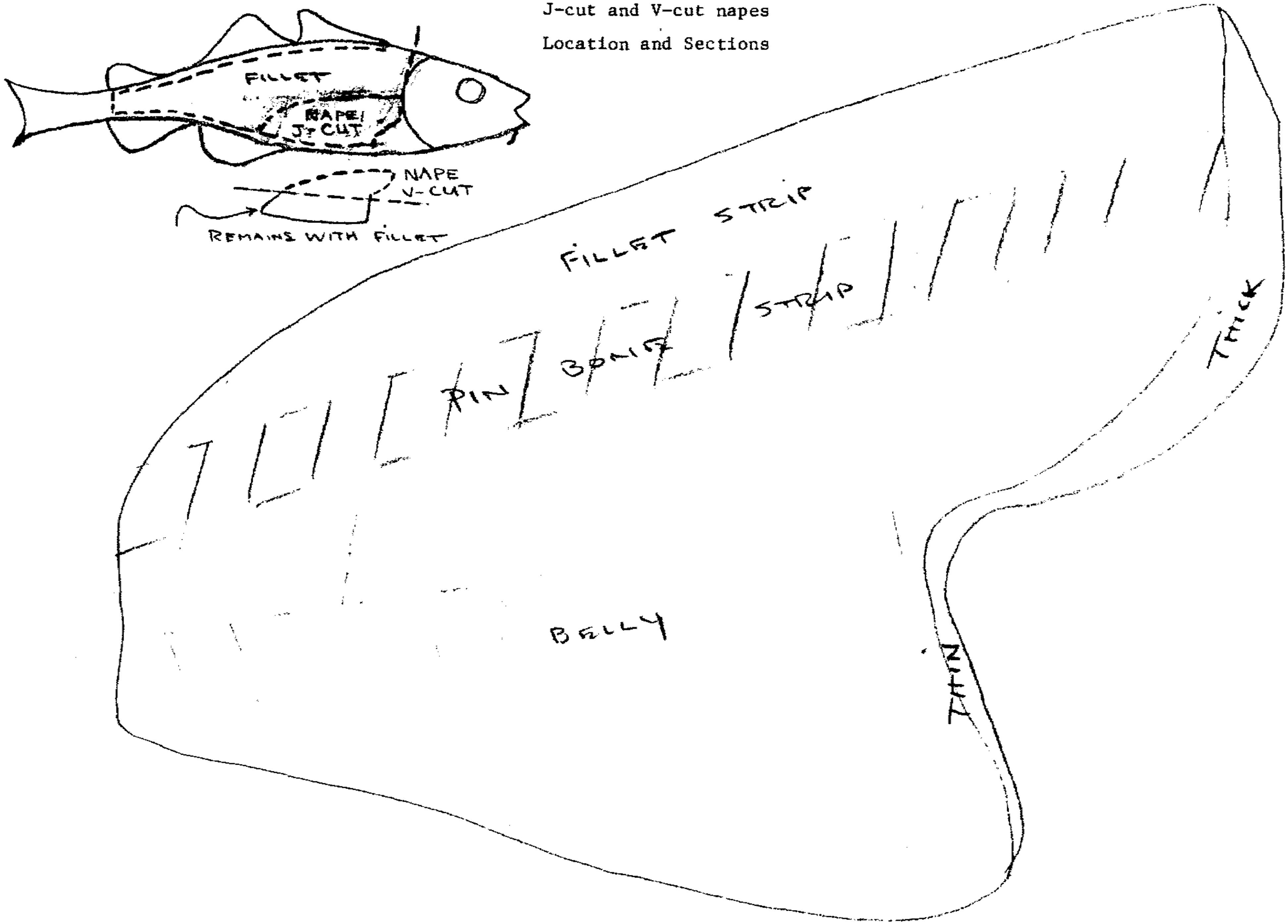


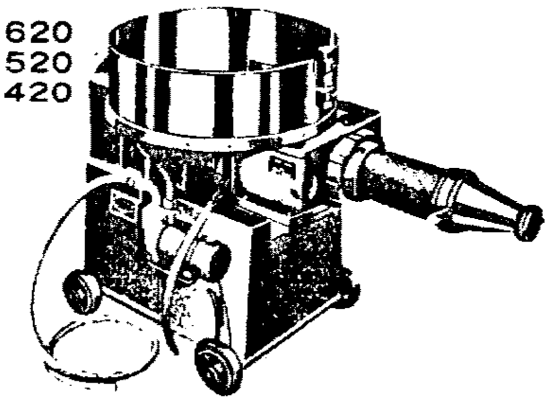
Exhibit 3

備文式 裏漉機 (ラセン強制冷却) P.A.T 第666195号外

BIBUN MEAT STRAINER

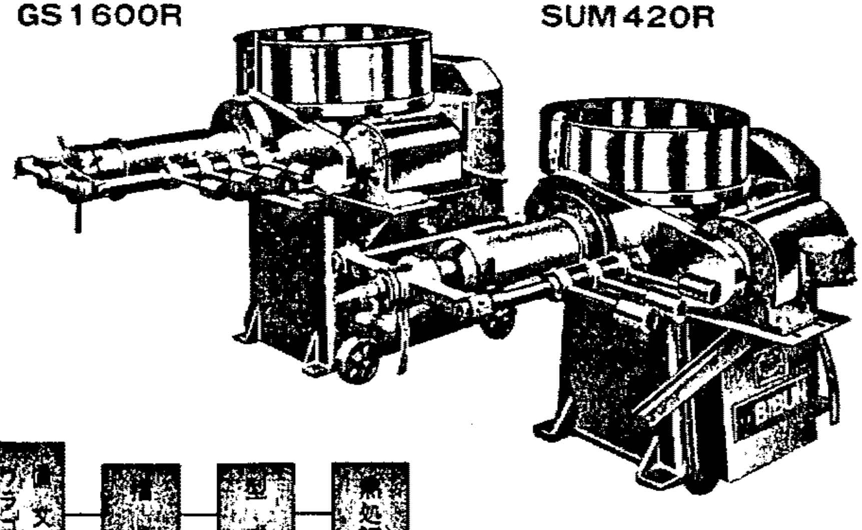
スーパー型(SUM)

SUM620
SUM520
SUM420

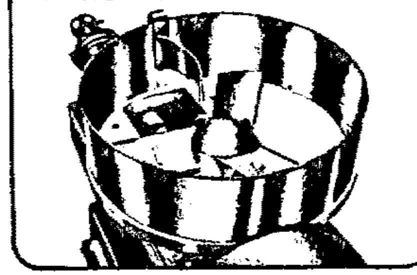


ロータリー式(プレート回転による新機構)

GS1600R　　SUM420R



自動送込方式



● 自動送込方式とは

従来は手かシャモジにより魚肉をラセン部へ入れており非常に危険性があり、又1台に必ず1人の人が付いていたが、本送込方式によると肉入ホッパーへ入れた魚肉が送込ベラ(2～3枚)によって移送され制御盤の作用により自動的にラセン部へ送込まれる。したがって危険性もなく人手もとりません。

◎良質蒲鉾を作る方法

調理 ― 魚洗 ― 採肉 ― 晒 ― 脱水 ― 備文式ウラゴシ ― 擂潰 ― 型成 ― 熱処理

本工程の説明

来のミンチの工程を廃止しウラゴシに置きかえ本機の使用によって筋・ウロコ・小骨等が完全に取れるので口当りの良い良質の煉製品を製造することができる。

仕様

良質かまぼこを製造するべく日夜努力されておられる煉製品製造業者の皆様御安心下さい…自動裏漉機が完成し御使用者から激賞され販売致しております。写真で見られます様に上部魚肉入口より魚肉を入れますと、自動送込方式により特殊ラセン部に送込まれ、ラセン回転による圧力でステンレス製特殊金網部より完全に筋・ウロコ・小骨等を除去された魚肉が製肉出口より、押出され筋・ウロコ・小骨等はカス出口より押出される構造です。尚、用途は魚肉・畜肉に限らず筋・皮を取除く製品に広く利用されて居ります。

特徴

● 肉質の向上
● 黒皮・不純物の除去
● 網目プレートの目詰り無し
● 作業中の網目プレートの掃除不要
● 肉温上昇無し(ラセン強制冷却)
● 能率の向上
● 作業性の向上
● 歩留の向上

