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TEACHING MANUAL FOR EXTENSION COURSES
IN WHITE FISH PROCESSING TECHNOLOGY

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PREFACE

The objective of this manual is to provide supervisory personnel with both theoretical and practical training in white fish processing. It is hoped that the reader will learn what constitutes good raw material and what quality finished product is. It is not expected that the reader will become an expert hand filleter, but rather obtain a "feel" for what to expect from an expert filleter.

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INTRODUCTION

John P. Doyle

The terms bottomfish and groundfish are commonly being used in Alaska to designate those species of finfish that are presently being underutilized in the state. A better term for the fish we are interested in is white fish. White fish as a group are low in oil content, high in protein, and have a predominance of white flesh. Dark or red flesh is a minor part of the total muscle. The fishes found in Alaska that are considered white fish are the cods, flounders (including halibut), soles and rockfishes. With the exception of flounders and soles, the white fishes spend most of their time off the bottom. With the exception of the halibut, it is these fish that we will be discussing and working with during this course.

Developing a coastal white fish fishery will necessitate significant structural changes in the state's fishing industry. New fishing methods and handling practices will have to be adopted in the harvesting sector. At the same time, the processing industry must acquire new equipment and skills, as well as learn different handling practices. It is necessary that better and much more careful handling techniques be introduced to and practiced by the industry from the very beginning. This is true both in the plant and on the vessel. The fish that you will be working with are much more delicate and spoil faster than those with which you have been working in the past.

This manual has been designed for people who have considerable experience in the fish processing industry since that is where the core of new skilled labor for the developing fishing industry exists.

PART I

INDUSTRY OVERVIEW

CHAPTER 1

RAW MATERIAL AND PRODUCTS

Per O. Heggelund

The domestic white fish fishery has shown a gradual expansion since 1972, but the white fish industry within Alaska is still considered a supplemental fishery for most fishermen. In Southeast Alaska, the fishery is highly diverse with different gear types directed toward species which are marketed almost entirely for human consumption. In the remaining part of the state, the fishery supplies crab bait. An effort, however, is presently being made to promote white fish as a food fishery throughout the state.

Alaskan Harvest

Pollock landings in Southeast Alaska (SEA) in 1978 reached 1.3 million pounds, a three-fold increase over the 1977 catch of 0.4 million pounds (Rigby, 1978). This increase reflects a refinement of trawl methods, rather than a general expansion of the fishery.

The unrecorded bait harvest may be estimated by: 1) number of crab deliveries; 2) the pounds of white fish (hanging bait) used each trip; and 3) the number of potential days certain vessels trawled for bait. Based on this data, an additional catch of 0.5 million pounds for the Western Gulf and 2.0 million pounds for the Bering Sea were caught and utilized for bait in 1978 (Rigby, 1978). In the future, with increased competition within the crab fishery, and with the better efficiency demonstrated with "hanging bait" in the Tanner crab fishery, the unrecorded bait catch for 1979 will probably double (Rigby, 1978).

Unrecorded catches of white fish also include 2.0 million pounds used for bait by the halibut fleet. In addition, capelin and small pollock, estimated at 6.0 million pounds in 1976, was harvested incidentally to the shrimp fishery (Rigby, 1978).

Resource Potential

The potential for the Alaska white fish industry is large. In terms of fishing areas, the state represents almost one-fifth of the entire northern hemisphere. These grounds are predominantly located in the Bering Sea and the Gulf of Alaska.

Trawling for pollock in SEA occurs during the spawning period, January to March, when the fish concentrate near the bottom. During this period, up to six percent of recoverable roe is obtainable, thus providing additional revenues for the industry.

Flatfish

Starry flounder is the main harvestable species, but some sole is also landed incidentally. In 1978, 1.0 million pounds of flounder and 70,000 pounds of sole were landed from fishing grounds near Petersburg (Rigby, 1978). The fishery occurs from September through January, when the flounders are concentrated prior to spawning.

Other Species

This group includes Pacific cod, Pacific ocean perch (POP), rockfish, and lingcod. Landings of these species primarily result as incidental catches in other fisheries. In 1977, the catches of all these species combined was relatively small, at 487,000 pounds (Rigby, 1978).

Bait

White fish harvested outside the Southeastern part of the state is essentially for bait, and has progressively increased with the expanding crab fisheries. Landings have increased from approximately 200,000 pounds in 1972 to 866,000 pounds in 1977 (Rigby, 1978). In addition, unrecorded catches are transferred to crabbers on the grounds, or simply harvested by crab vessels with bait trawls.

Alaska's waters are highly productive. At present, 3.5 billion pounds of fish are harvested (domestic and foreign) on an annual basis, while during the peak year (1972) the harvest was some 6.6 billion pounds.

Table 1-A shows the level of white fish catch in Alaskan waters for both 1972 and 1977. The peak catch in 1972 was taken mostly by foreign fleets which may have over-fished the stocks. Thus, proper management in the future is necessary to rebuild the stocks, in order to increase harvest to the maximum sustainable yield of 6.6 billion pounds (Arthur D. Little, 1978).

TABLE 1-A

WHITE FISH CATCHES IN ALASKA WATERS, 1972 AND 1977
(in thousands of metric tons, round weight)

	Maximum Sustainable Yield	1977 Catch		1972 Peak Catch	
		Amount	Percent of Maximum Sustainable Yield	Amount	Percent of Maximum Sustainable Yield
Pollock	2,100	1,101	52%	1,876	89%
Flatfish (except Halibut)	678	34	5	227	34
Rockfish	265	36	14	116	44
Pacific Cod	160	39	24	54	34
Sablefish	80	22	28	55	69
Atka Mackerel	55	28	51	5	9
Total	3,338	1,260	38%	2,333	69%

Source: Arthur D. Little, Inc. 1978

Intermediate Products From White Fish Filleting Operations

Individual Quick Frozen (IQF)

As the name implies, fillets are frozen individually, generally in a continuous manner. IQF fillets often receive the top unit price of any white fish product. If the product is inadequately glazed or packaged, a significant reduction in shelf life could result, due to extensive freezer burns or dehydration.

Institutional Product

This group of products is packaged for marketing directly to institutions. The products are differentiated according to the net weight of the package; that is, between 1 and 10 pounds.

The fillets are generally individually wrapped prior to being layered in the cartons. The process is very labor-intensive, thereby reducing the overall production capacity. Nevertheless, most suppliers feel the market is able to adequately compensate for the extra cost and they are predicting continued growth in this particular sector of the industry.

Block

Packaging and freezing in blocks has been the traditional way of processing white fish fillets. Depending on the market, the processors may produce four different blocks: 13-1/2, 16-1/2, 18-1/2, and 24-1/2 pounds. These blocks are used as raw material in the production of fish sticks or portion controlled fillets, commonly referred to simply as portions.

Laminated Block

This type of block is a fairly recent product. It is produced from fillets, belly flaps, and minced flesh, and is laminated in very strict proportions in order to give the finished portions adequate structural strength.

Laminated blocks receive a lower price than regular blocks. These blocks are receiving an increased amount of interest among processors because the process, including packaging, allows for automation.

Minced Block

Minced flesh is produced mostly from fillet trimmings (excluding parasites and blood spots) and collar cuts. These blocks are used in the production of extruded products and portions.

At present, the price for minced blocks is relatively low. However, the trend is for greater acceptability in the market which eventually will reflect in an increased price. When the price reaches the proper level, it is thought that the minced blocks could become the main volume product in white fish processing. The main reason for this is that mincing techniques will increase the product yield. More R & D, however, is necessary, particularly in the area of prolonging the shelf-life of minced blocks and extruded products, in order to increase minced flesh production above the present level of 5 to 10 percent of the total fillet production.

Tables 1-B and 1-C show a product mix for a typical white fish filleting operation on the Faroe Islands.

Major White Fish Products

Fish Sticks

Fish sticks were first produced in the U.S. in 1949 for sale at hot dog stands. A similar product was later made in England and named fishfingers.

Fish sticks are made from fillets frozen in block. A 13-1/2 lb. block, for example, is sawed into six slabs which, in turn, are cut into 40 equal sized (3-3/4" x 7/8" x 1/2") "sticks."

Following the sawing operation, the fish sticks are breaded and battered prior to deep-fat frying before entering the freezer. During this operation, the fish sticks remain frozen and at a uniform weight of one ounce.

Portions

Similar to fish sticks, portions are also made from fillets frozen in blocks.

Blocks are sawed into equal pieces of more than two ounces. These portions may have different configurations, for example, simulated fish fillets.

TABLE 1-B

FAROES WHITE FISH PRODUCT MIX

	BLOCK	IQF	MINCED	CONSUMER PACK	LAYER PACK
Cod	+	+	+	+	+
Haddock	+	+	+	+	+
Pollock	+		+		
Lemon Sole	(1)	+			
Plaice	(1)	+			
Ocean Catfish	+				
Ocean Perch	+			5 lb	
Ling	+			5 lb	
Tusk	+				
Greenl. Turbot	+ (2)				

(1) Bulk in 16-1/2 and 18-1/2 lb. blocks

(2) Bulk in 55 lb. boxes

Source: Poulsen, 1979

TABLE 1-C

MARKET DIFFERENTIATION FOR COD AND HADDOCK PRODUCTS

RAW MATERIAL	BLOCK PRODUCTION		IQF (1)		MINCED			CONSUMER PACK		LAYER PACK (1)	
	Size (#)	Market	Grades	Market	Raw Material	Block Size	Market	Packaging Weight	Market	Packaging Weight	Market
Cod	13-1/2	Eur/USA	2-3 oz	England	Pin bone cut	16-1/2	Eur/USA	5	USA	13-1/2	England
Haddock	16-1/2	"	3-4 oz	"	Trimmings	18-1/2	"	10 (2) (3)	"		
	18-1/2	"	4-5 oz	"				15 (2) (3)	"		
	24-1/2	"									

(1) Fillet with skin on
(2) Only for Cod
(3) Jumbo

Source: Poulsen, 1979

After sawing, the portions are breaded and battered similarly to fish sticks. However, different from fish stick production, portions are not deep fried, but rather frozen raw for later preparation at, for example, fast food restaurants.

CHAPTER 2

MARKETS AND DEMANDS

Per O. Heggelund

U.S. White Fish Market

The United States is the principal market for white fish products. In 1972, this country consumed about nine percent of the world catch of white fish and received 65 percent of the total world exports of fillets and blocks, while domestically producing only about two percent of the blocks (GAO, 1976).

Growth of the U.S. market for fillets and blocks has been phenomenal. In 1973, 855.4 million pounds of white fish products were consumed--practically all as fillets, steaks, portions, or fish sticks. The annual market growth rate averaged seven percent during the five years ending 1973, despite steady and sizable advances in price levels (GAO, 1976).

The continued rise in import volume, up almost 300 percent in ten years, has made possible the steady growth of the U.S. white fish market. During the same period, domestic landings have failed to improve, necessitating larger volumes of imported fillets and blocks to meet market needs (Table 2-A).

Increased world demand for white fish products has resulted in a supply market of traditional species. The source and composition of U.S. imports therefore are undergoing considerable changes. Fifty-eight percent of U.S. block imports during 1972 were cod, and 15 percent were pollock. These shares shifted to 43 percent and 29 percent during 1973, caused by the growing cod shortage, which forced increased dependence on other species such as Alaska pollock (GAO, 1977).

Alaska's Opportunity to Supply the U.S. Market

Alaska could potentially supply most of the white fish for the U.S. market. Table 2-B shows that Alaska white fish could replace foreign imports (except for cod) and still have 80 percent surplus for export.

TABLE 2-A

1976 U.S. WHITE FISH IMPORTS

Country	Amount (Thousands metric tons, product weight)	Percentage of Total U.S. White Fish Imports		
Canada	87	27%		) --78% (Canada through Norway)
*Iceland	60	19	) --51% (Iceland through Norway)	
*Denmark	37	12		
*Japan	33	10		
*Norway	33	10		
All Others	72	22		
Total	322	100%		

*Denotes countries expected to supply fewer U.S. imports in the future.

Source: Arthur D. Little, Inc., 1978.

TABLE 2-B

U.S. WHITE FISH IMPORTS AND CONSUMPTION VERSUS
ALASKAN WHITE FISH PRODUCTION POTENTIAL
(in thousands of metric tons, product weight)

	1976 U.S. White Fish Imports	1976 U.S. White Fish Consumption	Alaskan White Fish Maximum Yield
Cod*	135	154	64
Flatfish	46	67	236
Pollock	43	46	567
Haddock	35	34	--
Perch	31	34	80**
Whiting	9	30 (Whiting and Other combined)	--
Other	21		62
Total	320	365	1,009

* Includes all species of cod
** Total rockfish

Source: Arthur D. Little, Inc., 1978

The U.S. market is the most attractive market for Alaska white fish for reasons of:

- Its proximity
- Familiar distribution channels and markets
- Preferencing of highly processed products, which increases revenues.

(Arthur D. Little, Inc., 1978)

Marketing Channels for Selected White Fish in the U.S.

Pollock

Most Atlantic and Alaska pollock enter the U.S. market channels as imported blocks. Atlantic pollock primarily enters this country via Boston, while Alaska pollock from Korea and Japan is shipped to New York.

Despite the identical common name for the two white fish, there are significant quality differences between the two species. On the one hand, Atlantic pollock has intrinsically a darker color than Alaska pollock; thus it is primarily used in institutions. On the other hand, Alaska pollock tends to have higher water content because of tripolyphosphate application; thus it is usually breaded and sold as sticks on the retail market.

If tripolyphosphates were eliminated in block processing, which some firms already are doing, battered Alaska pollock portions could enter the institutional market. However, at present most pollock blocks are processed into sticks. Some 91 percent of the fish sticks are sold to retail stores and 9 percent to institutions. With respect to the relatively small amount of pollock portions processed, 47 percent are distributed to restaurants, 27 percent to retailers, and 26 percent to institutions (Combs, 1979).

The supplies of pollock to the U.S. market are highly concentrated. Four processors control about 85 percent of the market share. These processors have their own distribution channels, but may also utilize brokers. Smaller firms tend to use brokers or distribute through the larger processing firms who also supply warehousing. Due to the short shelf life, five to seven months, distributors tend to turn over their products every two weeks (Combs, 1979).

Ocean Perch

Most of the U.S. supply of ocean perch is imported as frozen fillets. Canada controls in excess of 80 percent of this market. The remainder of the supply is domestically landed and processed by a few domestic processors in Maine and Massachusetts, who tend to concentrate on fresh rather than frozen fillets (Combs, 1979).

The frozen fillets are packed according to market preferences. The retail market prefers skin-on fillets in one-pound cartons or five-pound cello packs. The institutional market, however, wants five-pound cello packs or 10- to 15-pound layer packs graded by fillet size. In terms of a market split, approximately half of the supply is sold in retail stores, with largest sales in the southeast and midwest (Combs, 1979).

Flounder and Sole

Domestic landings in New England supply its own fresh flounder market with fillets. A small amount of fresh round flounder, however, occasionally is imported from Canada. Most of the fresh fillets are sold to wholesalers who distribute to institutions, supermarkets, and small fish markets. Some 20 percent of the fillets are sold directly by processors to retailers and institutions (Combs, 1979).

In the midwest, fresh flounder fillets are shipped from Boston, Seattle, California, or Canada. The fillets are shipped to wholesalers in 10- or 20-pound packs and sold directly in that form to institutions, while as single fillets to retailers (Combs, 1979).

On the west coast, Dover sole and Petrale sole are most popular. Dover sole fillets are frozen for institutions, except restaurants. The restaurants' dislike for Dover sole, both fresh and frozen, is related to its soft and milky texture. Fresh Dover sole, however, is sold to some extent by retail outlets.

Dover sole and Petrale sole follow similar processing patterns. In contrast to Dover sole, Petrale is sold to restaurants, rather than other institutions. Retailers constitute the largest market for fresh Petrale fillets, but hotels and restaurants are also substantial markets (Combs, 1979).

Increased Demand for White Fish Versus Growth of the Fast Food Business

The fast food business in the U.S. has become a significant market for white fish products. In 1970, Canada's Department of Industry, Trade and Commerce interviewed key franchises across the United States. The companies interviewed accounted for an estimated 75 percent of the total sales of the industry. Based on the data obtained, it was estimated that the United

States fish and chip industry consumed some 46 million pounds of white fish in 1970. That year the greatest demand was for frozen cod fillets, which accounted for 85 percent of the supply (Raynes, 1971).

The growth of the fish and chip sector is primarily related to the introduction of fish portions. These uncooked, unbreaded portions (based on blocks 16-1/2, 18-1/2, and 24-1/2 pounds) permit precise serving and cost control for the outlets. The demand for fish portions in 1970 was some 15 times that for fish sticks in the food service sector. Thus the rise in the United States' consumption of fish portions closely parallels the growth in the fast food business.

The large chains in the fast food business, such as McDonald's, Burger Chef, Long John Silver, and Red Lobster are all substantial users of fish portions. The annual usage of portions by each of these companies in 1970 was some 10 million pounds. The relative importance of the fast food chains in the food service industry is indicated by the fact that in 1969, McDonald's Corporation and Burger Chef Systems ranked seventh and sixteenth respectively among food service operators in terms of food volume, with sales of $450.8 million and $225 million respectively. Food sales of the ten essentially fast food chains included among the leading 400 United States food service organizations, totalled an estimated $1,479 million in that year (Raynes, 1971).

The recent upsurge in demand for white fish fillets and portions can be more directly traced to the growth of fish and chip franchises in the United States. This development was started in 1965 when Haddon Salt established his first outlet at Sausalito near San Francisco. Within the space of five years, the industry had expanded to the point where there were an estimated 1,430 outlets consuming white fish in the United States.

The rate of growth in fish and chip franchises is perhaps best illustrated by the phenomenal expansion of Arthur Treacher's Fish and Chips Inc. franchises. In 1970, this company had 100 units operating and 30 units under construction. In contrast, this company had only 12 units in operation and 12 under construction in November 1969. Over this period of a single year, sales increased from $50,000 to over $1 million (Raynes, 1971).

The U.S. fish and chip industry is highly concentrated. The industry is dominated by three companies: Salt's Enterprises, Ltd.; Arthur Treacher's Fish & Chips, Inc.; and Alfies' Fish & Chips, Inc. In 1970 the combined number of outlets controlled by the three companies totalled some 556 units, over half the estimated fish and chip outlets in the United States at that date.

The outlets controlled by the major fish and chip chains are widely dispersed. In 1970, Arthur Treacher's units were spread over 27 states, including California, with the major concentration in Ohio. H. Salt units were located in most of the eastern states and in the western region, particularly California. At that time the latter company also operated five outlets in Canada, while the former was expected to extend its operations to that country.

A limited menu is a distinctive characteristic of the fish and chip industry. Fish and chips is the primary menu item, but is sometimes supplemented by Peg Legs, lobster tails, shrimp, and hush puppies. Higher prices for cod and the absence of suitable substitutes, however, prompts an increasing tendency to reduce the size of the fish serving and to add non-fish products to their menus.

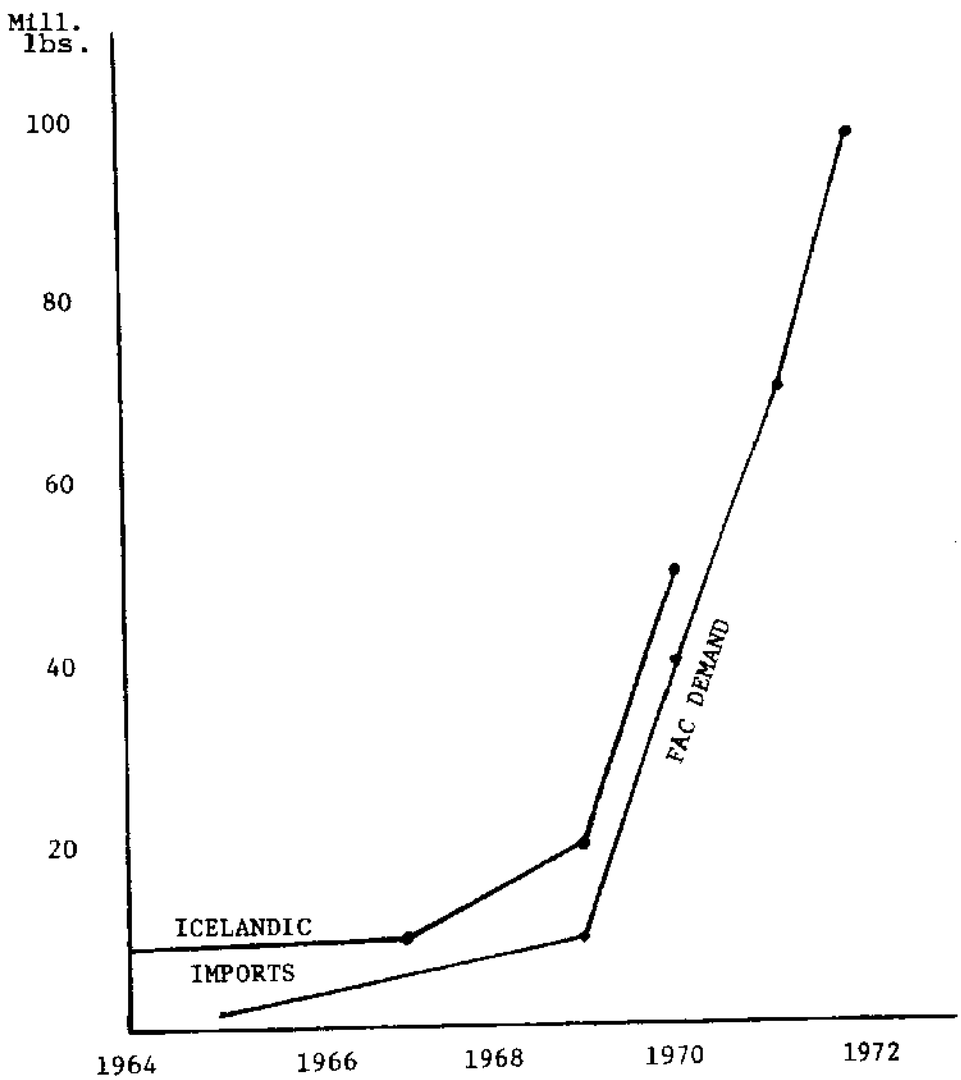
Despite the tight supply of cod, it still remains the universal raw material for the fish and chip industry. Cod is procured as quick frozen fillets in five-pound jumbo packs, with the major exception being Arthur Treacher's and Zuider Zee which prefer portions. Contrary to the general opinion in the trade, these two companies consider that it is more economical to purchase portions than to leave the portioning to the outlets. Arthur Treacher's initially used cod fillets (Raynes, 1971).