脱水肉をそのまま裏漉できる強制冷却方式

● 強制冷却方式とは

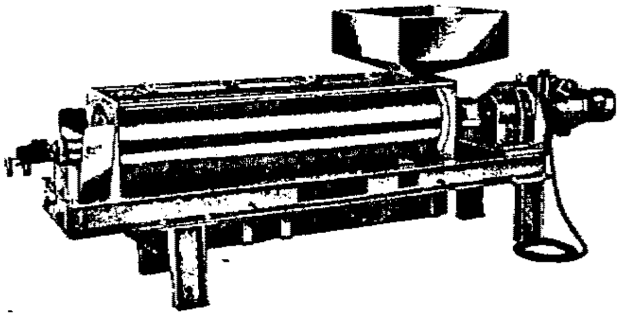
従来裏漉作業をする場合に著しい肉温上昇をすることが常識でありましたが本方式によると循環冷却水によって発熱部を強制冷却するので殆んど肉温上昇はありません。

仕様一覧

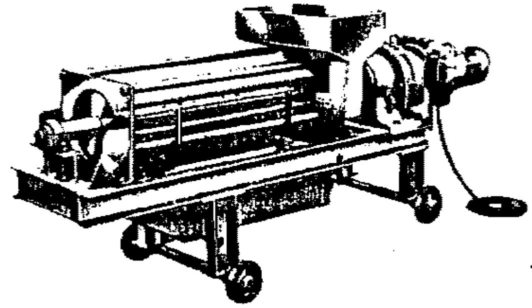
名称	SUM 620	SUM 520	SUM 420	GR 1,600R	SUM 420R
機械全高さ	1,050㎜	1,050㎜	900㎜	1,140㎜	1,200㎜
機械横巾	750㎜	750㎜	650㎜	1,050㎜	950㎜
機械板長さ	1,520㎜	1,450㎜	1,300㎜	1,800㎜	1,500㎜
所要馬力	11KW(15HP)	7.5KW(10HP)	3.75KW(5HP)	11KW(15HP)+0.75KW(1HP)	5.5KW(7.5HP)+0.75KW(1HP)
1時間処理能力	2,300～3,000kg	1,400～2,000kg	1,000kg	3,000kg	1,500kg
重量	550kg	440kg	330kg	700kg	400kg

自動連続脱水機 P.A.T出願済
BIBUN TYPE AUTOMATIC CONTINUOUS DEHYDRATOR

SR2000
SR1500 ラセン冷却



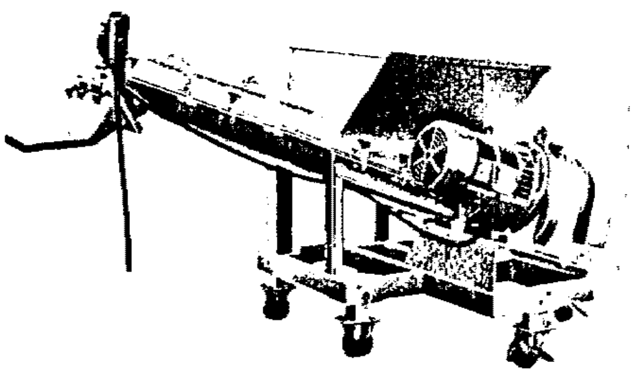
SR1000



名称	SR1,000	SR1,500	SR2,000
全長	2,360%	2,980%	3,410%
巾	640%	780%	780%
高さ	970%	1,280%	1,280%
馬力	0.75kW	1.5kW	1.5kW

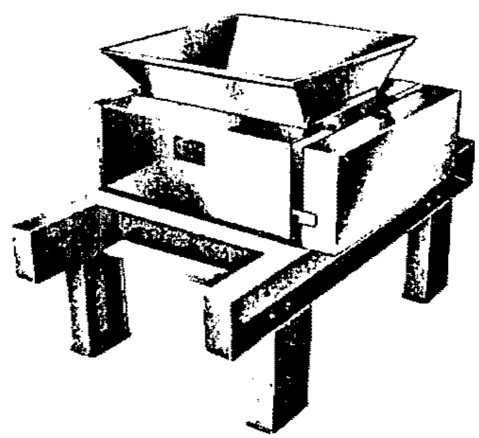
充填機
FILLING MACHINE

スリ身・カニ足・其の他



	SF20	SF15
高さ	1,040%	1,040%
横巾	1,250%	1,000%
縦長さ	1,900%	1,650%
馬力	3.7kw (5HP)	2.2kw (3HP)

ブツ切機
CUTTING MACHINE



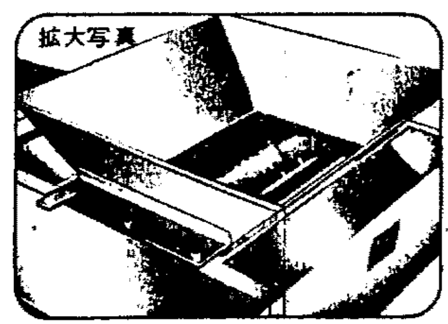


Exhibit 3 cont.

EXHIBIT 4

List of Surimi Related Literature
Submitted with Project Report

1. First Surimi Processing Manual
   Billy Thrash
   Nichibei Fisheries, Inc.

2. Crab Stick Making Process
   Bibun Corporation

3. Final Report, Surimi Plant, Northern Gulf of Mexico
   Billy Thrash
   Nichibei Fisheries, Inc.

4. The Japanese Kamaboko Industry
   Billy Thrash
   Alaska Fisheries Development Foundation

5. Fish & Krill Protein Processing Technology
   Taneko Suzuki
   Applied Science Publishers Ltd., London

6. Surimi - A Semi-Processed Wet Fish Protein
   Miyanchi, Kudo, Patashmik
   Marine Fisheries Review, Vol. 35, No. 12

7. Test of Silver and Red Hake
   Billy Thrash
   Nichibei Fisheries, Inc.

Exhibit 5

Yield Estimates for

Minced and Surimi

	Minced		Surimi
Fresh cod napes	100 lbs		100 lbs
Acceptable minced 1/	90		80
Dehydrated flesh 2/	76		64
Strained flesh			
1st fraction	57		48 @$1.00/lb. 4/
2nd fraction	11	@ $.50/lb.	10 @$ .80/lb.
3rd fraction 3/	4		3 @$ .50/lb.
waste	4		3
Sugar and Sorbital	-		5 @$ .40/lb. 5/
Total revenue	$36		$59
Total revenue per lb. fresh napes	$.36		$.59

Notes: 1/ dependent upon belt setting. 2/ dependent upon wash method and machine setting. 3/ 1st, 2nd, and 3rd fraction mixed for acceptable minced blocks, 3 rd fraction in surimi process for minced product only. 4/ example prices only. 5/ the $.40 represents the margin between the cost of sugar and sorbital and the market price of the surimi.

The labor cost per lb. (at $7.50 per hr.) would be on the order of $.05 for minced, and $.075 for surimi.

Exhibit 6

Example Production Volumes For
A Small ($50,000) Surimi or Mince Line

		Surimi Lbs. Per 8 hr. shift	Minced Lbs Per 8 hr. shift
Nape material to mincer	1/	4000	4000
Minced fish to wash and dehydrate	2/	3200	3600
Minced fish to strainer	3/	2560	3000
Strained flesh to mix and pack	4/	2640	2800

Notes: 1/ Skinless, viscera free material

2/ Fresh water required at a ratio of 3 H20 to 1 minced would be 150 gal. per hour for 1 wash and 300 gal. per hour for 2 washes.

3/ Using the smallest machines available 4 to 5 workers could produce the volume indicated above in the case of surimi and 3 in the case of minced.

4/ Includes 8% by weight additives (sugar 4% and sorbital 4%)

Exhibit 7

Market Statistics for
Fillets and Blocks

(1000's)

		1982 total	8 Yr. Increase
Imports of fillets			
	Cod	169,045	
	Other	271,871	
		440,916	64%
Imports of blocks			
	Cod	149,092	
	Pollock	61,018	
	Minced	30,720	
	Other	78,136	
		318,966	20%

Source: Fisheries of the United States
1974-75, 1982
U.S. Dept. of Commerce

Exhibit 8

Factors related to Jelly

Strength in Surimi

Copied from "The Japanese Kamaboko Industry" by
Billy Thrash, Alaska Fisheries Development Foundation,
1983.

SURIMI

Surimi is the main material for both the kamaboko and fish sausage industry. Many species of fish can be used to produce surimi, but Alaskan pollock is used most frequently.

The virtue of making surimi is being able to freeze and store this intermediate product for extended periods of time without losing quality. Surimi is basically a mechanically deboned fish flesh that has been washed with water. Minced fish, on the other hand, is a mechanically deboned fish flesh that has not been washed. Unwashed fish mince loses its functional properties rapidly in frozen storage, but surimi retains its functional properties for a significantly longer time.