The Coldwater Seafood Corp., representing seafood processors in Iceland and the Faroe Islands, is the main supplier of cod to the industry. The dominance of this company is primarily based on the high quality of the Icelandic and Faroe Islands products, paralleled by an agressive development of the initial market (Figure 2-A). Coldwater participates in institutional and restaurant shows and fairs, including gatherings of executives of fish and chip chains. This marketing strategy, backed by an efficient distribution system which maintains direct contacts with buyers, has led to Coldwater's emerging as the "real seller" in the trade.

The prevailing dominance by Coldwater has resulted in an almost complete lack of interest among other suppliers to service the industry. Two of the major fish and chip companies, for example, have been very active in the international market in order to locate supplies of cod to meet their specifications. Their success was minimal except for a short term supply from Norway. Norway has since preferred to supply the European market, and the situation has reached the point where at least one fish and chip chain is seriously considering investing in a fish catching and processing enterprise in Canada, as a means of ensuring a supply of cod of consistent quality (Raynes, 1971).

FIGURE 2-A

ESTIMATED ANNUAL DEMAND FOR COD FILLETS BY
UNITED STATES FISH AND CHIP FRANCHISES
AND IMPORTS FROM ICELAND



Suppliers of, for example, Canadian cod, are greatly inhibited by the unfavorable image of this product. The feeling within the trade is that Canadian cod is inferior to both the Icelandic and Norwegian product. Burger Chef, for instance, a company with over 1,000 outlets and an annual usage of cod portions in excess of 10 million pounds annually will not knowingly purchase Canadian cod.

The problem facing Canadian supplies is one of inconsistent quality. The defects range from the presence of parasites, pinbones, skin, black spots, belly-flaps and napes in fillets and blocks, to soft texture and unsatisfactory flavor. The isolated samples that have been exported from Canada have suffered from several of these defects, particularly the presence of pinbones and parasites. The presence of parasites in the fish is of major concern to the large companies because of the adverse publicity and the fear of intervention by the Food and Drug Administration (Raynes, 1971).

The inconsistency in white fish quality has resulted in Icelandic and Faroes products becoming the industry standard. Coldwater's fillet blocks are smooth, whereas the Norwegian product contains flaws, making it difficult to portion, thereby increasing the cost of in-store portioning.

This supply problem is of major concern to the industry. The three major companies are also concerned about the future availability of cod, and have seriously attempted to locate additional sources of supply. The executives of these companies are particularly concerned with the possibility that their ultimate expansion will be prescribed, not by consumer demand for the end product, but by the availability of suitable raw material (Raynes, 1971).

In light of the tight supply, the major companies are aggressively attempting to locate white fish as an alternative to cod. The success thus far has been minimal. In order to become acceptable, a substitute product must be white, bland, and of similar quality to that of cod. Alaska pollock and lingcod are substitutes, but their moisture content must be reduced. Dogfish has been found to possess an undesirable odor, while the South African hake tested had an "offensive stench."

If an alternate substitute to cod can be found in terms of texture and quality, the United States fish and chip industry should be expected to grow. It has been estimated that if the supply problem is solved, the industry may expand at a rate of over 300 percent in the next five years. The domestic fast food business, therefore, provides a significant market opportunity for the emerging white fish industry in Alaska (Raynes, 1971).

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PART II

REGULATIONS AND STANDARDS

CHAPTER 3

PRODUCT STANDARDS AND MARKET DIFFERENTIATION

Per O. Heggelund

Product Standards for Fillets

Scandinavian regulations concerning white fish fillets are very stringent. Norwegian regulations, for example, have fillet standards based on trimming or removal requirements.

Type A. Whole Fillets

1. Dorsal finbones
2. Backbone
3. Anal finbones
4. Caudal fin
5. Rib-bones
6. Pelvic finbones

Type B. Half Fillets

1. Dorsal finbones
2. Backbone
3. Anal finbones
4. Caudal fin
5. Rib-bones
6. Pelvic finbones
7. Pectoral finbones
8. Lower edge of belly flap

Type C. Clean Cut Fillets

1. Dorsal finbones
2. Backbone
3. Anal finbones
4. Caudal fins
5. Rib-bones
6. Pelvic finbones
7. Pectoral finbones
8. Collarbone
9. Thin belly flap meat

Type D. Boneless Fillets

1. Dorsal finbones
2. Backbone
3. Anal finbones
4. Caudal fins
5. Rib-bones
6. Pelvic finbones
7. Pectoral finbones
8. Collarbone
9. Belly flap
10. Pinbones

Types B, C, and D may be packed with or without skin. Only fillets A, B, C, and D are generally permitted. Fillet Type B with the collarbone and pinbones removed can be labeled "boneless fillet Type B." A fillet labeled "boneless fillet Type C" is a C-type fillet with the pinbones removed.

Fillet types B, C, and D are most commonly produced. These fillets can be marketed with or without skin, but no scales should be present. Fillets labeled "with bones" should have all bones except the pinbones removed. In boneless fillets, all bones should be removed.

Figure 3-A shows the three most common boneless type fillets. Fillet type B has part of the belly flap trimmed off. Fillet type C has more of the belly flap removed, while fillet type D is completely without belly flap. If fillet type B is produced, the belly flap has to be of the highest quality. Belly flaps that are torn, discolored, or have parasites should not be used for fillet type B.

Every fillet should be trimmed and candled so that parasites, bloodspots, discolorations, peritoneum (both black and white peritoneum), remnants of skin, skin membrane, scales, bones and fins are absent. When fillet type B is used, only minute remnants of skin may show on the belly flap.

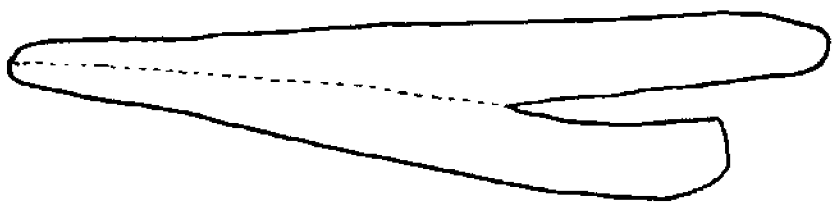
Before packaging, one should ensure effective drying of the fillet in order for the fillets to be clean and without excess water. A thawed fillet should not have a drip loss in excess of 6 percent of the total weight of the packed fillet.

Shipments of fillet type B can also contain fillet types C or D. Also, when shipping fillet type C, fillet type D may be included. When fillet type D is shipped, however, no other type of fillet can be included.

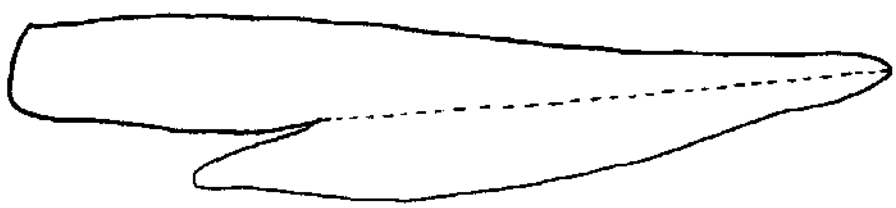
White fish fillets can also be cut into products as shown on Figures 3-B, 3-C, and 3-D, depending on market specifications.

FIGURE 3-A

Boneless
Fillet
Type B



Boneless
Fillet
Type C



Fillet
Type D

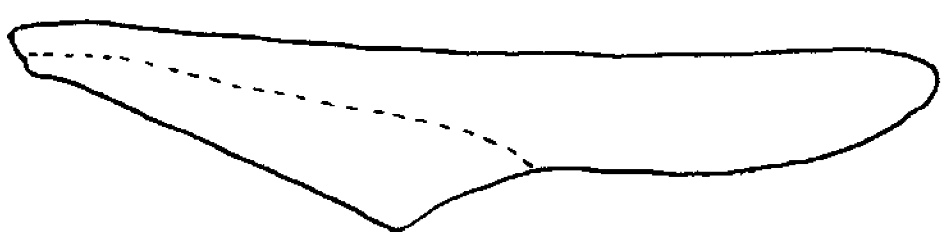


Figure 3-B

Small Size Fillet

Figure 3-C

Large Size Fillet

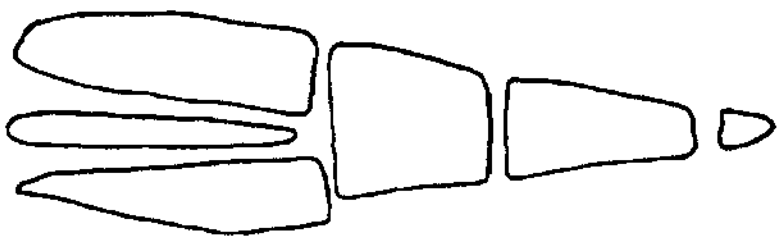
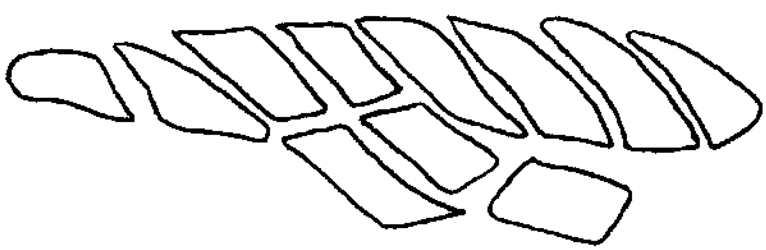


Figure 3-D

Pieces



Strip-loin

This product contains only the largest and thickest part of the back portion of the fillet. No pinbones should be present. Every strip-loin should be free of skin and bone and should have a length of approximately 11 inches.

Tails

This product is taken from the tail portion. Approximately 1 to 1-1/4 inches of the last part of the tail is removed and is used in blocks if the meat is of good quality. If the tail portion has been trimmed to the point of losing its natural shape, it should not be packed with other proper tail cuts.

Pieces

When the tail, back, pinbones and belly flap cuts have been made, the rest of the fillet can be cut into portions of approximately 5 to 6 inches. These pieces are commonly used in laminated block production. (See Figure 3-D.)

Center-cut

When cuts have separated the tail, back, belly flap, V-cut, and strip-loin, the remaining part of the fillet can be labeled "center-cut" (Figure 3-C).

Consumer Packs

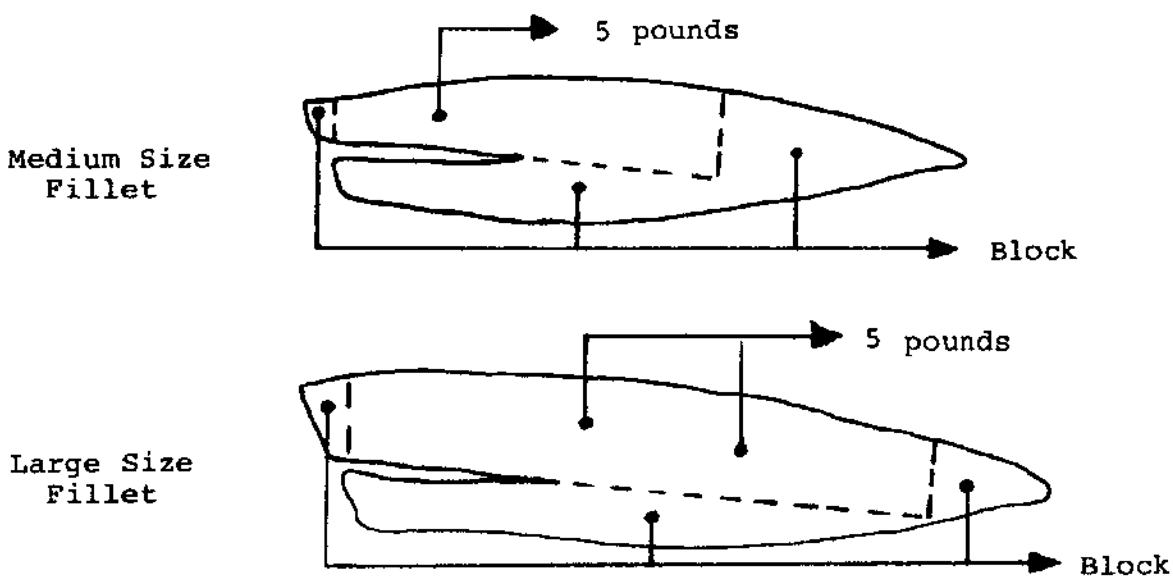
Cello Wrapped Fillets

Whole fillets or parts of a fillet are individually wrapped in polyethylene packages of 1 pound, 5 pounds, and 10 pounds (Figure 3-E). Packages labeled as "5 pounds" or "10 pounds" should contain 6 or 10 fillets of similar sizes. These fillets should be placed in cardboard boxes in order to produce uniform packages. The fillets should be layered with the skin side down, with the stretch-wrapped polyethylene providing adequate contact to prevent air pockets.

"Jumbo-pack" or whole fillets are similarly packed in polyethylene film. When wrapping these fillets, one should ensure that the fillets' natural shape is maintained.

FIGURE 3-E

FIVE-POUND STANDARD FILLET



Five-pound Standard Fillet

The fillet is trimmed with a cut from the root of the V-cut and back toward the tail, so that the belly portion is cut for packing in blocks. The end of the tail part is trimmed (Figure 3-E). The finished trimmed fillet should have a length of approximately 10 inches, and a weight of approximately 180 grams to a maximum of 400 grams. The weight of the fillets prior to freezing should equal 2,360 grams, plus/minus 30 grams. After freezing, the 5-pound pack should contain more than 2,280 grams, which allows a net weight declaration of 2,270 grams on the invoice.

Layer Pack

Fillets are packed in layers using polyethylene dividers. These layered packs make it convenient to remove one layer from the pack without having to thaw the whole package.

Careful handling and transporting of the cartons with layer pack fillets is necessary, thereby preventing the fillets from freezing together.

Sheets of polyethylene film that are wider and longer than the carton should be used, thus covering the fillets on all sides to prevent freezer burns or moisture loss during frozen storage.

Blocks

Fillets to be used in block production are packed in special cartons fitted for the different types of blocks used in the plate freezer. In order to ensure the proper net frozen weight of the blocks, the following gross weights should be used:

13-1/2 pound block: Minimum weight 6,129 grams.
Gross weight 6,265 grams, with a tolerance of +/- 30 grams.
Finished product must contain more than 6,200 grams.

16-1/2 pound block: Minimum weight 7,491 grams.
Gross weight 7,655 grams, with a tolerance of +/- 30 grams.
Finished product must contain more than 7,600 grams.

18-1/2 pound block: Minimum weight 8,399 grams.
Gross weight 8,585 grams, with a tolerance of +/- 30 grams.
Finished product must contain more than 8,500 grams.

24-1/2 pound block: Minimum weight 11,123 grams.
Gross weight 11,330 grams, with a tolerance of +/- 30 grams.
Finished product must contain more than 11,250 grams.

Packing requirements in block production are as follows:

1. The fillets which are packed in a block must be dry.

2. The fillets must be flat and even.

3. Blocks can contain fillet pieces less than 60 grams though not in excess of 10 percent (w/w). The pieces should be distributed throughout the block.

4. The fillets should be placed in the block frame with the inside of the fillet facing the bottom of the frame. In the top layer, the inside of the fillets should face the lid.

5. The blocks should be frozen immediately after packing. The temperature should be below -25°C when taken out of the freezer; otherwise the block will expand in storage.

6. Dimension of block:

Weight	Length	Width	Height
5 x 13-1/2 lb	508 mm	295 mm	41 mm
4 x 16-1/2 lb	483 mm	254 mm	63 mm
3 x 18-1/2 lb	483 mm	288 mm	61 mm
2 x 24-1/2 lb	483 mm	288 mm	81 mm

7. Only 1-1/2 bones are allowed per kg.

8. Only one parasite is allowed per two kg.

Minced Meat from Fillet Trimmings

Production

The perforated drum should have holes with a diameter of 5 to 6 mm.

Within four hours, calculated from the time of the candling operation, the trimmings should be minced, packed, and placed into the plate freezers. The minced meat should be packed and frozen immediately after it has been passed through the mincing machine. Liquids from the deboner should not be mixed with the minced meat.

Quality Control

At least one sample of 500 grams of the product should be taken for every production period. These samples are checked for bone, skin, peritoneum, and other foreign objects. The finished minced meat should not contain more than five bones per kilo of meat.

Minced Meat Blocks from Collarbones and Neck Areas

Raw material should consist of fresh collarbones and necks of cod and haddock. Collarbones and necks of Atlantic pollock should not be used. The common indices of freshness for collarbones and necks is the natural color of the fish muscle and the blood.

Washing of collarbones and necks should be done parallel with the production itself in such a manner that all of the general sanitary specifications for the plant and products are met.

Washing time should be from 5 to 10 minutes, depending upon the freshness of the raw material. After washing, the collarbones and necks should be drained on screens or perforated trays.

The fish should be minced or deboned immediately after it has been drained. Diameters of the deboning drums should not exceed 5 mm.

After deboning operations, the minced flesh should be free of any blood particles or peritoneum remnants.

To insure a proper dewatering procedure, the minced flesh should be given some extra time in perforated trays before packaging and freezing.

The deboner should be properly cleaned every four hours.

U.S. Standards for Grades of Frozen Minced Fish Blocks

Grades

The National Marine Fisheries Service recently issued standards for minced fish blocks (NMFS, 1978). The grading procedure is extremely elaborate, as shown in Tables 3-A and 3-B.

The maximum number of physical defects permitted are based on inspecting the products according to the check list shown in Table 3-B.

Sampling

For sampling frozen blocks of minced fish, an entire block should be used. If the flesh is thawed, a subsample of at least five pounds is adequate.

TABLE 3-A

MINCED FISH BLOCK GRADING STANDARDS

	Flavor and odor	Maximum number of physical defects permitted		
		Minor	Major	Serious
Grade A	Good	3	0	0
Grade B	Reasonably good	5	1	0
Grade C	Minimal acceptable	7	3	1

Source: NMFS, 1978

TABLE 3-B

Minced Fish Block Defects Permitted

Physical Defects	DIFFERENTIATION OF PHYSICAL DEFECTS		
	Minor	Major	Serious
1. Deteriorative color: excessive oxidation (yellowing) of lipid and browning	Slightly noticeable	Conspicuously noticeable	Conspicuously noticeable, affecting eating quality and appearance
2. Dehydration: loss of moisture during frozen storage	Affecting < 5% of surface area, easily removed	Deep penetration < 5% of surface area, difficult to remove	Deep penetration > 5% of surface area, difficult to remove
3. Uniformity of Size: conformity to the block dimensions	Average length, thickness and width < 1/8"	Average length; thickness and width deviation between +/- 1/8 to 3/8"	Average length; thickness and width > +/- 3/8"
4. Uniformity of Weight: conformity to declared weight	< -2. oz	≤ -2. oz	> -2. oz
5. Angles: angle formed by two adjoining surfaces	2 unacceptable angles	3 unacceptable angles	+4 unacceptable angles

TABLE 3-B (Continued)

Physical Defects	DIFFERENTIATION OF PHYSICAL DEFECTS		
	Minor	Major	Serious
6. Improper fill: # of 1 oz air or ice voids	$<$ 3 x 1 oz voids	$\leq$ 3 x 1 oz voids	$>$ 3 x 1 oz voids
7. Blemishes: # of pieces of skin, scales, blood spots, belly membranes	$<$ 20 per lb	20-40 per lb	$>$ 40 per lb
8. Bones: presence of bones $>$ 1/4"	$<$ 1 bone per 5 lb	2-3 bones per 5 lb	$>$ 3, but $<$ 10 bones per 5 lb
9. Flavor and odor: organoleptic evaluation on cooked product	Good--essential for Grade A	Reasonable--min. for Grade B	Min. acceptable--min. for Grade C
10. Texture: on cooked sample	Fairly firm, slightly spongy/rubbery; not mushy or gritty due bone fragments	Mildly spongy/ rubbery; slightly gritty due bone fragments	Spongy, rubbery, very dry/very mushy and gritty

Source: NMFS, 1978

CHAPTER 4

SEAFOOD REGULATIONS

Per O. Heggelund

Good Manufacturing Practices for Human Foods

At present there are no federal regulations which deal specifcifically with white fish filleting. "Good Manufacturing Practices" (GMP), regulations of the Food and Drug Administration, however, deals with human food processing in general; thus the regulation is also applicable to white fish processing. This chapter contains excerpts from this publication.

Personnel

The plant management shall take all reasonable measures and precautions to assure that no person affected by a communicable disease, or while a carrier of such disease, or while affected with boils, sores, infected wounds, or other abnormal sources of microbiological contamination, shall work in a food plant in any capacity in which there is a reasonable possibility of food or food ingredients becoming contaminated by such person, or of disease being transmitted by such person to other individuals.

All persons, while working in direct contact with food preparation, food ingredients, or surfaces coming into contact with the food shall:

- Wear clean outer garments, maintain a high degree of personal cleanliness, and conform to hygienic practices while on duty, to the extent necessary to prevent contamination of food products.

- Wash their hands thoroughly (and sanitize if necessary to prevent contamination by undesirable microorganism) in an adequate hand-washing facility before starting work, after each absence from the work station, and at any other time when the hands may have become soiled or contaminated.

- Remove all insecure jewelry and, during periods where food is manipulated by hand, remove from hands any jewelry that cannot be adequately sanitized.

- If gloves are used in food handling, maintain them in an intact, clean, and sanitary condition. Such gloves should be of an impermeable material except where their usage would be inappropriate or incompatible with the work involved.

- Wear hair nets, headbands, caps, or other effective hair restraints.

- Not store clothing or other personal belongings, eat food or drink beverages, or use tobacco in any form in areas where food or food ingredients are exposed or in areas used for washing equipment or utensils.

- Take any other necessary precautions to prevent contamination of foods with microorganisms or foreign substances including, but not limited to, perspiration, hair, cosmetics, tobacco, chemicals, and medicants.

Plants and Grounds

The area around a food plant shall be free from conditions which may result in the contamination of food, such as:

- Improperly stored equipment, litter, waste, refuse, and uncut weeds or grass within the immediate vicinity of the plant buildings or structures that may constitute an attractant, breeding place, or harborage for rodents, insects, and other pests.

- Excessively dusty roads, yards, or parking lots that may constitute a source of contamination in areas where food is exposed.

- Inadequately drained areas that may contribute contamination to food products through seepage or foot-borne filth and by providing a breeding place for insects or microorganisms.

Plant buildings and structures shall be suitable in size, construction, and design to facilitate maintenance and sanitary operations for food-processing purposes. The plant and facilities shall:

- Provide sufficient space for such placement of equipment and storage of materials as is necessary for sanitary operations and production of safe food.

Floors, walls, and ceilings in the plant shall be of such construction as to be adequately cleanable and shall be kept clean and in good repair. Fixtures, ducts, and pipes shall not be so suspended over working areas that drip or condensate may contaminate foods, raw materials, or food-contact surfaces. Aisles or working spaces between equipment and between equipment and walls shall be unobstructed and of sufficient width to permit employees to perform their duties without contamination of food or food-contact surfaces with clothing or personal contact.

- Provide separation by partition, location, or other effective means for those operations which may cause contamination of food products with undesirable microorganisms, chemicals, filth, or other extraneous material.

- Provide adequate lighting to hand-washing areas, dressing and locker rooms, and toilet rooms and to all areas where food or food ingredients are examined, processed, or stored and where equipment and utensils are cleaned. Light bulbs, fixtures, skylights, or other glass suspended over exposed food in any step of preparation shall be of the safety type or otherwise protected to prevent food contamination in case of breakage.

- Provide adequate ventilation or control equipment to minimize odors and noxious fumes or vapors (including steam) in areas where they may contaminate food. Such ventilation or control equipment shall not create conditions that may contribute to food contamination by airborne contaminants.

- Provide, where necessary, effective screening or other protection against birds, animals, and vermin (including, but not limited to, insects and rodents).

Sanitary Facilities and Controls

Each plant shall be equipped with adequate sanitary facilities and accommodations.

The water supply shall be sufficient for the operations intended and shall be derived from an adequate source. Any water that contacts foods or food-contact surfaces shall be safe and of adequate sanitary quality. Running water at a suitable temperature and under pressure as needed shall be provided in all areas where the processing of food, the cleaning of equipment, utensils, or containers, or employee sanitary facilities require.

Sewage disposal shall be made into an adequate sewerage system or disposed of through other adequate means.

Plumbing shall be of adequate size and design and adequately installed and maintained to:

- Carry sufficient quantities of water to required locations throughout the plant.

- Properly convey sewage and liquid disposable waste from the plant.

- Not constitute a source of contamination to foods, food products or ingredients, water supplies, equipment, or utensils or create an insanitary condition.

- Provide adequate floor drainage in all areas where floors are subject to flooding-type cleaning or where normal operations release or discharge water or other liquid waste on the floor.

Each plant shall provide its employees with adequate toilet and associated hand-washing facilities within the plant. Toilet rooms shall be furnished with toilet tissue. The facilities shall be maintained in a sanitary condition and kept in good repair at all times. Doors to toilet rooms shall be self-closing and shall not open directly into areas where food is exposed to airborne contamination except where alternate means have been taken to prevent such contamination (such as double doors, positive air-flow systems, etc.). Signs shall be posted directing employees to wash their hands with cleaning soap or detergents after using toilet.

Adequate and convenient facilities for hand washing and, where appropriate, hand sanitizing shall be provided at each location in the plant where good sanitary practices require employees to wash or sanitize and dry their hands. Such facilities shall be furnished with running water at a suitable temperature for hand washing, effective hand-cleaning and sanitizing preparations, sanitary towel service or suitable drying devices, and, where appropriate, easily cleanable waste receptacles.

Rubbish and any offal shall be so conveyed, stored, and disposed of as to minimize the development of odor, prevent waste from becoming an attractant and harborage or breeding place for vermin, and prevent contamination of food, food-contact surfaces, ground surfaces, and water supplies.

Sanitary Operations

Buildings, fixtures, and other physical facilities of the plant shall be kept in good repair and shall be maintained in a sanitary condition. Cleaning operations shall be conducted in such a manner as to minimize the danger of contamination of food and food-contact surfaces. Detergents, sanitizers, and other supplies employed in cleaning and sanitizing procedures shall be free of significant microbiological contamination and shall be safe and effective for their intended uses. Only such toxic materials as are required to maintain sanitary conditions, for use in laboratory testing procedures, for plant and equipment maintenance and operation, or in manufacturing or processing operations shall be used or stored in the plant. These materials shall be identified and used only in such manner and under conditions as will be safe for their intended uses.

No animals or birds, other than those essential as raw material, shall be allowed in any area of a food plant. Effective measures shall be taken to exclude pests from the processing areas and to protect against the contamination of foods in or on the premises by animals, birds, and vermin (including, but not limited to, rodents and insects). The use of insecticides or rodenticides is permitted only under such precautions and restrictions as will prevent the contamination of food or packaging materials with illegal residues.

All utensils and product-contact surfaces of equipment shall be cleaned as frequently as necessary to prevent contamination of food and food products. Nonproduct-contact surfaces of equipment used in the operation of food plants should be cleaned as frequently as necessary to minimize accumulation of dust, dirt, food particles, and other debris. Single-service articles (such as utensils intended for one-time use, paper cups, paper towels, etc.) should be stored in appropriate containers and handled, dispensed, used, and disposed of in a manner that prevents contamination of food or food-contact surfaces. Where necessary to prevent the introduction of undesirable microbiological organisms into food products, all utensils and product-contact surfaces of equipment used in the plant shall be cleaned and sanitized prior to such use and following any interruption during which such utensils and contact surfaces may have become contaminated. Where such equipment and utensils are used in a continuous production operation, the contact surfaces of such equipment and utensils shall be cleaned and sanitized on a predetermined schedule using adequate methods for cleaning and sanitizing. Sanitizing agents shall be effective and safe under conditions of use. Any facility, procedure, machine, or device may be acceptable for cleaning and sanitizing equipment and utensils if it is established that such facility, procedure, machine, or device will routinely render equipment and utensils clean and provide adequate sanitizing treatment.

Cleaned and sanitized portable equipment and utensils with product-contact surfaces should be stored in such a location and manner that product-contact surfaces are protected from splash, dust, and other contamination.

Equipment and Procedures

All plant equipment and utensils should be (1) suitable for their intended use, (2) so designed and of such material and workmanship as to be adequately cleanable, and (3) properly maintained. The design, construction, and use of such equipment and utensils shall preclude the adulteration of food with lubricants, fuel, metal fragments, contaminated water, or any other contaminants. All equipment should be so installed and maintained as to facilitate the cleaning of the equipment and of all adjacent spaces.

Processes and Controls

All operations in the receiving, inspecting, transporting, packaging, segregating, preparing, processing, and storing of food shall be conducted in accord with adequate sanitation principles. Overall sanitation of the plant shall be under the supervision of an individual assigned responsibility for this function. All reasonable precautions, including the following, shall be taken to assure that production procedures do not contribute contamination such as filth, harmful chemicals, undesirable microorganisms, or any other objectionable material to the processed product.

Raw material and ingredients shall be inspected and segregated as necessary to assure that they are clean, wholesome, and fit for processing into human food and shall be stored under conditions that will protect against contamination and minimize deterioration. Raw materials shall be washed or cleaned as required to remove soil or other contamination. Water used for washing, rinsing, or conveying of food products shall be of adequate quality, and water shall not be reused for washing, rinsing, or conveying products in a manner that may result in contamination of food products.

Containers and carriers of raw ingredients should be inspected on receipt to assure that their condition has not contributed to the contamination or deterioration of the products.

When ice is used in contact with food products, it shall be made from potable water and shall be used only if it has been manufactured in accordance with adequate standards and stored, transported, and handled in a sanitary manner.

Food-processing areas and equipment used for processing human food should not be used to process nonhuman food-grade animal feed or inedible products unless there is no reasonable possibility for contamination of the human food.

Processing equipment shall be maintained in a sanitary condition through frequent cleaning, including sanitization where indicated. Insofar as necessary, equipment shall be taken apart for thorough cleaning.

All food processing, including packaging and storage, should be conducted under such conditions and controls as are necessary to minimize the potential for undesirable bacterial or other microbiological growth, toxin formation, or deterioration or contamination of the processed product or ingredients. This may require careful monitoring of such physical factors as time, temperature, humidity, pressure, and flow-rate; and such processing operations as freezing, dehydration, heat processing, and refrigeration to assure that mechanical breakdowns, time delays, temperature fluctuations, and other factors do not contribute to the decomposition or contamination of the processed products.

Chemical, microbiological, or extraneous-material testing procedures shall be utilized where necessary to identify sanitation failures or food contamination, and all foods and ingredients that have become contaminated shall be rejected or treated or processed to eliminate the contamination where this may be properly accomplished.

Packaging processes and materials shall not transmit contaminants or objectionable substances to the products, shall conform to any applicable food additive regulation, and should provide adequate protection from contamination.

Meaningful coding of products sold or otherwise distributed from a manufacturing, processing, packing, or re-packing activity should be utilized to enable positive lot identification to facilitate, where necessary, the segregation of specific food lots that may have become contaminated or otherwise unfit for their intended use. Records should be retained for a period of time that exceeds the shelf life of the product, except that they need not be retained more than two years.

Storage and transportation of finished products should be under such conditions as will prevent contamination, including development of pathogenic or toxigenic microorganisms, and will protect against undesirable deterioration of the product and the container.

CHAPTER 5

SANITATION

John P. Doyle

This decade has all of us racing to keep up with technological changes, but there is still no substitute for good working conditions. Some of the most valuable assets to any industry are: a clean plant; well-lighted work areas; and capable employees who know where their tasks fit into the total work picture, who realize each job must be done well, and who understand the probability of advancement in status, rate of pay and prestige. No rule or regulation can take the place of a job well done.

Since May, 1969 when the Food and Drug Administation released the current "Good Manufacturing Practices" for manufacturers who process, hold, or pack human food, there has been an increased awareness of the need for better sanitation practices in fish plants and on fishing vessels. Some semi-related incidents have stimulated public awareness of the need for a clean-up, and the consumer is demanding a higher quality product. A more serious threat has been the implication of Salmonella food poisoning bacteria in a surprising array of food products. There is also a world-wide awareness in the fishing industry for the need for stringent quality control standards. A recent fish inspection and quality control conference sponsored by the Canadian government and the United Nations food and agriculture organizations attracted over 90 papers and was represented by more than 45 countries. At this time, it is not believed that anyone in this industry can reasonably question the need for better quality control for our fisheries products. One of the reasons fresh and frozen fishery products have not received strict attention in the past from regulatory agencies is that they have not been implicated in a disease-bearing capacity.

Why be concerned with sanitary operations? Fish are food; a fact that many plant personnel and fishermen tend to forget.

Employee Attitudes

The attitude of the employee toward plant clean-up and sanitation is one of the biggest problems facing the fish plant manager. Sometimes this poor attitude is perpetrated by plant management by turning over the clean-up job to the poorest workers, and turning it into a job of the lowest order, or by assigning an already exhausted crew to do what to them is pure drudgery. I believe a study of plant sanitation conditions would point to employee attitudes as one of the most important contributors to an unclean, unsanitary plant. The person charged with the responsibility of clean-up should be the plant foreman. The head of the clean-up crew should be paid on a level with the fish boss. The raise in the status of the clean-up crew will be reflected in a better job of cleaning. Remember, a poor attitude can negate the best sanitation technology.

What is meant by a clean plant? The plant is physically clean when all dirt, slime, blood, gurry, oil and grease are removed. It may still have a large number of bacteria on working surfaces, walls and floors. When these have been killed it is biologically clean. If a residue of detergent is left or sanitizing agent remains on working surfaces, it may get into the fish product, leaving an odor and bad taste. This, then, would be chemically unclean. The plant sanitarian's tools are: water, cleansers or detergents, the scrub brush, sanitizers, and more water, in just about that order. Detergents help to remove the dirt. Sanitizers kill bacteria. THE FUNCTIONS OF THE TWO SHOULD NOT BE CONFUSED.

Detergents

There are several types of detergents available. The best detergent for all-around use is inexpensive, approximately neutral and is biologically degradable. Purchase it in bulk. There are a number of proprietary cleaners on the market. These run the gamut from acid to alkaline. An acid cleaner will have a pH less than 7 and most generally in the neighborhood of 3, while an alkaline detergent will have a pH of over 7, generally in the neighborhood of 10.5 to 12. Look on the package for the pH of your cleansing product. A neutral product in the pH range of 6 to 8 will be less corrosive to machinery. Some detergents are chlorinated, some have corrosion inhibitors included, and some are touted as bacteriacidal. The latter claim is dubious. Jellies and foams are used to hold the detergents to the surface to be cleaned. They have their special uses as explained below.

Each of the basic types of detergent will handle some cleaning jobs better than others. Standard neutral detergents will hold the dirt and oil particles in suspension, permitting them to be washed away. Acids attack mineral deposits, and alkalis will attack fats and proteins. Chlorinated alkaline detergents are best for removing proteins (gurry which is built up on fish carts and tables). They are not sanitizers, as the alkalinity is too high to allow the chlorine to go into solution.

Sanitizing or Sterilizing Agents

The three most common sanitizing agents are chlorine, iodine, and phenols. Chlorine is used more than the other two in food processing plants. It is the least expensive and is readily available in several forms. Iodine is more expensive and not as available, but has some advantages. Phenolic compounds such as "Lysol," Creosol or Hexachlorophene should not be used in any fish processing plant, because very small quantities of phenols leave a long lasting odor and bad taste in most foodstuffs. Fish is no exception. When combined with even very small quantities of chlorine, phenolic compounds produce a very strong flavor.

Chlorine Compounds

There are two basic forms of chlorine available for plant sanitation. Gaseous chlorine is available in quantities ranging from cylinders to 30-ton tank cars. It is readily available in 150-pound cylinders, and equipment is available for feeding this directly into the plant water systems. The hypochlorite compounds are calcium hypochlorite and sodium hypochlorite. These are widely used in fish processing plants. Sodium hypochlorite is sold in liquid forms such as "Purex" or "Clorox." They are low in free chlorine, averaging about 5 percent to 6 percent. Calcium hypochlorite is available under such brand names as "HTH," "B-K," "Percloron" and others. The amount of available chlorine varies from 50 percent to 70 percent, depending on the sodium carbonate content. The higher the concentration of sodium carbonate, the lower the available chlorine.

It is very important to dilute the calcium hypochlorite to a maximum of 50 parts per million in order to obtain a low pH (see below). This is one place where the old adage of "if a little is good a lot is better" is <u>all wrong</u>.

The Germicidal Effect of Chlorine

When chlorine in a water solution comes in contact with microorganisms the cells will be killed if the concentration is high enough and the contact time is sufficiently long. According to the most generally accepted theories, the germicidal action of the chlorine compound is due to the hypochlorous acid produced when the compound is added to water. THE SPEED AT WHICH BACTERIA ARE KILLED IS DIRECTLY PROPORTIONAL TO THE CONCENTRATION OF HYPOCHLOROUS ACID.

The Advantages of Chlorine Gas

Chlorine gas is considered the best source of chlorination where large volumes of water are used. This certainly would apply to most Alaskan fish plants. The specific advantages are:

1. It is a pure substance and contains no other minerals.

2. It lowers the pH slightly, producing more hypochlorus acid.

3. It is easy to control and apply.

4. It is the least expensive source on the basis of pounds of available chlorine.

The main objection is the cost of the chlorination equipment. This cost, however, is balanced by the lower price of the product over a sufficient period of time.

Hypochlorites

Hypochlorites are the second choice because:

1. When they are added to processing water, the other chemicals such as calcium chloride and sodium chloride are produced which may have an adverse effect on the quality of the product.

2. The amount added is difficult to control.

3. They raise the alkalinity of the water and add to mineral deposits on equipment.

4. They are more sensitive to organic matter in the water and lose their germicidal powers faster.

5. They are more difficult to store, and they deteriorate on long standing.

6. They are more costly. Sodium hypochlorite is too expensive for general plant use because of the relatively low amount of free chlorine. It is,

however, ideal for boat use, as fishermen tend to use a too-high concentration of the other types of hypochlorites. There is a general tendency in the plants to use too high a concentration of products such as "HTH" or "Percloron." These products are highly alkaline; in other words, they have a high pH. At a concentration of 25 parts per million calcium hypochlorite, the pH is 9.35. At 100 ppm, the solution has a pH of 9.75, and at 1,000 ppm yields a pH of 11.10. At these high levels, the amount of free chlorine produced is greatly reduced, and very little hypochlorous acid is available to attack the organisms. Table 5-A shows the relative efficiency of the three chlorine compounds.

Concentrations of 5 ppm available free chlorine should be present in processing waters. This concentration will not produce an off-flavor in fish products. For sanitizing equipment and surfaces after cleansing, the concentration should be increased to 25 to 50 ppm with a residual of free chlorine content not under 25 ppm at the washing end of the water line. This concentration is high enough to kill exposed bacteria in a very short time. Do not use a sanitizing agent in place of cleansers. Remember, exposed bacteria would be killed. If deposits of slime and gurry are left on machinery or working surfaces, the chlorine will react with the protein producing chloramines, which have a very slow germicidal activity. As a result, very little chlorine will be available to kill spoilage bacteria.

Instructions to Clean-up Crews

A word is necessary about water use. It is a good idea to conserve water. Shovel up the gurry, blood, etc., before wash down. Cleansers are more effective when used with warm water--120° to 140° F is ideal. The one drawback to using warm water is that it will raise the temperature of the surface on which the bacteria live, increasing their growth rate astronomically. Use steam sparingly, if at all. It may be necessary in limited areas to use steam to remove fats and oils. Steam is sometimes necessary to remove the thick oil and fat deposits left by salmon egg processing.

Rinsing and sanitizing should be done with cold water to cool the contact surface heated by the warm water wash. Thus, remaining bacteria will have less chance to grow and multiply.

TABLE 5-A

RELATIVE KILLING POWER OF HYPOCHLORITES AND GASEOUS CHLORINE

Chlorine Compound	Total Free Chlorine ppm	pH*	Time Required to Kill 99.9% of Cells
Chlorine gas	5 ppm	7.0	1 minute
Calcium hypochlorite	5 ppm	7.4	2 minutes
Sodium hypochlorite	5 ppm	7.6	2.5 minutes

* pH of untreated water was 7.2

Suggested Periodic Cleaning Schedule

I. Before the season starts:

A. Require thorough cleaning of all machinery, tanks, tables, floors, walls and ceilings to remove dirt and bacteria-bearing dust.

B. Sanitize all working surfaces with 25 ppm chlorine solution.

II. Continuous cleaning:

A. Tables, floors and other working surfaces should be sloped to effect continuous draining to prevent standing water which builds up bacteria populations.

B. Rinse each cart or tub each time it is emptied.

III. Morning clean-up:

Before operations start for the day, rinse all working surfaces with cold water containing approximately 5 to 10 ppm residual free chlorine, as a precaution to remove any cleanser and sanitizing agent left from the previous clean-up.

IV. Each coffee or rest break:

A. As practical, run all fish that have come on to the line through processing steps.

B. Remove all static material from working surfaces; in other words, bits of fish, gurry, etc.

C. To remove all slime and blood, flush and rinse all working surfaces with water containing 5 ppm residual free chlorine.

D. Shovel all waste from the floor.

V. Lunch break:

A. Clear line of all fish.

B. Remove all gurry from the working surfaces.

C. Shovel all waste from floor.

D. Drain all washing tanks.

E. Rinse all working surfaces, wash tanks, tubs, carts, and floor with high-pressure hose, using 25 ppm free chlorine solution to cut slime and lower bacterial count.

F. At end of lunch break, flush all surfaces with 5 ppm free chlorine solution to clean away all excess chlorine.

VI. End of day clean-up:

Repeat items A through D above.

E. Rinse all working surfaces with cold water containing 25 ppm chlorine.

F. Remove cowlings to expose all machinery that comes in contact with the fish.

G. Scrub all working areas with cleanser and scrub brush, or a high pressure detergent dispenser.

H. Scrub all cutting boards and place in a tank containing 100 ppm chlorine solution (to kill all bacteria in the wood grain it is almost necessary to place cutting boards in a retort and give them a cook).

I. Rinse all areas with stronger chlorine solution of 30 to 50 ppm. Allow 10 minutes contact time.

J. Scrub down floors and walls. A large floor broom with stiff bristles is effective for this.

K. Rinse all surfaces with clean water or 5 ppm chlorine solution. This low level of chlorine will prevent corrosion of metal surfaces.

VII. End of week:

In certain areas and on equipment, fish carts and chutes, a hard dried deposit tends to build up. This is the place where jelly or foam additives in harsh detergents may be useful. This is difficult to remove by using ordinary detergents and a scrub brush. By using the techniques outlined above, this dried-on material should be held to a minimum. If the problem does arise, strong detergents mixed with a jelly or foam suspension will help considerably. The jelly or foam will hold the detergent to the surface. Remember, alkali detergents attack oil and proteins.

Procedures on use:

A. Rinse away all loose material, mix chemicals in the tank following manufacturer's recommendations.

B. Spray all hard-to-clean areas and other surfaces which have a heavy deposit of static material.

C. Let stand 30 minutes to an hour, then rinse thoroughly. Strong alkali detergents will corrode metal surfaces.

D. It may be necessary to use an acid detergent once a month or several times during a season. Acid detergents will remove the mineral deposits. Do not use acid detergents on concrete floors, as acid will pit the concrete.