The most important characteristic of Japanese kamaboko is the elastic quality called ashi (jelly strength). Ashi is related to the species of fish, freshness of fish and techniques used in processing surimi. Many U.S. marketing surveys have reported that American consumers did not like the strong ashi characteristics of the finished Japanese kamaboko products. However, ashi is also related to the keeping quality of the surimi. Therefore, the goal of the surimi processor is to maximize ashi in the frozen surimi even though ashi may not be used at full strength in the finished product. Furthermore, a surimi with a stronger ashi can be extended further by the addition of water, starch, and soy to produce a more economically priced finished product.

The essential element in forming a strong ashi or jelly strength is a protein structure in the muscle called actomyosin. The basic principle in the production of surimi is:

1. To remove the natural substances in the fish (water soluble matter and inorganic salts) that will speed up the denaturation of actomyosin.

2. To add cryoprotectants (sugars and phosphates) that will slow the denaturation of actomyosin during frozen storage.

The removal of water soluble protein and inorganic salts is done by washing the minced fish in three parts of chilled water. The cryoprotectants added back to the surimi are 5 percent sugar, 5 percent salt and .2 percent phosphate.

Assuming that fresh Alaskan pollock and good processing techniques are used, the denaturation of myosin is the major effect of lowering quality in surimi (myosin is part of the actomyosin structure).

Below is a model of the denaturation of myosin in frozen surimi (Figure 4).

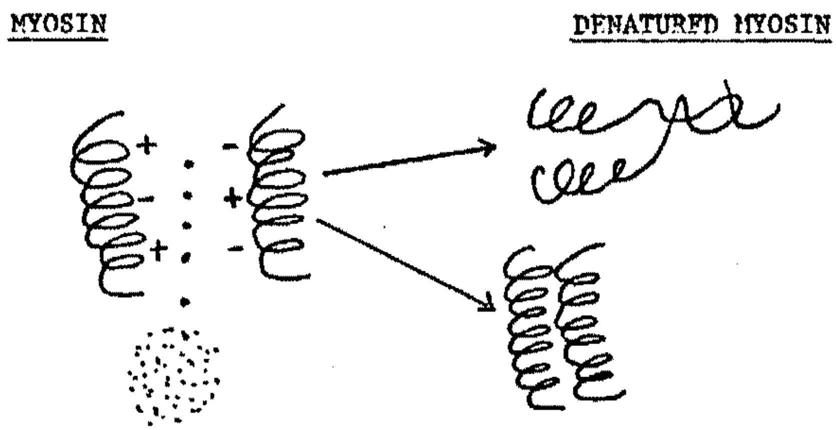


FIGURE 4 DENATURATION OF MYOSIN IN FROZEN STORAGE (FROM DR. MATSUMOTO, SOPHIA UNIVERSITY).

Even after surimi is frozen, movement and chemical reactions still continue on the molecular level. Myosin proteins have plus and minus charges which attract each other. When surimi is frozen, the water migrates from between the proteins to form ice crystals. With no water to separate them, the proteins come together and form bonds, or unwind and form bonds. After thawing, water can not go back between the proteins to break the bonds. The bonded proteins are denatured and can not be used by the kamaboko processor to form the elastic network known as ashi. If a kamaboko maker tries to produce a product from surimi which has no ashi, the product will not hold its shape; it will become mushy or break and fall apart.

Removing the inorganic salts and water soluble matter decreases the chance that myosin will form bonds in frozen storage. The addition of sugar and sorbitol act as an anti-freeze preventing the formation of ice crystals and keeping the water between the proteins. Surimi is actually is a semi-frozen state even though it is held at temperatures well below freezing.

Preventing the denaturation of actomyosin by washing is of great importance. Unfortunately, washing reduces the yield of the surimi product. The low yields associated with surimi production are hard for Americans to accept, particularly when compared to the high yields of unwashed minced fish. However, failure to wash mechanically deboned fish has a major disadvantage.

A large processor of frozen blocks reported that blocks containing minced fish can not be placed in frozen storage. The blocks containing mince must be consumed within 90 days of production. This means that minced fish blocks must be produced, frozen, shipped to a secondary processor, made into a finished product, distributed to the retailer, purchased by the consumer, and eaten within 90 days to get a good product.

Surimi on the other hand, can be held in frozen storage at -35°C for seven months with no significant change in quality. Surimi held at -20°C will change only slightly in seven months. Surimi held at -10°C changes rapidly but much less so than does minced fish.