Personal Hygiene

This is perhaps the area of the greatest contamination. Some of the basic steps which you might post on the bulletin board in your plant are:

1. All long hair should be confined by hair nets.
2. Beards should be confined by snoods or hair nets.
3. Wash hands before going to place on fish line. Use a bacteriacidal soap in the washroom.
4. Have a dip pan with a sanitizing agent outside washroom door. All personnel should dip their hands in the solution after each trip to the washroom or after each break. In this case, an iodine solution is best, as it will change color on becoming inactive.

5. Have pans with iodine solution available for all workers wearing gloves. Gloves should be washed in clean water at the beginning of each break, and placed in the sanitizing solution during break. This solution will need to be changed after each break. The use of knit polypropylene gloves is recommended, as polypropylene is easy to clean and will not support bacterial growth.

It would be well for the foreman to come in and do the initial morning spraydown. This should assure a good job and give him a chance to pick up any trouble spots in the clean-up. Crews should be staggered so that one or two people clean up during the break rather than an inefficient job done by the whole crew.

The above outlined procedures will cost in equipment and labor, but can result in an overall economy of operation. Manpower is the most expensive element involved. A small crew trained to do the job will be much more economically efficient than what may be your present system of everyone "pitching in" and giving a hand. You will also have a cleaner plant, improved product and better working climate for all concerned.

Suggested Additional Reading

Cleaning and Sanitizing Agents for Seafood Processing Plants, by Jong Lee. S.G. No. 21, April 1973, Oregon State University Extension Service, Marine Advisory Program.

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Laboratory Manual for Food Canners and Processors, 1968 by National Canners Association, The AVI Publishing Co., Inc., Westport, Conn., Vol. 2, Chapters 16, 17, 18.

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PART III

CLASSIFICATION OF RAW MATERIAL

CHAPTER 6

INTRINSIC QUALITY

Per O. Heggelund

Introduction

As seafood processors, our overruling assumption is that fish is food which is to be consumed by human beings. This assumption implies that our raw material, and eventually the products, should be of a wholesome quality. What constitutes quality rests ultimately with the fish eater--the consumer.

Quality parameters based on the consumer's preferences, or simple dictionary definitions, all fall short of giving us a working tool. Consumers' preferences change constantly; dictionary definitions, like "Degree or grade of excellence or grade of goodness," are both too static and general. We, therefore, have had to impose our own quality standards based on the marketplace, the nature of our raw material, and available technology.

In the most general terms, seafood can be categorized according to its pre-harvest and post-mortem quality. Schematically, seafood quality can be further specified in terms of the time continuum shown in Figure 6-A.

In the seafood industry, we have primarily been concerned with post-mortem quality control. The reasons for this emphasis are:

1. Most fish is caught in the wild, making it difficult to control or manipulate the quality of the harvest.

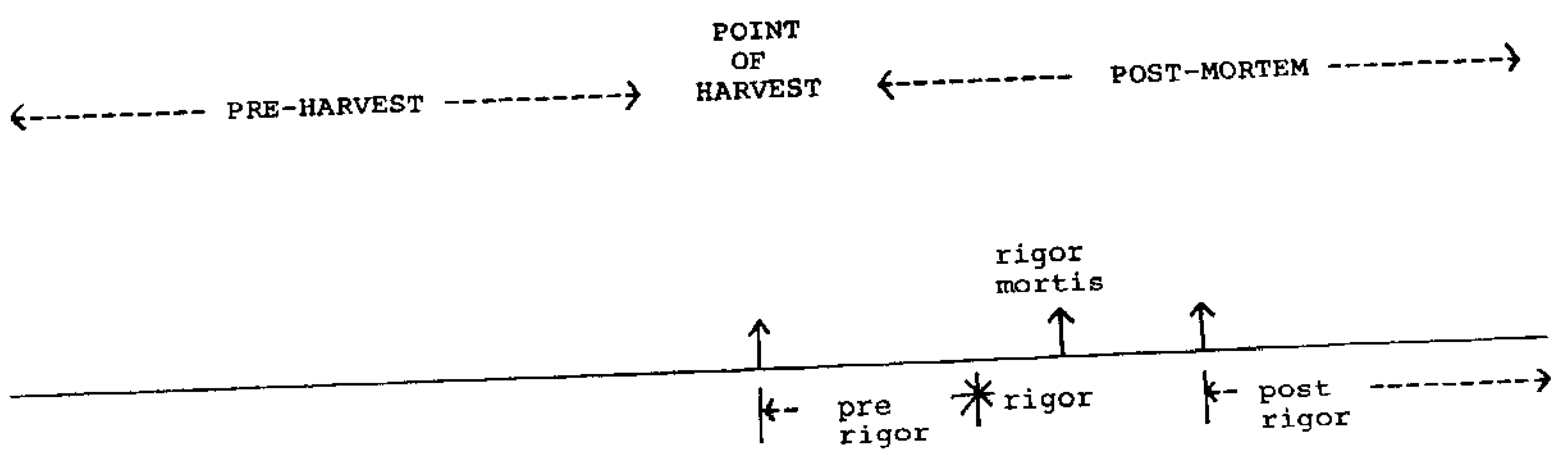
2. Fish spoils more rapidly after death than most foods, and thus has demanded most of our attention.

The development in other food industries may indicate the evolution which also will occur in the seafood industry. The red meat and poultry industries, for example, stress the characteristics of the meat at the time of slaughter in determining the grade or quality according to:

1. color
2. texture of muscles
3. fat and protein composition.

FIGURE 6-A

TIME CONTINUUM FOR CHANGING SEAFOOD QUALITY



These quality characteristics are controlled by special feed rations, and post-mortem deteriorations are seldom encountered to the degree often seen in the seafood industry.

The seafood is not at this point yet, due to our inability to control the environment of most fish, and the failure of fishery management to base the harvesting seasons on the pre-harvest quality of the raw material. "Fresh fish" quality grading, therefore, is based entirely on the extent of post-mortem deterioration.

This is unfortunate. We now overlook other important factors that should be considered when judging quality of fish. However, as we gradually improve our methods for controlling post-mortem deterioration, we will become increasingly aware that the "other" quality parameters, reflecting, for example, the physical conditions of fish at the time of death, are important.

A similar sequence of events has occurred in the dairy industry. Bacterial deterioration was long the main quality problem in this industry. With improved sanitation, pasteurization, and refrigeration, the bacterial problem was reduced and the shelf life extended.

Despite the extended shelf life, new problems arose. During storage, the milk tended to develop cardboard flavors. Previously, these flavors were masked by the by-products of bacterial deterioration in dairy products.

Similar to the dairy industry, reducing bacterial or post-mortem spoilage of seafood will result in:

1. conditions permitting other types of deteriorations to predominate

2. focus attention on the difference in quality resulting from physical conditions of the fish.

Despite the fact that today's seafood technology is primarily concerned with the treatment of dead fish, it should always be remembered that before fish can be dead, it must be alive! What happened to it in life will always affect its final quality, how it keeps, and its suitability for processing.

This suitability for processing is reflected in the intrinsic quality of the fish, which is the sum of attributes that are inherent in the harvested raw material (Connell, 1975). The objective of this chapter is to specifically address the factors that affect the intrinsic quality of fish.

Cod--A Typical White Fish

Cod may be taken as an example of a typical white fish. It is torpedo-shaped, with a transparent slimy skin covering the scales (see Figure 6-B). It has three vertical fins along the back (the dorsal fins), and two beneath the tail behind the vent (the anal fins). In addition, it has a pair of pectoral fins and a pair of pelvic fins. The main function of all these fins is to act as stabilizers and brakes, and not for forward motion. The tail most commonly propels the fish. The tail is not just the tail fin, but rather the whole body behind the vent. A third of the weight of a cod fillet is therefore tail muscle (Burgess et al., 1967).

The whole muscle system of a cod is attached to a bony skeleton. The skeleton or fish bones are frequently a nuisance to the consumer and processors who remove these during filleting. In white fish, like cod, the so-called dorsal ribs (pinbones) are often allowed to remain, in order to prevent a five percent loss in yield and a peculiar-looking fillet (Burgess et al., 1967).

Table 6-A gives some information on the proportions of some of the different parts of a white fish. Species having a large head, such as lingcod, give much lower yields of dressed fish than fish having smaller heads, for example, salmon. Dressed fish averages about 73 percent flesh, 21 percent bone, and 6 percent skin.

Fillet yields from white fish depend on the species being processed, and varies between 20 and 30 percent based on whole fish. When steaks are cut from whole fish, the yield is between 65 and 70 percent (Stansby, 1963).

Living in the Sea Presents Its Problems

The life cycle of most fish species is very dependent on the available food supply. When food is available, a fish will gorge itself; when it is not, it starves. The fish may have to make an annual fast either because food is not available, or because they cannot hunt during the long Arctic night.

Starvation periods may also follow the spawning cycle. The roe of salmon, for example, grows to such a size that it is doubtful whether the fish could absorb any food, even if it were available. Thus, toward the spawning cycle, the flesh becomes too soft for a prime smoked product or even for the fresh market.

Soft flesh may also occur in an active, feeding fish. The stomach contains microscopic glands that excrete digestive

FIGURE 6-B

DIAGRAM OF A COD

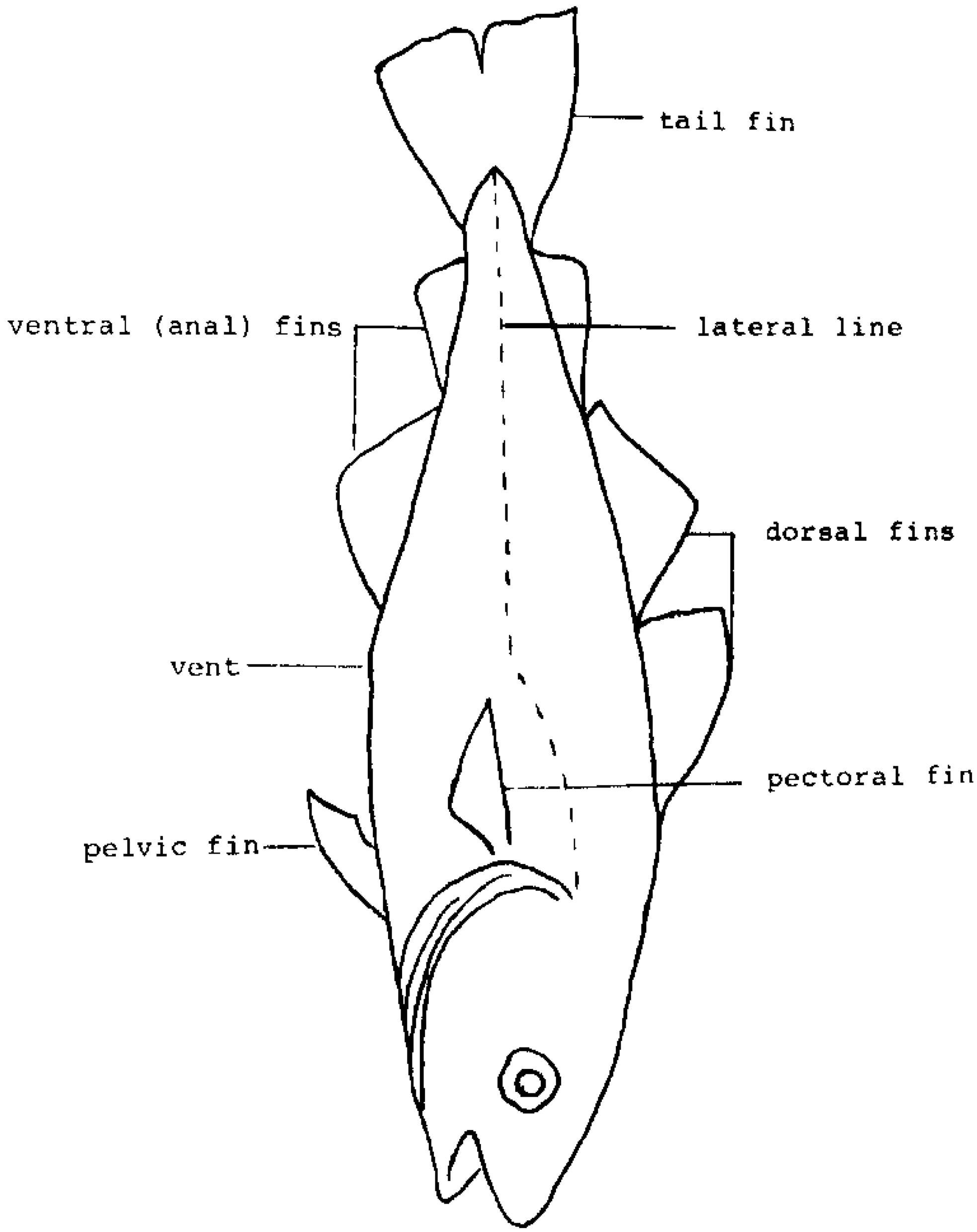


TABLE 6-A

YIELD FROM SEVERAL SPECIES OF FISH

Species	Dressed Fish	Liver	Viscera Less Liver	Other Trimmings
	%	%	%	%
"Average" species	65	2	8	25
Flounder	67	1	7	25
Lingcod	54	1	8	37
Sockeye salmon	73	2	6	19

Source: Stansby, 1963

enzymes. After the death of the fish, enzymes in the stomach, and also the intestines, leech out and digest any of the proteins of the flesh. This fact explains why so-called feeding herring rapidly become soft or broken.

Living in the sea presents problems other than just obtaining food. The fish are also continually subjected to a strain produced by the difference in strength of the salt solution of the blood and the stronger salt solution of the sea. There is always a tendency for water to be lost from the body at a greater rate than it can be replaced, thereby increasing the concentration of salts in the blood. To solve this problem, marine fish have evolved a special system of cells on the gills, the chloride cells, whose function it is to continually remove part of the salt from the blood. The blood otherwise would become as salt as the sea itself.

To further deal with this particular problem, some specific biochemical solutions have evolved. The cartilaginous fishes, for example, produce trimethylamine oxide, ammonia, and urea in order to equalize the osmotic difference. Urea can be tolerated in quite high concentrations and the sharks, dog-fishes, skates and rays have as much as 2 to 5 percent in the blood and tissues. The fish of this group, therefore, tend to gain water from the sea. Excess water, however, is much more easily removed than excess salt (Burgess et al., 1967).

Fish is also sensitive to temperature. The body temperature of birds and mammals is rather finely controlled; in contrast, the body temperature of fish is not controlled, but related to that of the surrounding water. Thus the fish could have a tendency to become immobilized if the temperature became too cold. In order to deal with this particular problem, most Arctic fish species have "antifreeze" compounds in the blood, and the lipids are highly unsaturated.

Conditions and Composition

It has long been known that in all species of fish, seasonal changes in certain bodily characteristics occur. Fish may appear thinner, flabbier, and less lively at certain times. The flesh may also become watery or softer and contain less protein and fat, which results in both poor sales appeal and lower processing yields.

Poor condition commonly occurs post-spawning, which for many Arctic species is in the spring. Just before spawning and during it, food reserves in the flesh or the liver are transferred for the development of the gonads. In addition, during and after spawning, most fish do not feed. As a result, the flesh becomes severely depleted of protein, carbohydrate and fat. When fish begin feeding again, the normal good condition is quickly recovered (Connell, 1975).

Jelly Consistency

Cooked white fish often has a soft, gelatinous or sloppy consistency. This jelly-like consistency has been observed in extreme cases in halibut, rockfish, arrow tooth flounder, and American plaice.

Large American plaice particularly develop this inferior textural consistency. These large fish are females over 60 cm. The fillets are jelly-like and quiver when touched; they are glossy and opalescent. The moisture content also is four percent higher than normally observed. This increase is made at the expense of the protein, which decreases by about 30 percent of its own normal value (Poulsen, 1979).

A study carried out from 1948 to 1954 regarding the jellied conditions in American plaice showed a large degree of incidence on the Grand Bank. Table 6-B shows that the larger specimens had a higher incidence of "jelly fish." It was also found in this study that in warmer and deeper waters, fewer incidents of jelly consistency occurred among the larger fish.

It has been theorized that jellied conditions may appear because of protein impoverishment following the spawning cycle. Fish living in very cold water, in particular, fail to compensate for the loss of flesh protein due to sexual maturity. As the protein of the flesh declines, water is absorbed to replace it. This theory is supported by the fact that jellied conditions are at a minimum from January to March, prior to spawning. The remaining nine months the instances of jellied conditions seem to be rather constant.

Over the last ten years, the instances of jellied American plaice has shown a declining trend. The grounds are less populated, and the average size of the harvested plaice has decreased. Both facts seem to have caused the reduction in jellied plaice harvested by trawler on the Grand Bank (Poulsen, 1979).

Changes in Fat Content

Fatty fish, like sardines, sprat, herrings, mackerels and anchovies have very marked quality changes. The fat content

TABLE 6-B

DISTRIBUTION OF JELLY FLESH CONSISTENCY
AMONG AMERICAN PLAICE

Length in cm	% of Jelly Fish
32-35	0
36-39	0
40-43	0
44-47	5
48-51	2
52-55	9
56-59	17
60-63	27
64-67	35
68-77	67

Source: Poulsen, 1979

of herring flesh, for example, can vary from 4 to over 18 percent between the starvation period after spawning and the height of the feeding period (Figure 6-C). During this whole period, the weight is kept constant by a reduction in the flesh's moisture content. Canned and kippered herring, for example, both depend on a high fat content in the flesh in order to produce the best product. Herring harvested after spawning are, therefore, unacceptable as raw material for these specialty products.

Gaping

Gaping is a tendency of fillets, particularly those cut from thawed whole frozen fish, to split into fissures and holes (Connell, 1975). It has been observed in the United Kingdom that at certain times of the year void-free blocks of cod fillets are difficult to produce. The exact cause of this problem has yet to be identified. One observation, however, is that cod in poor condition, with high flesh pH, gapes less than those in good condition with low pH (Connell, 1975).

Chalkiness

Halibut has one specific quality problem known as "chalkiness." The flesh, when stored on ice, tends to develop a white and dull appearance. This particular problem is mostly associated with fish that has a pH below 6. The low pH, it is thought, is brought about because the live fish had high glycogen content from heavy feeding (Connell, 1975).

Pacific halibut and yellowtail on the Nova Scotian Banks are quite often affected by the "chalky" phenomenon. In chalky yellowtail, the flesh is whiter and gritty (that is, not flaky), and after boiling, the flesh loses its characteristic fiber structure. With increasing chalkiness, the fish has a lower percentage of water and higher percentage of protein. In relation to water and protein content, this phenomenon is apparently the opposite of the jellied condition in the American plaice (Poulsen, 1979). The chalky phenomenon is more distinct in the larger fish than in the smaller. In some cases, as much as 80 percent of a trawler load is chalky or semi-chalky.

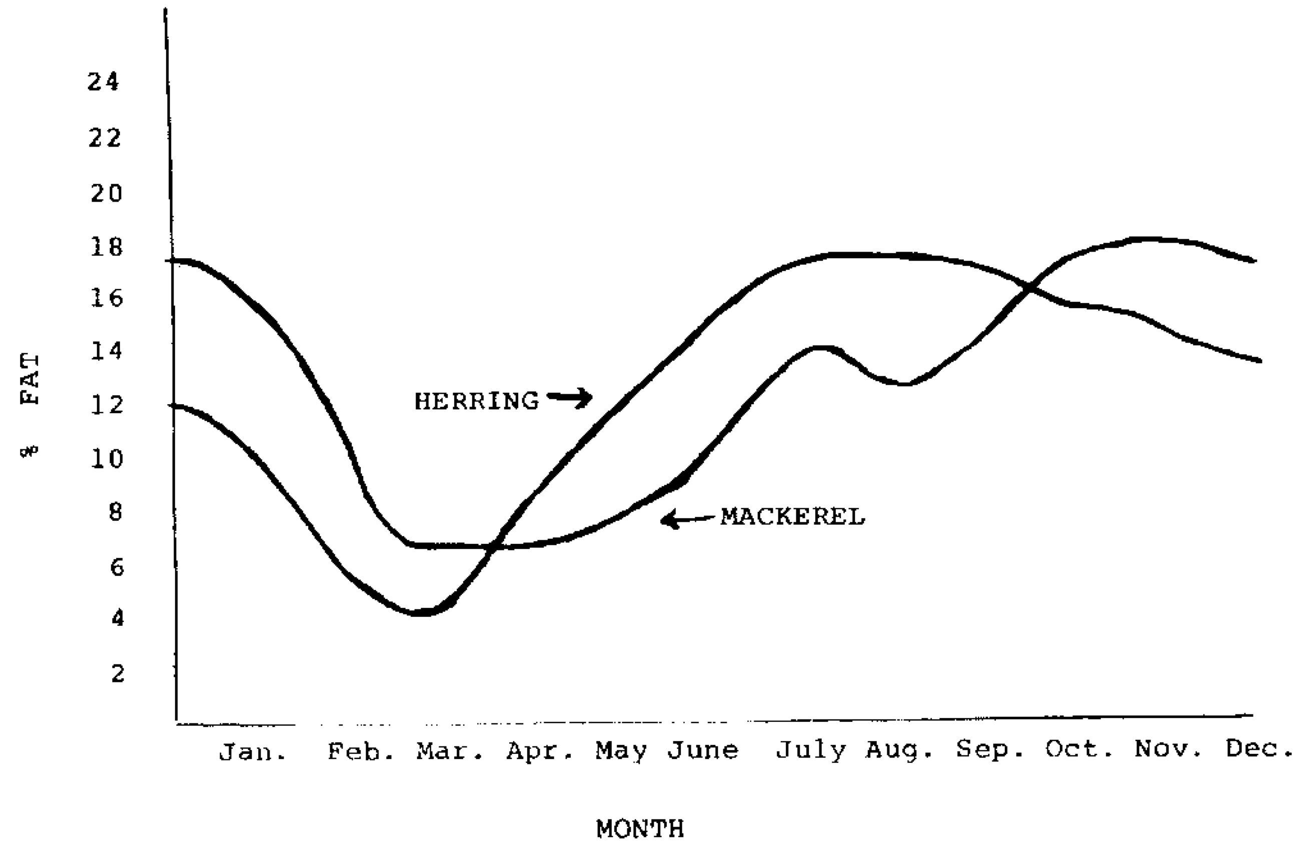
The chalky and semi-chalky fillets are not accepted by most plants, and basically only two Nova Scotian plants allow their trawlers to fish for yellowtail.

Other Changes

Differences in intrinsic composition can have a significant effect on quality. Lean fish in poor condition spoils more

FIGURE 6-C

CHANGES IN FAT CONTENT



Source: Connell, 1975

rapidly than the same in good condition, even if adequate refrigeration is used. The reason may be related to the fact that the pH of lean fish is high due to a low glycogen content, thereby reducing the amount of lactic acid produced pre-rigor (Connell, 1975).

Low pH of cod flesh also affects the shelf life of frozen fillets. Fillets with low pH tend to toughen more rapidly. Similarly, "honeycombing," a specific textural defect of canned tuna, has been related to an exceptionally low pH of the flesh.

These particular problems and others related to intrinsic quality tend to vary with fishing grounds and spawning times. Mackerel, for example, when harvested on the same ground, may contain fish which spawn at different times of the year. In addition, fish harvested by vessels fishing several grounds may vary in intrinsic quality. Thus the lowering of intrinsic quality, partly made possible through the increase in the production of frozen seafood, has dramatically changed the old rule that a particular fishing season was timed for the prime fish (Connell, 1975).

Implementation of an adequate quality control program directed toward solving of intrinsic quality problems can be achieved by proper geographical and seasonal management and inplant grading procedures. In Norway, for example, a seasonal limitation is placed on the sprat fishery in order to ensure that the best quality raw material is used for canning. In addition, when catches of varying condition are landed, the catch should be graded according to specific markets.

Parasites and Other Organisms

A parasite is an organism which sustains its life by depending directly upon another organism for its nutritional needs. Fish, like all other animals, are liable to be infected by parasites. Because infected fish should not reach the consumer, this section will discuss the major types of fish parasites and how they may be recognized.

Fortunately, few parasites found in fish are harmful. The few that may cause diseases in humans are only found in tropical areas, and thus are of minor concern to us. Nevertheless, the average consumer does not know this fact, and may react negatively to the product if it contains parasites. It is therefore in our best interest that all parasites be removed before the product reaches the consumer.

Parasites are sometimes difficult to identify. Even within one group, for example the roundworms, the symptoms vary to such a large degree that exact identification of the species of parasite is difficult. Nevertheless, quality control personnel should be aware of the common identification procedure in order to recognize the parasites during routine quality control inspections.

Protozoa

Protozoa are microscopic, one-celled organisms. They are free living and harmless, but a few cause disease in humans and animals. Protozoal infections most often occur in the flesh, and may result in a softening of the flesh. Lesions on the skin can also be traced to protozal infections. For aquaculturists this problem is quite serious.

Protozoal infection caused by the Myxosporidian (Chloromyscium thyrsites) is probably most commonly encountered in the seafood industry. This organism occurs in a number of species of fish, including Atlantic hake. In hake, immediately after capture, the Myxosporidian is difficult to detect. After the fish has been stored in ice for a few days, however, the infected flesh becomes soft (toothpaste-like), due to the proteolytic enzymes produced by the parasite. "Milky hake" is the common description of this occurrence (Connell, 1975).

Flatworms (Platyhelminths)

Among flatworms, the flukes and tapeworms are of most concern to the seafood processor.

Adult tapeworms and flukes found in fish occur mostly in the gut and are therefore removed with the viscera. Larval tapeworms may, however, be found in the flesh of, for example, halibut. Of the flukes, the small and harmless larva of Crytocotyle lingua, which exists as a dark colored cyst on the skin of gadoids, herring, and mackerel, is most common. This larva produces a peppered effect of dark spots which is removed with the skinning.

One important disease in humans is caused by eating the live cysts of one special type of flatworm, the broad tapeworm, Diphyllobothrium latum. This tapeworm has been common in some European countries. The adult worm is found in the human intestine, while fish act as intermediate hosts. These include salmon, trout, pike and perch (Connell, 1975).

Roundworms (Nematodes)

Nematodes are found in the gut or viscera, or encysted in the flesh of most gadoid species. The encysted form is of most concern to the processor, since it is difficult both to see and to remove. The best example is the cod worm (Porrocaecum (Terranova) decipiens), which can be recognized by its yellow coiled larval stage. The level of incidence of the larva has partly been found to relate to the seal population which contain the adult nematode.

Fish nematodes generally are harmless, but Anisakis larvae may, if eaten live, cause serious inflammation of the stomach. Cases have been traced to herring in Europe and to squid in Japan.

Nematodes cannot survive prolonged freezing and cold storage. Norwegian, Dutch and Japanese regulations therefore require certain types of fish product which are eaten raw to be frozen and stored at -20°C for at least 24 hours before being released for sale (Connell, 1975).

Control Measures

Control of parasites in nature can be achieved by:

1. Reducing the numbers of previous hosts, for example seals, in the case of "cod worm" parasite.

2. Avoiding fishing areas known to yield heavily infested fish.

3. Grading or examination of the catch.

In modern filleting operations, the examination for parasites is carried out during the candling and trimming operations. The fillets are placed on a translucent surface illuminated from below. The parasites are removed either by using the knife point or, in heavily infested areas, simply by trimming the area off the fillet. The procedure is necessary since stringent customer or statutory regulations may specify limits of parasites per unit weight.

Proximate Composition

The proximate composition of fish varies widely. Table 6-C, however, gives the general range in values for proximate composition for fish. The extreme values for the moisture, protein, and ash of fish vary by only three to five times. In contrast, oil may show a 300-fold variation. Even within the same species of fish, the oil content of one individual may

TABLE 6-C

PROXIMATE COMPOSITION OF EDIBLE PORTION OF FISH

Statistic Calculated	Moisture	Protein	Oil	Ash
	%	%	%	%
Average	74.8	19	5	1.2
Range	28-90	6-28	0.2-64	0.4-1.5
Ratio high to low	3.2	4.7	320	3.8

Source: Stansby, 1963

be more than ten times greater than that of another. These individual variations have been found to correlate with fishing seasons and geographical area, or with age, sex, and size of the fish. In addition, feed intake and degree of energy expenditure seem to govern the proximate composition of most fish. For example, salmon caught during the late summer and fall have much lower oil content than those taken during the spring (Stansby, 1963).

The wide variation in the proximate composition of fish preclude average values as a practical tool. A better tool is to classify various species according to well-defined categories as shown in Table 6-D.

Category A characterizes fish by a high protein content between 15 and 20 percent, and a low oil content below 5 percent. Many species in category A have oil contents near the low limit of this range; that is, 1 or 2 percent.

Category B is the second most common type, where the fish retain high protein of 15 to 20 percent, but a medium oil content in the range of 5 to 15 percent.

Category C represents a much less common type of fish, having a high oil content, over 15 percent. When the oil content is high, usually the protein content is below 15 percent.

Fish in category D have low oil content, below 5 percent, and a high protein content, over 20 percent. Although not many species fall into category D, the ones that do, that is, tuna and halibut, are quite important commercially.

Water

Similar to most living organisms, the principal component of fish is water, accounting for as much as 80 percent of the edible flesh in lean fish. In fatty fish the moisture content drops and is replaced by oil so that the sum of the two is close to 80 percent.

The moisture in fish tissue is held tightly by colloidal as well as chemical forces. This water retention of fish flesh is greatest in freshly caught fish. Freezing and refrigeration of fish both result in reduced water retention.

When a fish is being frozen, the water in the fish does not start to freeze at 32°F, but rather at about 30.5°F. As the temperature is lowered, more water freezes. Even at 22°F only about 70 percent of the water is frozen (Stansby, 1963).

TABLE 6-D

TYPES OF FISH

Category	Type	Oil Content %	Protein Content %	Prototype
A	Low oil-high protein	under 5	15-20	Cod
B	Medium oil-high protein	5-15	15-20	Sockeye salmon
C	High oil-low protein	over 15	under 15	Siscowet lake trout
D	Low oil-very high protein	under 5	over 20	Skipjack tuna
E	Low oil-low protein	under 5	under 15	Clams

Source: Stansby, 1963

Protein

The nutritional value of fish is based on its protein content. Proteins, as very large molecules, are made up of amino acids, nine of which are essential to human survival. Fish contain all these amino acids.

The protein content of healthy fish flesh is about 16 to 18 percent. Functionally, the proteins can be classified according to their solubilities. Water-soluble proteins, albumins, represent 10 to 20 percent of the proteins of fish muscle. Salt-soluble protein, globulins, make up the remaining 70 to 90 percent. It is therefore possible to dissolve almost all fish muscle with the proper combination of salts and water (Stansby, 1963).

When fish is cooked, the protein becomes denatured and loses its solubility. Loss of solubility in salt solutions is responsible for failure to obtain a nice surface gloss on a smoked fish from a badly cold-stored article. The gloss is due to a dried film of extracted protein. From the nutritional point of view, however, protein denaturation of this kind does not matter (Burgess et al., 1967).

Fat

Fat or lipids are used biochemically as a means of storing excess body fuel. If a fish consumes more food than it requires to satisfy its immediate needs for energy, it will deposit the surplus as fat. In turn, when the total food intake is less than required for energy expenditure, some of the tissue fat is used to satisfy the energy requirements.

Different species of fish deposit their fat in quite different tissues. The very oily livers of the fish of the cod family are a good example. Almost the total fat of the gadoid family is stored in the liver, and the flesh contains mere traces. Thus there is no margin for significant fluctuations in the fat content of the flesh, although marked variations occur in the amount of fat in the liver. Other fish deposit part of the total fat in the body tissues and part in the liver or other organs. Halibut, for example, deposits most of it in the head and body tissues, but appreciable amounts do go into the liver. In the herring almost all of the fat is present in the head and body tissues (Burgess et al., 1967).

The fat content of the body tissue is what counts from a practical point of view. In the case of herring, this can be as low as 3 to 5 percent, reached about April. In May and June, when the herring start to feed, the fat content may rise to over 20 percent. Subsequently, during summer and autumn, the fat content declines as feeding activities slow down. Then when the spawning period begins, the fall becomes much more rapid.

Despite the cycling variations of the fat content, the water and fat content stay constant at about 80 percent. This fact implies that when a fish deposits fat in its flesh, this fat replaces an equivalent amount of water. Likewise, when the fish draws on its reserves of flesh fat, water replaces the fat withdrawn.

Minor Component - Nitrogenous Bases

Nitrogenous bases are related chemically to ammonia. For the seafood technologists, trimethylamine oxide and urea are the most important. These compounds are colorless solids, with hardly any smell. This situation changes when bacteria start to grow on fish. The enzymes produced by the bacteria convert trimethylamine oxide into trimethylamine itself and urea into ammonia, both of which have a very strong odor.

Both trimethylamine oxide and urea are present in relatively large concentrations in sharks, dogfish, rays and skates. In other marine species, trimethylamine oxide is also abundant, while only traces of urea exist. Freshwater fish contain much less trimethylamine oxide than do marine fish, but even a little free trimethylamine can produce a strong odor. In fact, while trimethylamine in high concentrations smells like ammonia, in very low concentrations it smells like bad fish (Burgess et al., 1967).

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PART III

Chapter 6

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PART IV

HANDLING OF RAW MATERIAL

CHAPTER 7

POST-MORTEM CHANGES IN FISH

Max Andersen

"Daughters and dead fish are no keeping wares" is an old English proverb. This chapter, though, refers to fish only, which are well known for their quick rendering of "freshness." Fish are normally evaluated as perishable goods.

Table 7-A shows an evaluation scheme that is used in the European Common Market. It gives the most important organoleptic changes in fresh, gutted fish.

Fish which are landed and buffer-stored ungutted often emit an off-odor from the belly cavity long before the meat becomes tainted.

Belly-burst caused by internal digesting processes in fish which have fed heavily, in some cases, occurs only a few hours after death.

The organoleptic changes in the fish can also be evaluated by examining a boiled sample of fish flesh. The fresh, seaweedy, sweet, delicate odor that is found in the newly caught fish disappears rapidly (Phase 1). After a stage without any characteristic odor and taste (Phase 2) the fish becomes clearly questionable (Phase 3), starting with a slight sour or fruity taste and smell. Later on, it smells and tastes of ammonia and, lastly, it becomes putrified (Phase 4).

The evaluation scale changes in favor of a 10-grade scale, with 10 showing the ideal taste, 8 still being a good quality, while 6 is given to the fish without taste and smell. The limit for edible fish is 4.

From this graduation one can plot a curve of quality versus time to know how long it takes a fish to become putrified under different storing methods. The graph for ice-stored cod (32°F) will show up almost as in Figure 7-A.

Biochemical Changes

For a short period after the fish has died, the muscle cells will continue the normal physiological processes. The

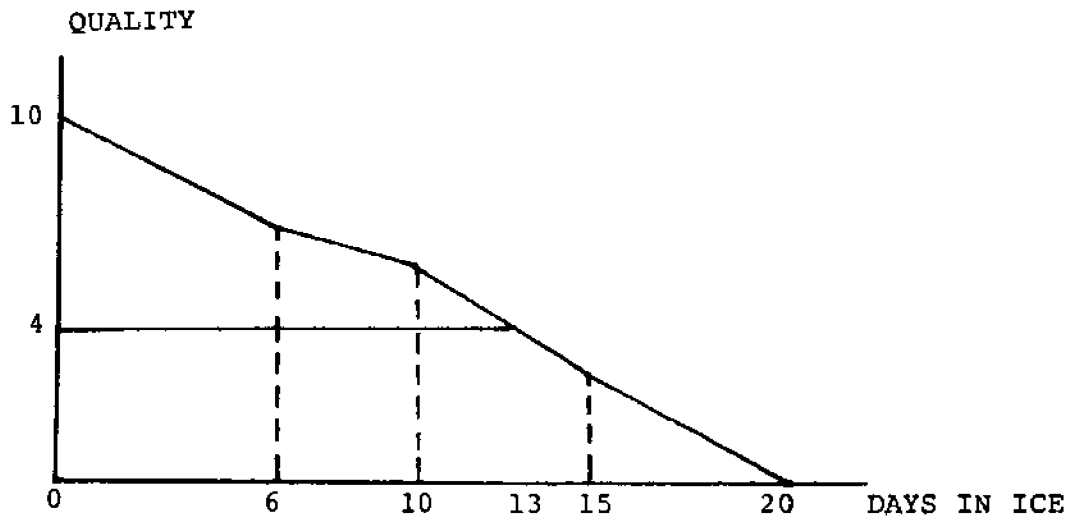
TABLE 7-A

SCORING SYSTEM FOR ORGANOLEPTIC ASSESSMENT OF RAW AND COOKED WHITE FISH FILLETS

Odor/Flavor	Appearance	Quality Score
Very fresh, seaweedy, specific for the species	Firm and white	10
Fresh, specific for the species	Firm, no discoloration	8
Loss of odor/flavor neutral, no off-odors	Firm, few discolorations accepted	6
Slight off-odors	Soft, severe discoloration	5-4
Severe off-odors, putrid	Soft, discolored	3-0

Figure 7-A

ORGANOLEPTIC CHANGES IN SPOILING COD



Phase	1	0 - 6 days	:	no marked spoilage
"	2	7 -10 "	:	lack of odor/flavor
"	3	11 -14 "	:	some sourness, slightly sweet to fruity odor/flavor
"	4	14 "	:	H_2S and other sulphidy odors, fécal, strong ammoniacal odors/ flavor

normal level of adenosine triphosphate (ATP) is maintained by phosphorylation of adenosine diphosphate (ADP); energy for this process is created by breaking down phosphocreatine and by anaerobe glycolysis of glycogen. Lactic acid is created by this process. The function of ATP is that of a plasticizer forming a cushion between the muscle filaments. When the normal ATP-level can no longer be maintained, the structural proteins of the muscle cell (myosin, actin) will form very strong cross-bridges causing the muscle to contract like telescopes. The muscle changes from being soft and flexible to being hard and rigid. This state is described as rigor mortis.

When rigor mortis sets in, the lactic acid causes the pH in the muscle to drop from 7.0-7.2 to about 6.2-6.5. The low content of glycogen in the fish muscle (< 0.5%) causes a high post mortal pH compared to the mammalian muscle. The duration of rigor mortis greatly depends on the condition of the fish when caught, where it is caught, and how. In starved and exhausted fish and fish stored at high temperatures, the onset of rigor mortis is quick, with only a slight drop in pH in the meat. Differences according to species are very pronounced; small, highly active fish--for example, mackerel and herring--pass through rigor quickly while the opposite occurs in flatfish.

The breakdown of the nucleotides continues through dephosphorylation, de-amination and cutting off ribose, thereby creating inosine monophosphate (IMP) and hypoxanthine (Hx). The flow of the process is:

$$ATP \longrightarrow ADP \longrightarrow AMP \longrightarrow IMP \longrightarrow INO \longrightarrow Hx$$

The rate at which the breakdown of the nucleotides takes place is dependent on the same factors as mentioned above. In a rested cod muscle stored at 32°F, all ATP and glycogen disappear within four days, IMP after seven days, in which time the Hx level has risen drastically as shown in Figure 7-B, but great diversity, depending on species, must be expected.

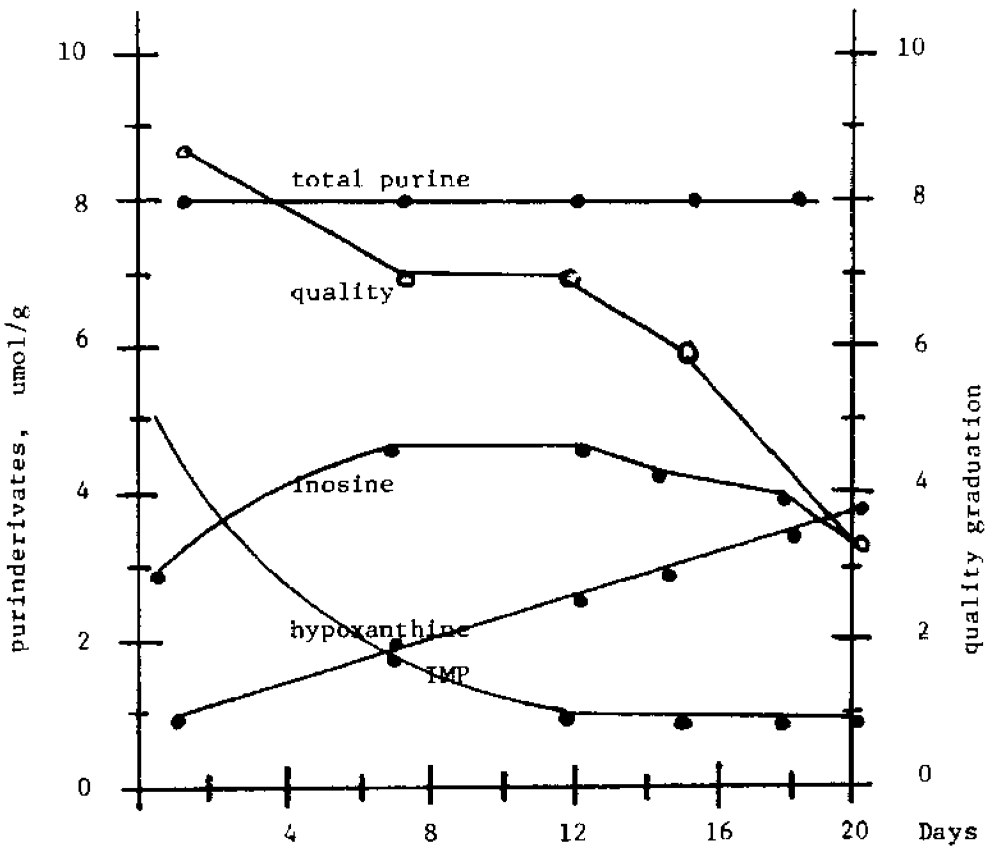
The creation of IMP takes place very quickly in most fish species, presumably within the first 24 hours. It is known that IMP fortifies the taste; and the gradual loss of taste due to refrigeration is because of the loss of IMP. On the other hand, Hx has a bitter taste that gives the fish an off-flavor.

Proteins and N-containing Extracts

The first post-mortal changes in the protein fraction involve the physical characteristics. The biochemical processes of

FIGURE 7-B

QUALITY CHANGES IN LEAN WHITE FISH IN RELATION TO BREAKDOWN OF CERTAIN NITROGEN COMPOUNDS



rigor mortis, mentioned above, change the solubility of the proteins. The extent of these changes depends on the pH, insofar as a low pH causes increased insolubility both to sarcoplasmic protein and structural protein. In addition, protein hydrolysis takes place, catalysed by muscle cathepsines. Fish can spoil and become inedible before any proteolysis can be encountered. An exception, however, is the autolytical processes in the gut of feeding fish, where the strong digestive enzymes cause decomposition and "belly burst" within the first few hours after catch.

By far the greatest changes occur in the group of nitrogenous compounds. Differences in the content of these substances cause a difference in the putrification of various types of fish. High content of urea in some cartilaginous fish gives rise to the strong development of ammonia, and high content of histidine in fish such as tuna and mackerel gives rise to development of histamine in the process of decay. In white fish with low fat content, such as cod, pollock, hake, etc., the best known process is reduction of trimethylamine oxide (TMAO) to trimethylamine (TMA) and further to ammonia. This process is slow during the first week of storage, but after 8 to 10 days of ice-storing of cod it accelerates and a strongly rising level of TMA and/or TVB (Total Volatile Base) can be measured in the meat just prior to condemnation for human consumption. Simultaneously, traces of hydrogen sulphide or other putrial smells occur, caused by the decay of the sulphur containing amino acids. Creation of hydrogen sulphide is most pronounced in the case of anaerobic storage.

Changes During Refrigerated Storage

Regardless of the size of the initial flora, the fish is inevitably contaminated through catch and handling on-board, but this contamination consists to a large degree of the same cold-tolerant species as mentioned above. During refrigeration, the amount of germs increases in the meat and on the surface. After a resting phase of a few days at the start of storage, counts of 10^7-10^8/g are reached in the ensuing 9 to 10 days during which time variation in the composition is seen as the Pseudomonas species become dominant.