Furthermore, the finished products made from surimi have a long shelf life. For example, the imitation crab leg can be held under refrigeration for 90 days, the the imitation shrimp can be frozen for up to one year, and the retorted fish sausage product can be held at room temperature for six months and longer. The long shelf life of kamaboko products enables them to be distributed through normal distribution channels.

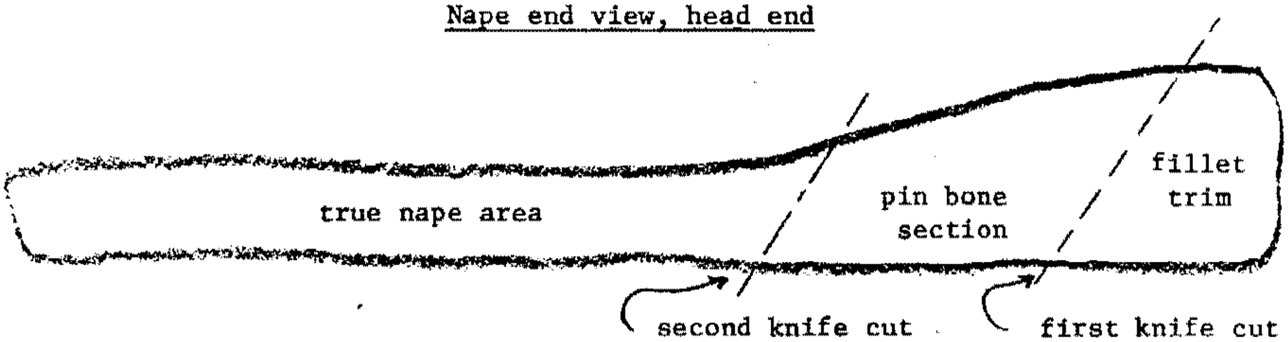
Surimi is sold on the basis of jelly strength. The higher the jelly strength, the higher the price of surimi. An effort to increase the yield of surimi by failing to wash the product will lower the jelly strength. Therefore, there must be a trade off between yield and jelly strength.

Exhibit 9

Nape Rendering Diagram

Belly flap (nape) from above

Nape end view, head end



Simple cutting machine for making cuts

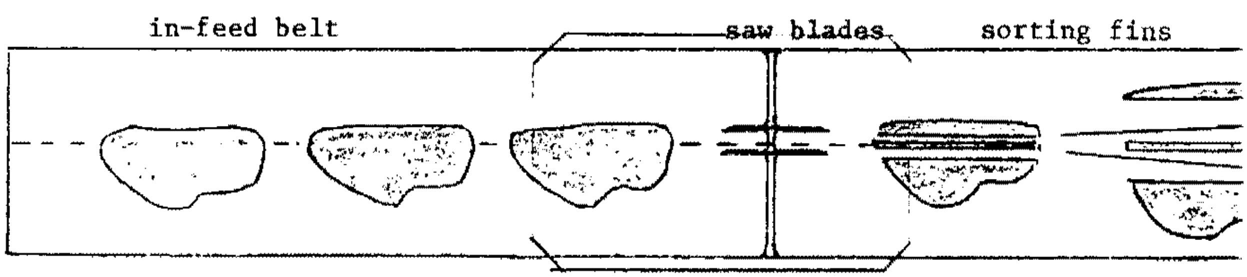


Exhibit 10

Comparison of Revenue Per Lb.
Various Nape Cuts

	Small Napes 1 cut	Large Nape 1 cut	Large Nape 2 cut
Fresh cod napes skin off, bone in	100 lbs.	100 lbs.	100 lbs.
Clean nape material	60 lbs.	40 lbs.	50 lbs.
Market value/lb.	$.75	$.75	$.75
Labor/lb.	.12	.12	.17
Net revenue/lb.	$.63	$.63	$.58
Total revenue	$ 38	$ 25	$ 29
Mincing stock	40 lbs.	60 lbs.	50 lbs.
Finished minced	28	42	35
Market value/lb.	$.50	$.50	$.50
Total revenue	$ 14	$ 21	$ 18
Total Nape plus Mince revenue	$ 52	$ 46	$ 47
Revenue/lb. napes entering process	$.52	$.46.	$.47

Note: labor cost/lb. assumes $7.50 per hour labor
and 90 lbs. per hour produced (input basis) per person.