The contamination of the surface of the fish will eventually reach the meat. Accelerated invasion of the meat will happen if the fish is handled roughly.

Enzymes and Their Role in the Decomposition of Fish

The complex post mortal changes in fish are affected by a sequence of enzymatic actions. The first steps in decomposition of nucleotides are catalysed by enzymes from the tissue (autolytic) while later stages can be influenced by bacterial enzymes.

Thus enzymatic degredation of fish can be depicted as follows:

$$ATP \xrightarrow[F]{A} IMP \xrightarrow[S]{A} INo \xrightarrow[F,S]{A,B} Hx \xrightarrow[S]{A,B} Xa$$

where A is autolytic, B is bacterial, F is fast and S is slow processes.

The initial decomposition of nitrogenous compounds is caused by tissue enzymes; thus the lower amines are rendered available to further decay by bacterial enzymes.

Comparing the decomposition in sterile and contaminated cod muscle, the process TMAO$\rightarrow$TMA only takes place under the influence of bacterial enzymes.

Oils

The fish oil is very labile owing to the high content of unsaturated fatty acids. A certain degree of hydrolysis takes place during refrigeration causing an increase in the content of free fatty acids. The hydrolysis is less important when fat fish is stored in the round, especially at high temperatures.

During refrigerated storage of fat fish, the main changes are made up of oxidizing the unsaturated lipids with the formation of peroxides. These peroxides are further decomposed to aldehydes and ketones.

The oxidation will cause a yellowish or brownish discoloration of the surface of the fish meat and simultaneously a rancid smell and taste will occur. The rancid aroma is not caused by the peroxides which are tasteless, but by the subsequent breakdown products. Therefore, it is possible to find low peroxide numbers when analyzing even very rancid fish.

Microbiological Changes

While the flesh of live fish is normally regarded as sterile, all external and internal surfaces are polluted with germs and other microorganisms. The amount and kind of this flora to a great extent depends on the surroundings of the fish; that is, water temperature, bottom nature, pollution, etc. Depending on these conditions the number of bacteria on the surface of a fish varies from a few hundred to some hundred millions per square inch. Almost every existing bacteria has, from time to time, been isolated from fish, but the main part of the microbial flora consists of cold-tolerant gram-negative species, such as Pseudomonas, Moraxella, Flavobacter, and Vibrio species.

The decomposition of sulphur-containing amino acids which cause the generation of hydrogen sulphide is also brought about by bacterial enzymes.

As far as the lipids are concerned, autolytic hydrolysis takes place in cod muscle at -22°F, but even when storing cod muscle at 32°F or higher, there is no evidence that bacterial enzymes are involved to any great extent in the hydrolysis of lipids.

In conclusion, it can be stated that in general, autolysis gives most fish an off-odor; in fat fish specifically, lipid oxidation acts as a reducer of quality, while in white fish bacterial activity spoils the fish.

CHAPTER 8

LOW TEMPERATURE PRESERVATION

Max Andersen

Effect of Temperature on Spoilage

In order to slow down the spoilage process of fresh fish, three basic principles must be applied:

careful handling
cleanliness
cooling.

Care in handling is essential because unnecessary damage can provide access for spoilage bacteria through cuts and wounds, thus accelerating the spoilage process. Cleanliness is important and can be achieved by: (1) gutting and washing the fish soon after catch to remove the natural sources of bacteria; and (2) ensuring that the fish are always handled in a hygienic manner to minimize chances of contamination.

Most important of all: the fish must be chilled quickly and kept chilled.

The speed with which the bacteria grow depends on temperature, and indeed temperature is the most important factor controlling the speed at which the fish spoils. The higher the temperature, the faster the bacteria multiply, using the flesh of the fish as substrate. Subsequently, when the temperature is kept low, bacterial action can be halted. Frozen lean fish, stored at a very low temperature, for example -22°F, will remain wholesome for a very long time because the bacteria are either killed or are completely inactive at this temperature, and chemical action is very slow. But even at 14°F, bacteria can still grow, though only at a very slow rate. Therefore, for long-term storage, freezing and cold storage are necessary.

It is not possible to keep unfrozen fish at a temperature low enough to stop bacterial action completely, because fish begins to freeze at about 30°F; but it is desirable to keep the temperature of unfrozen fish as close to this as possible to reduce spoilage. This low temperature is achieved by using plenty of ice.

At temperatures just above the melting point of ice, bacteria become much more active and fish, consequently, spoils more quickly. Cod kept in ice becomes inedible after about 15 days, whereas if kept at 41°F, it will be unfit to eat after about six days, and at 59°F, it could be rejected already after only one or two days.

How Long Will Fish Keep in Ice?

Generally, fish of the same species follow the same pattern of spoilage. Fish from different families, however, and different species within a family, may show unidentical spoilage patterns.

Small fish commonly spoil more rapidly than larger ones. Also, fish that have been feeding heavily spoil more quickly than fish that have been starving.

Some members of the gadoid family spoil quicker than cod; haddock and pollock, for example, spoil more rapidly and whiting even faster. Generally, ocean perch and flatfish keep better than cod when iced.

Fatty fish, however, spoil rapidly even in ice. Herring with a fat content of 15 percent or more can become inedible after only one to two days; and four to five days is usually the limit for safe keeping of herring at any time of the year.

Why Cool Fish in Ice?

Ice is an excellent cooling medium for fish. It has a very high cooling capacity per weight or volume; that is, 36.43 kcal (144.2 Btu) of heat are required to melt one pound of ice. Ice is harmless, portable, and cheap. It is especially valuable for chilling fish, since rapid cooling is possible through close contact of fish with small pieces of ice and melting water. Ice keeps the fish cold, moist, and glossy, and prevents the drying that often accompanies other methods of chilling.

Ice is its own thermostat and, since fish is mainly water, ice maintains fish at a temperature just slightly above freezing point. The point of equilibrium for marine fish, iced on-board, is 30.2°F since the mixture usually contains some salt and blood.

Why Not Use Other Cooling Methods?

There are other ways of chilling fish besides using ice. For example, cold air can be blown over them; dry ice (solid CO_2)

can be packed close to the fish; or, the fish can be immersed in chilled water.

Refrigerated sea water (RSW) or slush ice are suitable alternatives when chilling large quantities of small whole fish, especially on board the fishing vessel. These methods are discussed later. The use of cold air or dry ice is less satisfactory.

When cold air alone is used, as in refrigerated rooms, the heat removed from the fish rapidly warms the air. The air then rises and is cooled by contact with the coils of the cooler and moves, by convection, back to the fish. Very little heat is required to increase the temperature of air, say 1°F. It requires, for example, 10,000 times more heat to melt a given volume of ice than to heat the same volume of air from 32°F to 33°F. Thus, if quick chilling is to be achieved, a large volume of cold air has to come in contact with the fish. The dry air may cause loss of water from the fish. In addition, the air in some parts of the chill room will be colder than in others, thereby partially freezing fish even though the thermostat is set above 32°F. Slow freezing of the fish can affect appearance, flavor and texture.

Dry ice and liquid nitrogen also are less suitable than ice for chilling fish. First, the temperature difference is very great. Dry ice, for example, has a temperature of -110°F, which may freeze the fish too quickly, thereby damaging the fish by stresses developed as the water in the fish freezes. If this method is to be employed, the fish have to be cooled indirectly by the cold vapor from the dry ice or liquid nitrogen. Another fact to consider is that both dry ice and liquid nitrogen are more expensive than ice.

Nature and Properties of Ice

In order to appreciate why ice is such a useful means of chilling fish, it is necessary to discuss the specific properties of ice, and simple principles of thermodynamics.

When water freezes at 32°F, it is transformed from a liquid to a solid state. A specific quantity of heat has to be removed in order to achieve this transformation. Subsequently, the same amount of heat has to be added back to facilitate the melting process. However, the temperature during the melting process will not rise above 32°F until all the ice has melted. The amount of heat required to melt ice is known as latent heat, and it is always a constant value (144.2 Btu/lb) for ice made from pure water, and with a small variation in ice made from public water sources. The relatively large value associated with the latent heat of ice makes ice such a widely used source of refrigeration in the fishing industry.

More heat is needed to warm water than to warm almost any other substance to the same degree. For example, to raise the temperature of 1 pound of sub-cooled ice by 1° would only require 0.5 Btu. If the capacity of a substance to hold heat is compared with that of water, it is called specific heat. Thus, the specific heat of water is 1, and that of ice is 0.5. Fresh fish, which contains about 80 percent water, has a specific heat of 0.84.

As already stated, 1 pound of ice, when melting, will consume 144.2 Btu. If the temperature of ice is below the freezing point of 32°F, let us say 27°F, heat required to melt the ice equals:

$$1 \text{ lb ice} \times 32-27 \times 0.5 = 2.5 \text{ Btu}$$

When the ice reaches 32°F, it requires 144.2 Btu to melt, thus giving a total of 146.7 Btu required to melt one pound of ice at a temperature of 27°F.

The 2.5 Btu gained from cooling the ice are negligible, but handling ice at 27°F is more convenient because the ice is "dry", preventing aggregation of the flakes.

In order to further explore the thermodynamic properties of ice, let us look at the cooling capacity of the cold water once the ice has melted. For illustrative purposes, assume that 1 pound of melted ice at 32°F rises to 34°F as it flows over the fish being chilled. Since the specific heat of water is 1, the amount of heat that will be extracted from the fish will be:

$$1 \text{ lb} \times 34-32 \times 1 = 2 \text{ Btu.}$$

Again, this amount is small compared with the large amount, 144.2 Btu, needed to melt 1 pound of ice.

Before we go on to consider how ice cools fish, and what quantities are needed, let us look more closely at different types of ice.

Ice Is Ice

Everyone in the fishing industry has heard arguments that ice made at one port is better than that made at another port; that natural ice is better than artificial; and that "old" ice is better than newly made ice.

The properties of freshwater ice from different sources are for all practical purposes the same. The cooling capacity of ice is always the same: One pound of ice at 32°F requires 144.2 Btu of heat to melt, whether the ice has been made from hard tap water or soft rain water; whether the ice is fresh or one year old.

If, however, ice has melted, much of its cooling capacity has been lost. Slushy ice should never be compared with the same weight of ice alone.

One pound of ice will, theoretically, cool 7 pounds of cod from 55°F to 32°F. However, in practice, a great deal of the cooling capacity is absorbed by cooling the surroundings, so that even on trawlers fishing in Arctic waters, 1 pound of ice is used to cool only 2 pounds of fish.

Ice in small particles made by different methods will have different densities. A ton of crushed block ice may occupy only 56 ft^3; a ton of tube ice, 66 ft^3; and a ton of flake ice, 75 ft^3. It is essential, therefore, when comparing different ices, to compare equal weight; what may appear to be the same amount of ice may be an equal volume, but 1 ft^3 of flake ice has far less cooling capacity than 1 ft^3 of crushed block ice.

<u>Seawater Ice</u>

The effective cooling capacity of seawater ice in comparison with freshwater ice is mightily disputed. Depending on the equipment, seawater ice may be less homogenous than freshwater ice when newly made. In addition, brine will also leak out of the ice during storage so that seawater ice does not have a precisely fixed melting point. For this reason, fish kept in seawater ice may sometimes be found to become partially frozen, and that it may have taken up salt from the ice.

However, where the choice has to be made between an inadequate supply of freshwater ice and plenty of seawater ice, there is little doubt that seawater ice should be used in order to retain the best quality of the product. Seawater ice is of particular advantage on board ships for supplementing port supplies on long trips, or in communities where fresh water is scarce. However, one should keep in mind that the bacteriological standards of seawater for ice production always are the same as for fresh water.

<u>How Ice Cools Fish</u>

When ice is placed in close contact with the fish, heat is transferred from the warm fish to the ice, thus lowering the temperature of the fish and melting the ice. The amount of ice needed to chill a given weight of fish can be calculated.

Consider, for example, a 20 pound box of fillets at a temperature of 50°F. The specific heat of fish is about 0.9; hence to cool 20 pounds of fish from 50°F to 32°F requires the removal of:

$$20 \times (50-32)°F \times 0.9 = 324 \text{ Btu}$$

Ice will absorb 144 Btu/lb, so that the amount of ice needed to chill the fish is 324/144 = 2.25 pounds. In practice, when fish is iced in a box, some ice will be used in cooling the box and more will melt during transportation. More than the 2.25 pounds which we have calculated must therefore be used; how much more will be shown later. Nevertheless, the simple calculation shows that unless at least 2.25 pounds of ice are melted, it is impossible to chill 20 pounds of fish from 50°F to 32°F.

How Long Would the Fish Take to Cool?

Let us assume that fillets are layered with ice. If the layers are four inches thick, then the distance from the center of the layer equals two inches. Further assume the initial temperature of the fillets to be 50°F and that of the ice 32°F, hence a temperature difference of 18°F and a temperature gradient of 9°F/inch.

This cooling rate decreases as the fillets cool. For example, at 41°F, the temperature gradient has decreased to 4.5°F/inch. Consequently as the temperature of the fillets approaches that of the ice, the rate of cooling is minimal. It takes, for example, four hours for the center of the fillet layer to cool from 50°F to 34°F if the fillet layer is four inches thick, while an additional hour is needed to cool the same fillet layer one more degree, to 33°F.

Table 8-A shows that a thin fillet layer will cool fairly quickly on ice, while a thick layer will take longer. Therefore, to chill fillets quickly, it is essential to keep the distance between each fillet and the ice at a minimum. Practically speaking, this means that the ice must be distributed uniformly between fillets or fish.

Amount of Ice Needed for Proper Chilling

First, let us assume that the sole purpose of the ice is to cool the fish and to absorb heat from the outside environ-

TABLE 8-A

COOLING RATES OF COD FILLETS

Thickness of Fillet Layers	Time to Chill From 50°F to 32°F
Inches	Hours
3	2
4	4
5	6-1/2
6	9
10	24
24	120

ment. Table 8-B shows the amount of ice needed to cool 22 pounds of fish down to 32°F.

In order to compensate for most outside environmental conditions, the rule of thumb is that it takes one pound of ice to cool two pounds of fish.

Since the environmental conditions are never constant, it is essential to monitor the temperature of the iced fish.

Other Methods of Chilling

Refrigerated sea water (RSW) and chilled sea water (CSW or slush ice) at 32°F are used for cooling, storing and transportation of fish. The difference between the two systems is that RSW uses mechanical refrigeration, while CSW uses ice.

RSW has replaced ice in some parts of the industry because of the following advantages:

1. greater speed of cooling

2. reduced pressure on the fish

3. lower holding temperature possible

4. quick handling of large quantities of fish is possible with little delay or labor involved

5. in some cases, extended storage time.

RSW systems, however, also have their disadvantages, such as uptake of salt and water by species of low fat content, loss of protein, and anaerobic spoilage.

Nevertheless, RSW systems have been successfully employed when:

1. the disadvantage of salt and water uptake is unimportant compared to the extended storage period

2. bulk chilling is necessary for both fishing vessels and processors.

Salt Uptake

Salt uptake is probably the limiting factor against application of RSW systems. Excessive salt uptake may render white fish unacceptable for the frozen market. Salt uptake in

TABLE 8-B

COOLING EFFECT OF ICE

Initial Temperature of Fish	Weight of Ice
°F	lbs
86	8.38
77	6.83
68	5.51
59	4.19
50	2.87
41	1.54

industrial fish is also critical and should not exceed 0.5 percent in the raw fish.

Salt uptake in general depends on:

1. species and size of fish
2. salt content of the RSW
3. ratio of RSW to fish
4. storage time.

Table 8-C shows uptake of salt in cod fillets stored in RSW in a ratio of 2:1. In this experiment, members of the taste panel detected a noticeable salt level after three days of storage. Thus salt uptake may indeed limit the application of RSW.

Loss of Protein

Fish commonly lose some of the protein during ice storage and in RSW. The protein loss from fish in RSW is twice that observed using good icing practices, but equal when the fish is iced in bulk.

Weight Gain

Fish immersed in CSW initially gain weight, but it is eventually lost during prolonged storage. Fish in RSW also gain weight, but the gain is slow and continues for two or three weeks in some cases. The weight gain depends on species and is normally in the range of 2 to 5 percent during two weeks' storage. Flatfish, for example, show a larger weight gain per storage period than cod, which gain about 0.5 percent. The problem of water uptake is less critical with fatty fish.

Spoilage of Fish

One of the major disadvantages of RSW storage is the potential growth of anaerobic bacteria which causes objectionable flavors and hydrogen sulphide odors.

In contrast, ice, which contains a fair amount of air, prevents growth of anaerobic bacteria.

Bacterial spoilage within RSW systems could affect the entire catch, whereas ice stowage tends to confine the spoilage.

TABLE 8-C

SALT UPTAKE IN COD DURING RSW STORAGE

Storage (Days)	RSW (% Salt in Fillets)	ICE (Control)
5	0.3	0.1
9	0.5	0.1
15	1.0	0.1

Carbon Dioxide

Dissolved carbon dioxide (CO_2) in RSW inhibits bacterial growth, thereby extending the storage life of the fish. CO_2 is an odorless, colorless gas which, combined with water, forms a weak acid. Its solubility depends on the salinity of the solution and the temperature. In general, 160 times more CO_2 than O_2 can be dissolved in water. When RSW is saturated with CO_2, the pH is reduced from about 7.5 to 4.0. The acid environment inhibits the growth of most of the bacteria.

One disadvantage of adding CO_2 is its corrosive property, thus requiring acid-resistant tanks. In addition, CO_2 will permeate the flesh of the fish, which tends to cause abnormal headspace if the fish is canned.

Cleaning

The RSW system must be kept scrupulously clean.

The initial charge of sea water should be as clean as possible; therefore, tanks should not be filled with water from harbors or river estuaries.

Cleaning should begin immediately after the fish have been removed and while the system is still wet; otherwise slime and other foreign matter will dry and prove difficult to remove. Pipes, including pumps and heat exchangers, should be flushed thoroughly, cleaned, and sanitized.

Stowage

Proper handling and stowage aid in ensuring a prime quality product. The fish should be kept refrigerated and under sanitary conditions. Even in a well-designed plant, improper handling can result in a poor quality product.

The importance of good practice at sea cannot be over-emphasized. Fish begin to spoil as soon as they are harvested. Any mis-handling on board, even on short trips, will result in a poor quality product. The length of the fishing trip and on-board handling of the catch will eventually influence the value of the catch.

Methods of Handling and Stowage

Lean Fish

Lean fish have their fat or lipids contained in the liver, as opposed to fatty fish where fat is distributed throughout the body tissues. Lean fish are usually bottom-living species and are caught mainly by trawl, seines, or longline, whereas fatty fish are pelagic.

Lean fish caught by large vessels should be gutted at sea, but crew size may preclude this practice for small fish.

In general, immediate gutting of white fish will produce the best quality product, particularly if the fish has been feeding. If the fish have starved prior to harvest, it may be permissible to omit the gutting stage in order to avoid any long delay in chilling; gutting always adds to the risk of contamination.

When fish are stowed in ice, each fish should be separated from the others by a layer of ice to accelerate the cooling process. In addition, if the fish are not separately iced in order to avoid any contact areas but the ice, an anaerobic spoilage will develop, producing foul odors which result in what are known as stinkers or bilgy fish.

During ice stowage, fish are cooled by the meltwater, which transfers the heat from the fish to the ice. Because of the physical shape of flake ice, it melts faster than crushed block ice when in direct contact with the fish. Flake ice therefore cools the fish quicker. The melting ice removes bacteria and traces of blood, thereby aiding in preserving the freshness of the product if adequate drainage is provided.

Discoloration

Any deviation from the white color has a detrimental effect on the marketability of white fish fillets. Most discoloration is caused by blood remaining in the product.

Blood discoloration is caused either by improper bleeding or bruise marks. This discoloration, besides reducing the appearance of the product, also accelerates rancidity.

Based on experiments conducted in Denmark, the following conclusions can be drawn:

1. The fish should be bled as soon as possible after capture.

2. The best bleeding method is to cut the throat, including the main vein along the backbone, or to remove the gills.

3. Gutting is now an acceptable method of bleeding.

4. A few minutes' bleeding time is sufficient, but if the bleeding is prolonged, it is advisable to keep the fish in cold water.

5. Live fish, and fish that are dead but have not yet entered the stage of rigor mortis should be treated with the greatest care, as physical mishandling at this time causes severe discoloration in the final fillet.

Polyphosphate Dip to Prevent "Thawing Drip"

An extremely difficult problem in the fish industry has been the fact that frozen fish is subject to excessive loss of moisture during thawing. The lost moisture, known as <u>drip</u>, carries with it a considerable portion of the soluble protein, minerals and other nutrients. The loss of moisture on thawing may be as high as 20 percent of the fish weight following prolonged frozen storage, and as high as 14 percent after only one month of frozen storage.

Moisture retention is improved by application of polyphosphate at 0.5 percent (Denmark).

Cod, for example, when treated with polyphosphate at this level, showed a 10 percent weight increase after six months' cold storage, and subsequent thawing of the same fillets showed a drip loss of only from 1 to 3 percent compared with from 7 to 9 percent for untreated fillets.

<u>Summary of Good Stowage Practice</u>

1. Stow the fish in ice as quickly as possible.

2. Adequate icing is essential even for the shortest periods of storage. Fish begin to spoil as soon as they are dead, at a rate five times quicker at 50°F than at 32°F.

3. Always use clean, fresh ice.

4. Use small pieces of ice. Large pieces of ice may bruise the fish and have less chilling effect.

5. Use plenty of ice in layers between the fish.

6. Do not overload a box or shelf. The box or shelf on top will squash the fish below.

7. Use too much ice rather than too little.

8. Do not pack fish tightly, preventing meltwater from draining.

9. Place gutted fish belly down, thereby aiding proper drainage.

PART V

WHITE FISH PROCESSING

CHAPTER 9

RAW MATERIAL

Kai Kaersgaard

Introduction

Raw material for white fish processing should be of the highest possible quality. The quality is determined by the physical condition of the fish when harvested, and the methods and techniques employed in handling the catch. To judge the quality, the fish are usually inspected at the time of landing.

For this discussion, we assume that the raw material consists of four species: Pacific cod, Alaska pollock, Pacific ocean perch, and flounders. The expected supply of each species and the shape and size of the individual fish are important factors to be considered when planning the production lines.

Based on the raw material, one must decide which products attain a quality product for each species. When the necessary operations have been decided upon, machines are chosen to execute these operations. Having chosen the machines, a layout of the production lines can be drawn up.

The production lines can either be fitted into an existing building or a new building may be erected.

A plant layout is made, space requirements are estimated for the processing proper and all peripheral functions.

After construction of the plant, operation of the plant begins. The operation is monitored by process and sanitary control programs in order to obtain the best quality products.

Raw Material Requirements

General Considerations

Fish intended for freezing should be of the highest possible quality. The quality of the fish when caught is determined by the physical condition of the fish, and includes appearance, size, percentage of fat, amount of feed, damage to skin, and presence of foreign substances. The quality of the fish on delivery to the processor will be the result of the methods and techniques employed in fishing, practices in handling and conditions of storage.

Fish Spoilage

Spoilage begins as soon as the fish dies. The first obvious change that takes place after death is the development of bodily stiffening or rigor mortis. Within a few hours after death, the body becomes rigid, as the muscles themselves become tense and hard. The condition wears off slowly, and after a period of some days, rigor can be said to have ended, although there is no sharp or abrupt termination of the condition. If the duration of rigor is long, it is regarded as a sign of good quality.

Fish spoil mainly from two causes: (1) by its own enzymes; and (2) by invading bacterial breakdown.

Enzymes, even when present in very low concentrations, are able to accelerate specific chemical reactions. It is believed that some of these enzyme reactions are involved in the flavor changes that occur during the first few days of iced storage.

It is because of the softening effects of the gut enzymes that fish are generally, but not invariably, gutted at sea. Gutting is not always essential, although it is generally regarded as a wise precaution. Fish that have not been feeding may remain edible slightly longer if not gutted, but the flesh may be slightly discolored by the blood, and ungutted Pacific ocean perch, for instance, will probably keep better in ice than the gutted fish.

Millions of bacteria are present on the skin, gills, and in the gut of the living fish. They do no harm to a living fish, but the flesh of gutted cod and similar species will be invaded by these bacteria after two to four days of iced storage. Careful gutting will remove many bacteria, and washing will also reduce the numbers on the surface, but it is practically impossible to remove them all.

Characteristics of spoiling fish are the resultant effects of a host of different changes. The spoilage pattern in any particular species of fish generally follows much the same pattern regardless of the origin of the fish, but there are wide differences in the patterns of different groups.

On-Board Handling of the Catch

Proper handling of the fish on board will improve the quality of the fresh fish landed. The better the fish, the better the market price, which will be reflected in a better price to the fishermen for the fish landed. Furthermore, a high quality fish yields more fillets than a poor quality fish. These factors then are also good reasons for emphasizing the importance of good and careful handling of the fish on board.

It is recognized that small hauls result in better quality fish, since less physical damage is done to the fish. Handling on deck is much easier and is much less trouble for the fishermen when the hauls are of reasonable size. Before the new catch is taken on deck, the previous catch should be stowed in the hold and the deck washed to remove guts and other offal.

On deck, the catch should be placed in enclosures to avoid damaging the fish through being rubbed against the deck.

Handling the catch should begin as soon as it comes on board. All trash fish should be stowed in a separate hold. Catches of mixed species should preferably be sorted on board according to species.

Fish kept in pre-gutting storage facilities should not be piled too high as this can result in the catch being damaged by pressure.

If the fish are to be gutted, this should be done immediately after the fish have been landed on deck. The reasons for prompt gutting are, (1) to sever some of the main blood vessels, allowing the fish to bleed, and (2) to remove the guts which would otherwise cause softening of the flesh and accelerate spoilage. If some fish are in a state of rigor before handling, no attempts should be made to bend them since this would damage the fillet. If rapid gutting is not practical, whole fish should be washed and chilled as soon as they come on deck. After gutting, all the fish should be washed gently to remove blood spots and visible contaminants such as gut content. The slime of the fish must not be removed. Following gutting and washing, the fish should be stowed without delay under chill conditions.

Inspection

Various techniques have been devised for measuring the degree of spoilage of fish. None is entirely satisfactory, but all of them have important commonalities. Three main types of measurements are usually employed: physical, chemical, and sensory (organoleptic) methods.

One of the best known of the sensory methods defines the various stages of spoilage through which a fish passes from freshness to being putrid:

1. The general appearance. The appearance of the eyes, gills, and outer surfaces.
2. The appearance of the flesh, particularly at the cut surface along the backbone and at the belly flaps.
3. The texture of the raw fish, as evaluated by the reaction to touch.
4. The odor of the raw fish, particularly at the gills and body cavity.
5. The odor of the cooked fish.
6. The flavor of the cooked fish.
7. The texture of the cooked fish.

The characteristic stages of spoilage for each one of these quality factors have been described and numerical scores have been allotted to each stage.

In cod and haddock, properly stowed in ice, four well-defined phases of spoilage can be accounted for. These phases roughly correspond to periods of 0 to 6 days, 6 to 10 days, 10 to 14 days, and 14 days and more in ice. They also correspond approximately to quality gradings used by some of the larger producers in Britain.

Phase I:	first quality (for fresh and freezing)
Phase II:	second quality (for fresh and smoking)
Phase III:	for smoking and salting
Phase IV:	condemned

During Phase I, some loss of natural flavor and odor occurs. Toward the end of Phase II, the fish lacks odor and flavor. In Phase III, the fish begins to taste stale, its appearance and texture begin to show obvious signs of spoilage, the gills and belly cavity smell distinctly "off."

All these changes, which in the later stages are almost entirely due to bacteria, occur at an ever increasing rate until by the fifteenth or sixteenth day, when Phase IV begins, the fish is putrid and, in general, regarded as inedible.

In a general way, it is possible to relate the bacteriological and chemical changes to the four phases of spoilage as assessed by sensory means, but no chemical method gives the same degree of accuracy in measuring freshness as a properly trained taste panel. On the other hand, chemical methods are usually faster and require fewer staff to operate them.

Perhaps the most widely used chemical test has been the estimation of trimethylamine (TMA) in a given weight of flesh. It has been used very successfully on cod, haddock, and similar species of low fat content. The method depends on the breakdown by bacteria of the substance trimethylamine oxide to give the odoriferous substance trimethylamine. Really fresh fish have very low TMA values, which rise progressively during spoilage.

Other chemical tests are total volatile bases (TVB), ammonia, volatile reducing substances (VRS), tetrazolium and hypoxanthine.

Species Dealt With in This Manual

Pacific Cod

Scientific name: *Gadus macrocephalus* from the Latin *gadus* (codfish), and the Greek *macros* (large) and *cephalos* (head).

Common usage may continue to refer to this species as plain "cod" or as "gray cod" to distinguish it from the other species currently referred to as varieties of cod.

The maximum sustainable yield estimated mid-1978, is 160,000 metric tons. The level of domestic catch in 1977 was about 1,000 metric tons.

Total allowable catch in the Gulf of Alaska was estimated as 6,300 metric tons for the year 1977.

Length: up to 3 ft. 3 in. (1 meter). The average length in the catch is estimated as over 2 ft.

Pacific Cod is marketed:

Fresh:	whole gutted, fillets, sliced
Frozen:	round, dressed and as fillets, also kneaded meat (Japan)
Smoked:	seasoned and smoked meat slice (Japan)
Dried:	in Japan, sold as Hirakidara or Sukimidara
Salted:	lightly salted, sliced (Japan)

The price of the raw material is estimated at 17 cents per pound.

The product price is estimated at $1 per pound for block-frozen fillets, and $1.20 for IQF fillets.

Alaska Pollock

Scientific name: Theragra chalcogramma from the Greek roots ther (beast) and agra (food - of fur seals); and chaleos (brass) and gramma (mark).

Also known as walleye pollock and bigeye in America.

The maximum sustainable yield estimated mid-1978, is 2,100,000 metric tons. The level of domestic catch in 1977 was about 1,000 metric tons.

Total allowable catch in the Gulf of Alaska was estimated as 126,000 metric tons in 1977.

Length: up to 3 ft. (91 cm).

Alaska Pollock is marketed as:

Frozen:	round, dressed, fillets or minced in blocks, also used for Renseihin (Japan)
Salted:	various ways, similar to cod
Dried:	after curing in brine or dry salt (Kirakidara, Sukesodara, Japan); also by repeated freezing and thawing (Tokan-hin)

Spice cured:	fish fillets or slices pickled with salt and rice wine lees
Liver & viscera:	important source of vitamin oil
Roe:	cured with salt, often mixed with red pigment, usually packed in barrels or boxes (Tarako, Momijiko, Japan)

The price of the raw material is estimated at 7 cents per pound.

The product price is estimated at 68 cents per pound for block-frozen fillets, and $1 for IQF fillets.

Pacific Ocean Perch

Scientific name: Sebastes alutus from the Greek sebastos (magnificent), and aloytos (unwashed, speckled).

Also commonly known as rockfish or menuke rockfish.

The maximum sustainable yield estimated mid-1978, is 265,000 metric tons. The domestic level of catch in 1977 was about 1,000 metric tons.

Total allowable catch in the Gulf of Alaska was estimated as 30,000 metric tons in 1977.

Length: up to 20 in. (51 cm). The average length in the catch is estimated as over 1 ft.

Pacific ocean perch is marketed fresh or frozen (whole or fillets); the liver is used for vitamin oil extraction.

The price of the raw material is estimated at about 10 cents per pound.

Flounders (Except Halibut)

There are several species of which, based on the 1977 catch figures, the following are the most common:

Starry Flounder (Platichthys stellatus)

Size: up to 36 in. (91 cm).

Yellowfin Sole (Limanda aspera)

Size: up to 17.6 in. (45 cm).

Rock Sole (Lepidopsetta bilineata)

Size: up to 23.5 in. (60 cm).

Flathead Sole (Hippoglossoides elassodon)

Size: up to 18 in. (46 cm).

The maximum sustainable yield estimated mid-1978, is 678,000 metric tons. The domestic level of catch was about 1,000 metric tons in 1977.

Total allowable catch in the Gulf of Alaska was estimated as 23,500 metric tons in 1977.

Flounders are marketed:

Fresh: whole gutted, or as fillets, with or without skin

Frozen: whole gutted, or as fillets, with or without skin

Smoked: whole, headed and gutted fish, salted and hot-smoked.

The raw material price is estimated at from about 12 to 14 cents per pound.

CHAPTER 10

UNIT OPERATIONS IN WHITE FISH PROCESSING

Kai Kaersgaard

General Description of Main Operations

Deicing

Deicing is the separation of fish and ice. The purpose of deicing is to make the further processing of fish easier; for example, for the feeding of processing machines. Dumping the fish and ice into a vat filled with water is the most common method of deicing. The ice floats up to the surface and the fish are removed by means of a conveyor.

Sorting

Sorting is the classification of fish according to species. It is necessary to sort the fish in order that each species may be processed on the most suitable processing line. Sorting also makes it easier to fix prices on the raw material. The fish are normally sorted by hand.

Grading

Grading is the sorting of fish into two or more size groups. The purpose of grading is to place fish in the right size range to suit the processing machines, or to enable fish in a number of specified size ranges to be offered for sale.

One method used for grading of ungutted white fish consists of two pairs of parallel rollers that are inclined at a slight angle and placed one above the other. The gap between the upper pair is wider than the gap between the lower pair. The rollers of each pair rotate in opposite directions so that in the gap their surfaces are moving upwards. Fish are fed from a hopper onto the top pair of rollers; small fish fall through the gaps between both pairs of rollers and are collected at a take-off point, while large fish are held between the top rollers and are conveyed to a second take-off point. Fish in the required size range fall through the top rollers but are held by the bottom rollers and conveyed to the processing machines.

Weighing

For control purposes, weighing is a must. The product can, for example, be weighed in the following stages of processing:

1. Weighing of raw material purchased and weighing of finished products sold would give total yield.

2. Weighing of raw material drawn from stowage and weighing of frozen finished products would give production yield.

3. Weighing of intermediate product before and after processing would give intermediate yield. For example, in the case of cod, the yield of heading, filleting and skinning, and the trimming process.

Gutting

Gutting is the removal of the guts. White fish are normally gutted immediately after capture for three main reasons: (1) to reduce spoilage by removing the principal source of bacteria and digestive juices; (2) to prevent contamination of the catch from gut contents; and (3) to facilitate bleeding so that the flesh does not become discolored by blood.

Fishermen can gut three to six fish a minute by hand. There are, however, British, German and Danish machines available commercially for gutting of round white fish species, such as cod, haddock and whiting, on board the fishing vessels. Other machines are also available for gutting fish ashore.

Washing

Fish require washing at several stages during the processing. Washing may be achieved as part of a sequence of operations as in gutting machines, or as a separate operation in a washing machine. Typically, whole white fish are washed immediately after gutting and again after removal from iced stowage and before filleting.

Washing helps to remove spoilage bacteria, blood, dirt, and waste material from the surface of the fish, and from the belly cavities of gutted fish, thus slowing down decay, improving appearance and reducing contamination.

Two main types of washing machines have been developed: (1) those which move the fish through a spray, and (2) those which move the fish through a bath. Spray washers are typically inclined rotating drums fitted with an internal spiral and a succession of spray nozzles. Washing machines should be able to remove at least 90 percent of the surface bacteria of the fish.

Heading

Heading is the removal of the head. Most filleting machines, but not all, require the fish to be headed first.

Machines that head the fish by making straight and various angled heading cuts are very versatile and can be used on practically all types of white fish. Other machines cut in a semicircle so that only the head and collar bones are cut off, saving the neck meat (V-cut). For the production of klipfish (dried and salted fish) a round cut machine is used to head the fish so that it retains the collar bones.

Filleting

Filleting is the process of removing a side of irregular size and shape from the carcass by cuts made parallel to the backbone. This can be done in various ways, resulting in different types of fillets:

1. Block fillet (butterfly fillet, cutlet, double fillet) Flesh from both sides of a single fish, usually joined along the back.

2. Cross-cut fillet (fillets from flatfish) The flesh from each side is removed as a single piece.

3. Quarter-cut fillet (fillets from flatfish) The flesh from each side is taken off in two pieces.

4. Single fillet A single fillet is the flesh from one side of the fish.

Filleting machines are available commercially for a number of species of white fish. However, because of the considerable differences in shape and structure among the species, and the need to remove the maximum amount of bone-free flesh, the filleting machines are usually designed to process only one or two species and to make only one type of product; for example, single fillets or block fillets. Most models require the fish to be headed first, so matched heading machines are available for use with most of these filleting machines.

Skinning

Skinning is the removal of the skin. Skinning is necessary for the production of skinless fillets, and many production outlets, such as the manufacturers of fish fingers and fish portions, require the fillets to be skinned.

In most types of skinning machines, the tail of a fillet is gripped between two knurled rollers and, as the skin is pulled through the roller, the fillet is separated by an oscillating knife blade. On one model, the fillets are conveyed skin uppermost under a refrigerating drum. The skins freeze to the cold surface, a band knife separates flesh from skin, and the skins are subsequently scraped off the drum. On another model, the fillets are pressed skin downwards on a conveyor belt, and the skins are separated by a band knife that is easily adjustable for skin thickness.

Trimming

Trimming is the removal of bones, ragged edges, tears and flaps, discolored flesh, blood clots, black membrane, and parasites. Trimming is a manual process.

Packing

For the protection of retail consumer packs and also for aesthetic reasons to promote sales, wrapping should be provided. As far as possible, the packaging should be airtight to prevent oxidation of the product and have high resistance to penetration of water vapors. Among the materials used for packaging fish are waxed or plastic-coated cartons.

Freezing times can be considerably extended by the insulating effect of the wrapper; therefore, consideration should be given to whether the fish should be wrapped before or after freezing.

Freezing

Freezing is a process which is carried out with appropriate equipment in such a way that the temperature range of maximum crystallization is quickly passed. The quick freezing process shall not be regarded as complete unless and until the product temperature has reached 0°F (-18°C) or lower at the thermal center after thermal stabilization.

Equipment for freezing must be able to lower the temperature quickly so that, after thermal stabilization, the temperature in the thermal center is the same as the storage temperature.

The purpose of freezing fish, either fresh or processed, is to obtain a commodity that can be stored for some months and then, on thawing, offer a product that has hardly been changed by the process.

The three most important methods of freezing fish are:

1. Plate freezers: direct contact between the fish and a refrigerated metal plate.

2. Air blast freezers: blowing a continuous stream of refrigerated air over the product.

3. Immersion freezing: immersing the fish in a low temperature liquid.

Mincing

Mincing is the separation of fish flesh from bones and skin by extruding the flesh as mince through a perforated drum.

Overfishing and declining catch rates have forced the fish industry to make more efficient use of what is caught and to reduce waste. About 65 percent of the weight of a gutted fish is edible flesh, but filleting rarely removes more than about 50 percent; the use of bone separators enables the processor to recover some or all of the 15 percent still remaining on the parts discarded after filleting.

In one model, a tough elastic belt presses the waste fish onto the outside of a perforated stainless steel drum; the flesh is squeezed through the holes into the drum, while bones and skin are scraped off the outside of the drum and discharged to waste. A screw conveyor pushes the flesh through the drum to a collecting point.

Processing of Pacific Cod

Production Flow and Control Point (Figures 10-A and 10-B)

The fish are dumped into the deicing machine. Mixed species catch is sorted according to species, perhaps on specially designed sorting tables. The fish are then graded, either manually or in white fish grading machines, into two or more sizes, to provide fish in the right size range to suit the processing line.

Two processing lines may be necessary, one for big cod, the other for smaller cod. Weighing and inspection can take

FIGURE 10-A

BASIC PROCESSES - PACIFIC COD

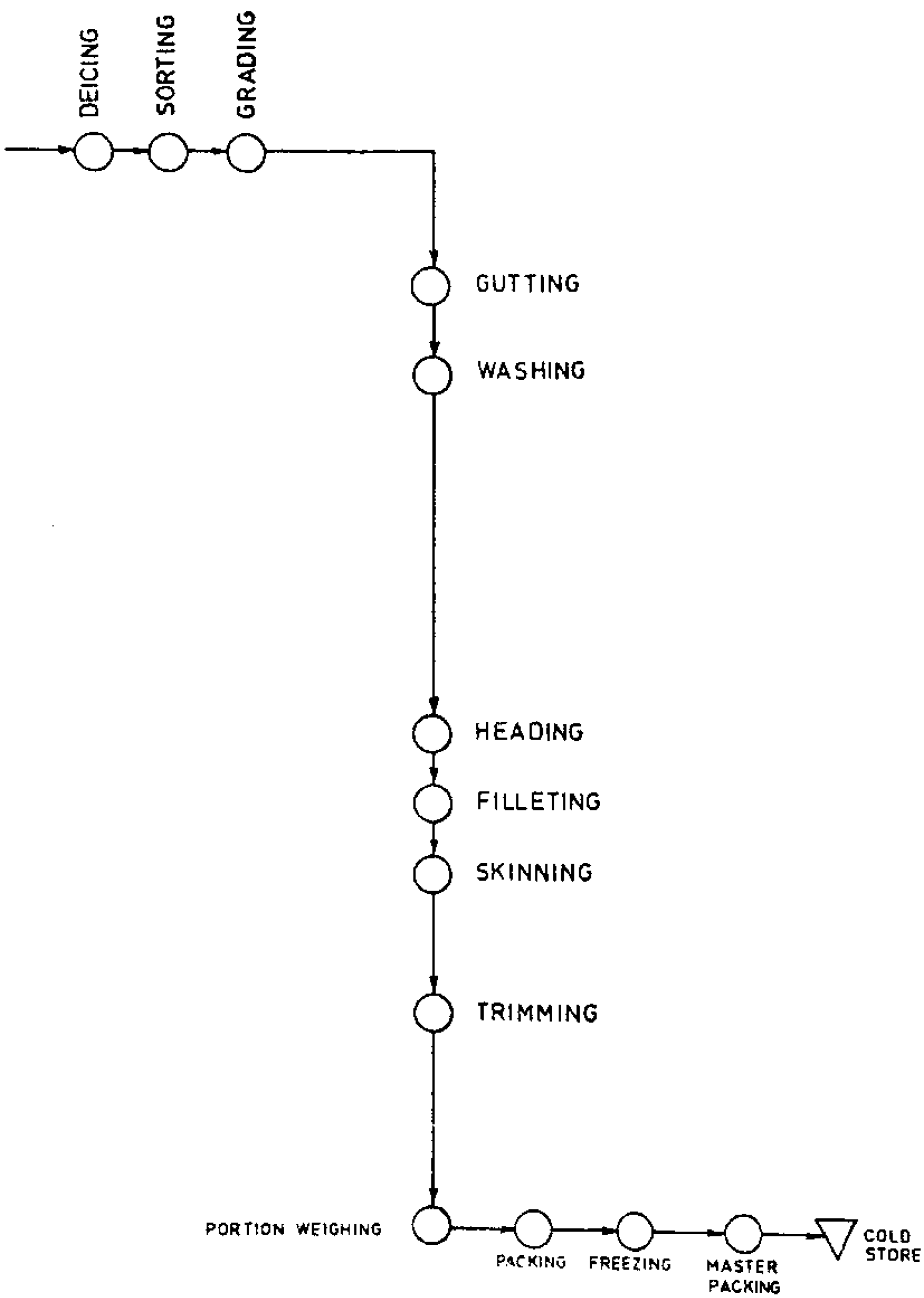
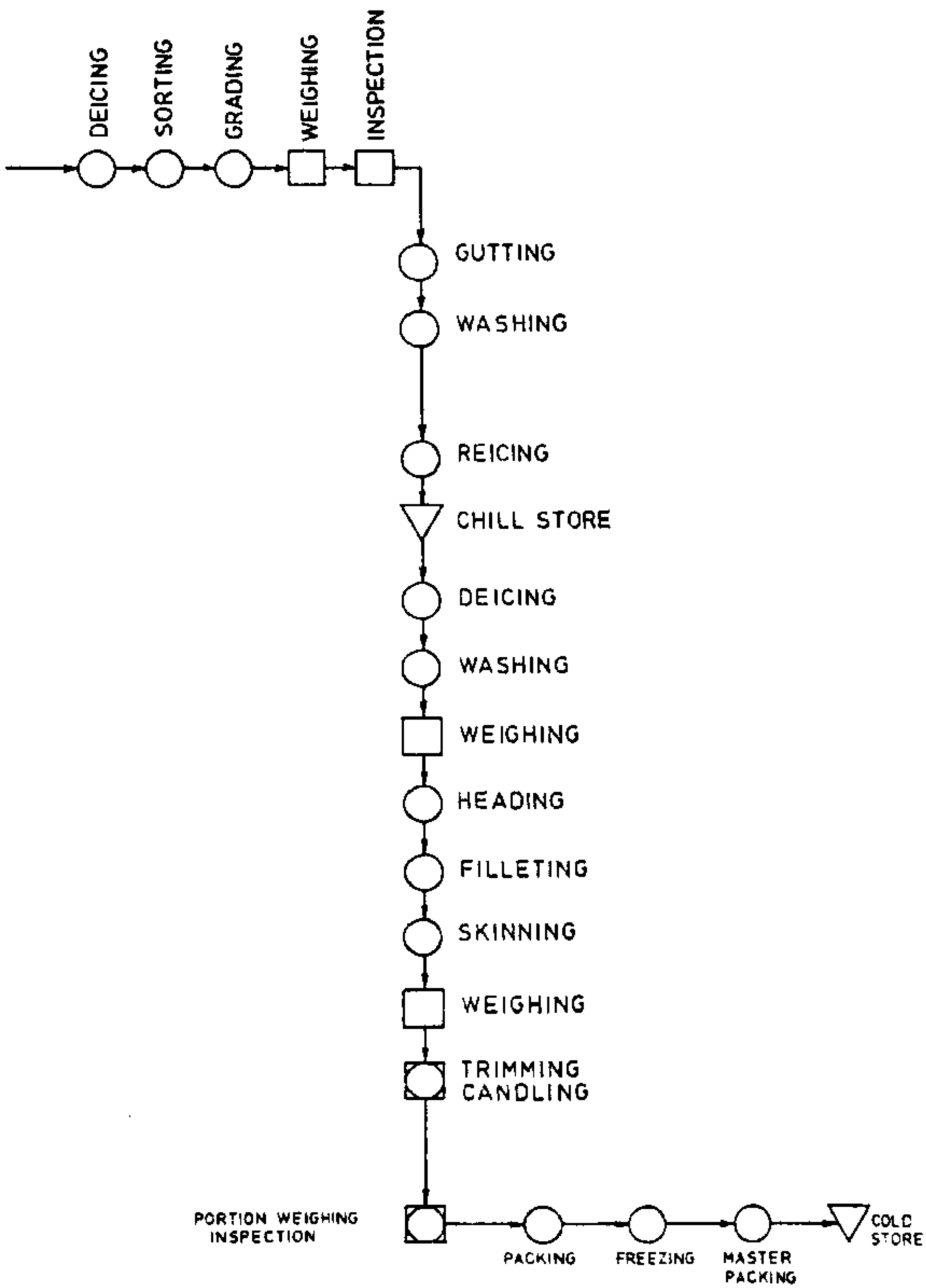


FIGURE 10-B

CONTROL POINTS AND BUFFER - PACIFIC COD



place either before or after grading. The fish are then fed to the gutting machine and washed. If the fish are not to be processed immediately, they are iced in boxes for storage in a chill store. The fish are then deiced again before further processing.

After gutting, washing, and storage in chill store, the fish can be weighed for controlling the production yield.

Following the weighing operation, the fish are transported to the heading machine; from there to the filleting machine, and then to the skinning machine, before manual candling and trimming.

Prior to the candling line is a weighing station, where the fillets are weighed in boxes containing the approximate contents of one freezing frame. The fillets then are transported in the boxes to each working place where they are candled and trimmed. After inspection and trimming, the fillets are control-weighed and transferred to the packing line. After packing, the fillets are put into freezing frames. The frames are placed in a freezing rack and the fillets are frozen in a plate freezer. The fillets can also be individually frozen with subsequent vacuum-packing.

After freezing, the fillets are masterpacked and the finished product goes to the cold store.

Yield (Table 10-A and Figure 10-C)

To determine the total yield, the raw material purchased and also the finished products sold must be weighed. Production yield is determined by weighing the raw materials drawn from storage and/or receiving area and the frozen finished products entering the cold store. By weighing before and after trimming, the intermediate yield for the filleting and trimming processes can be determined.

The quality of the raw material is inspected before processing and the fillets are inspected during or after trimming.

Processing of Alaska Pollock

The fish is dumped into the deicing machine (Figure 10-D). Mixed species catch is sorted according to species. If necessary, the pollock is graded to fit the processing machines. Weighing and inspection can take place before or after grading.

The fish are headed in the heading machine. After heading, the fish are collected on a conveyor and the roe is removed from the females.

TABLE 10-A

YIELDS FROM COD

Component	Ungutted Weight %	Gutted Weight %
Head	21	25
Guts	7 (5-8)	
Liver	5 (2-7)	
Roe	4 (1-7)	
Backbone	14	16
Fins and belly flaps	10	12
Skin	3	4
Fillets, skinned	36	43
Total	100	100

FIGURE 10-C

MATERIAL FLOW - PACIFIC COD

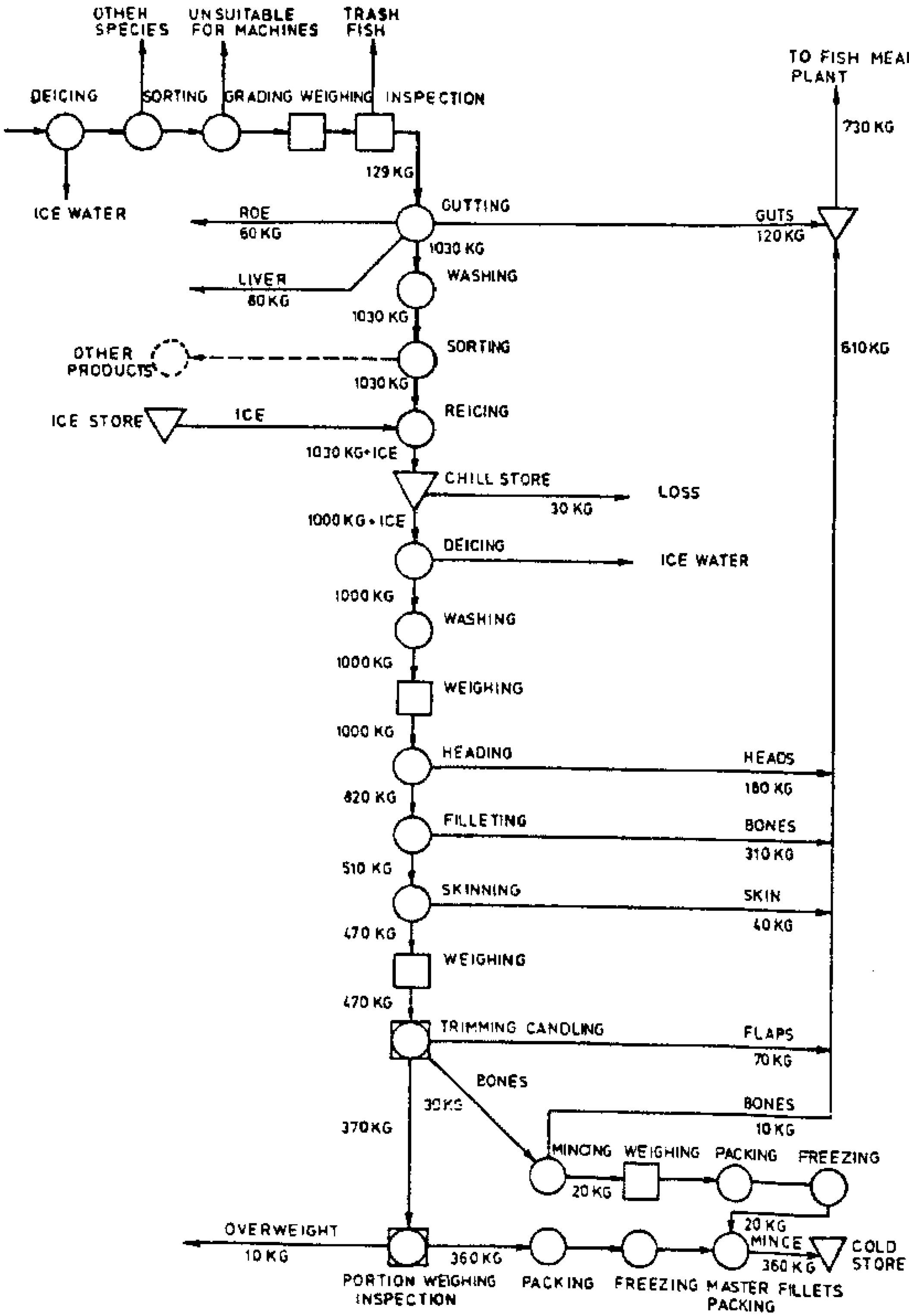
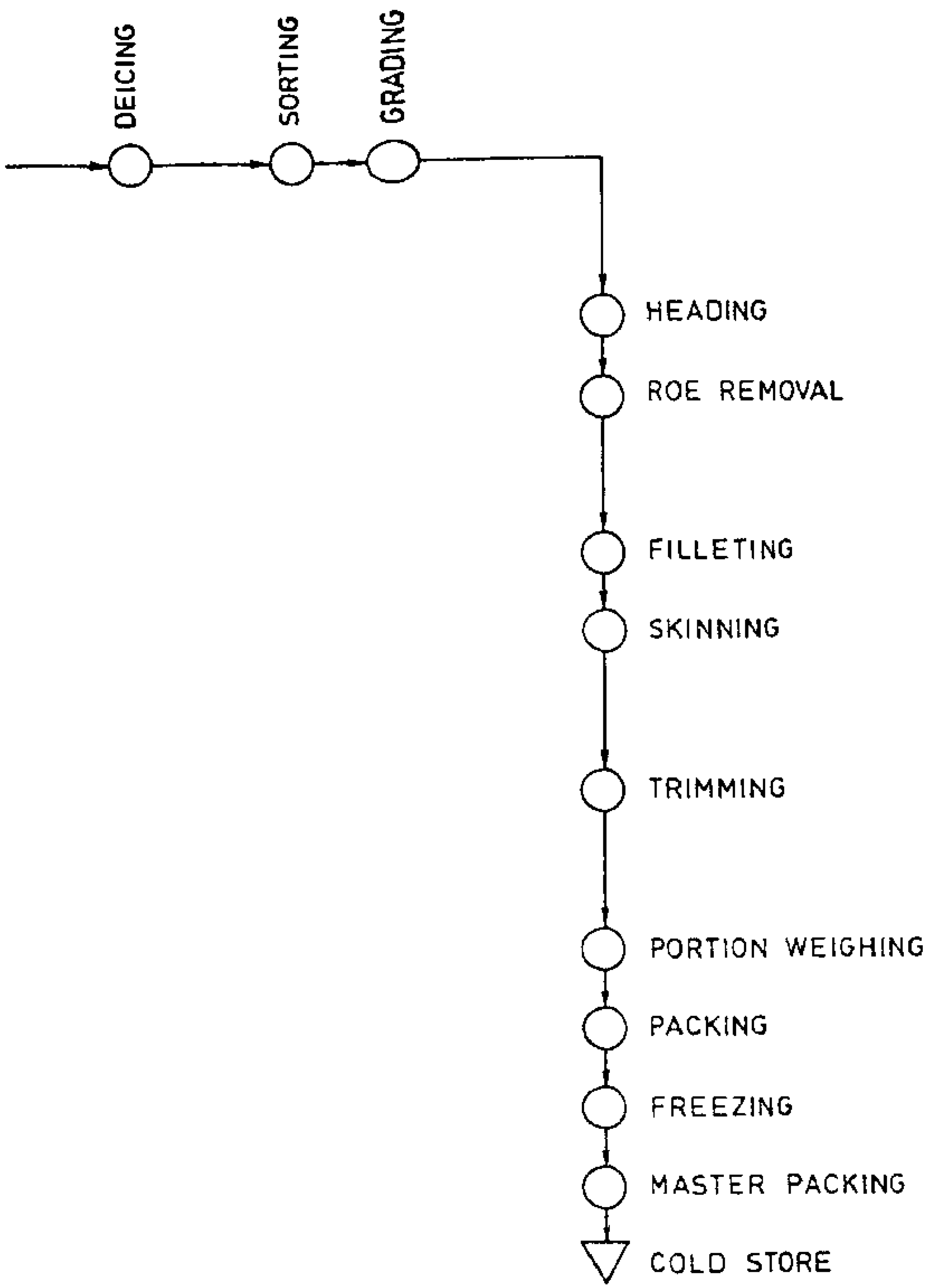


FIGURE 10-D

BASIC PROCESSES - ALASKA POLLOCK



After roe-removal, the fish are transported to the filleting and skinning machine. The skinned fillets are transported to the treatment line, where they are weighed in boxes containing the approximate contents of one freezing frame.

After trimming and inspection, the fillets are control-weighed. The product can be block-frozen and packed in two-section freezing frames and frozen in a plate freezer.

After freezing, the blocks are separated from the frames and masterpacked.

The finished product goes to the cold store.

The process control points (Figure 10-E) are essentially the same as those used in the processing of Pacific cod.

Intermediate yield for the roe collection would be of interest here.

Processing of Pacific Ocean Perch

The fish are dumped into the deicing and washing machine (Figure 10-F).

For mixed species catch, sorting is necessary.

After weighing and inspection, the fish are transported to the scaling machine and then conveyed to the filleting machines. The fillets that leave the machine are either transferred to the skinning machine for skinless fillets, or the skinning machine is by-passed for skin-on fillets.

The fillets are transported to the treatment line, where they are weighed in boxes containing the approximate contents of one freezing frame. The fillets are transported in circulation boxes to each working place. The fillets are inspected and trimmed on the working tables, control-weighed and transferred to the packing line. The fillets can be block-packed in freezing frames and frozen in a plate freezer.

After freezing, the blocks are separated from the frames and masterpacked, and the finished product goes to the cold store.

The process control points (Figure 10-G) are essentially the same as for cod.

FIGURE 10-E

CONTROL POINTS AND BUFFER - ALASKA POLLOCK

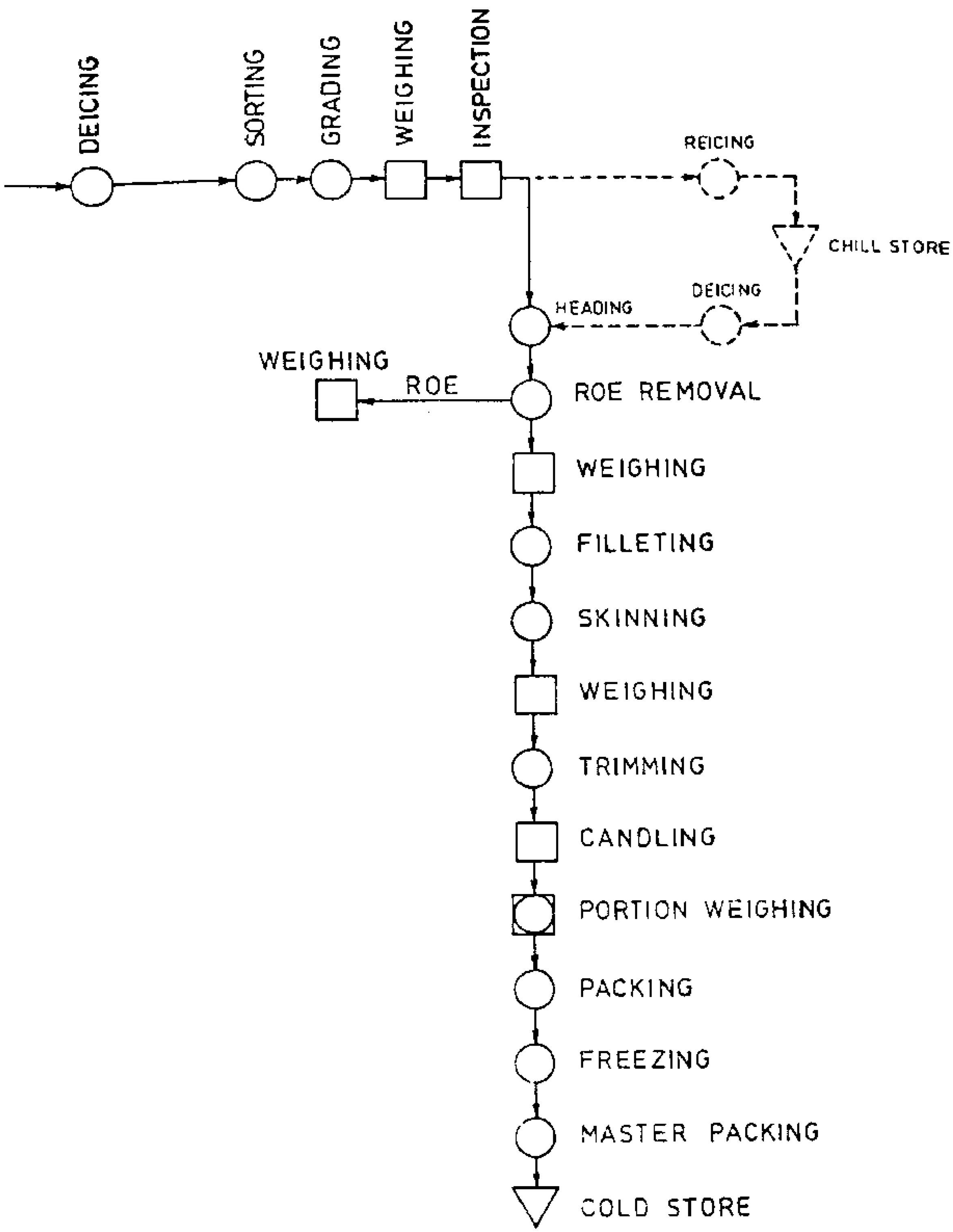


FIGURE 10-F

BASIC PROCESSES - PACIFIC OCEAN PERCH

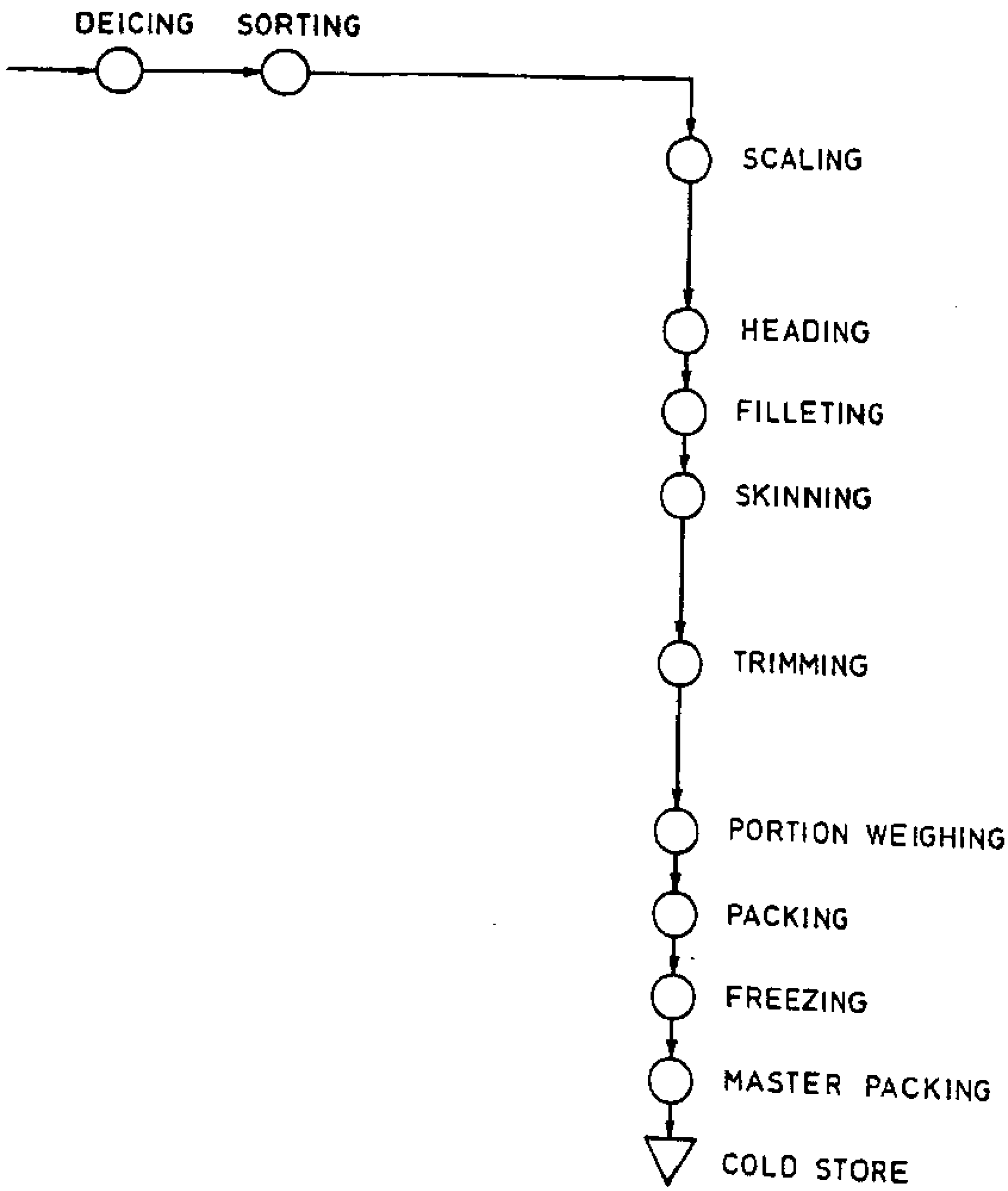
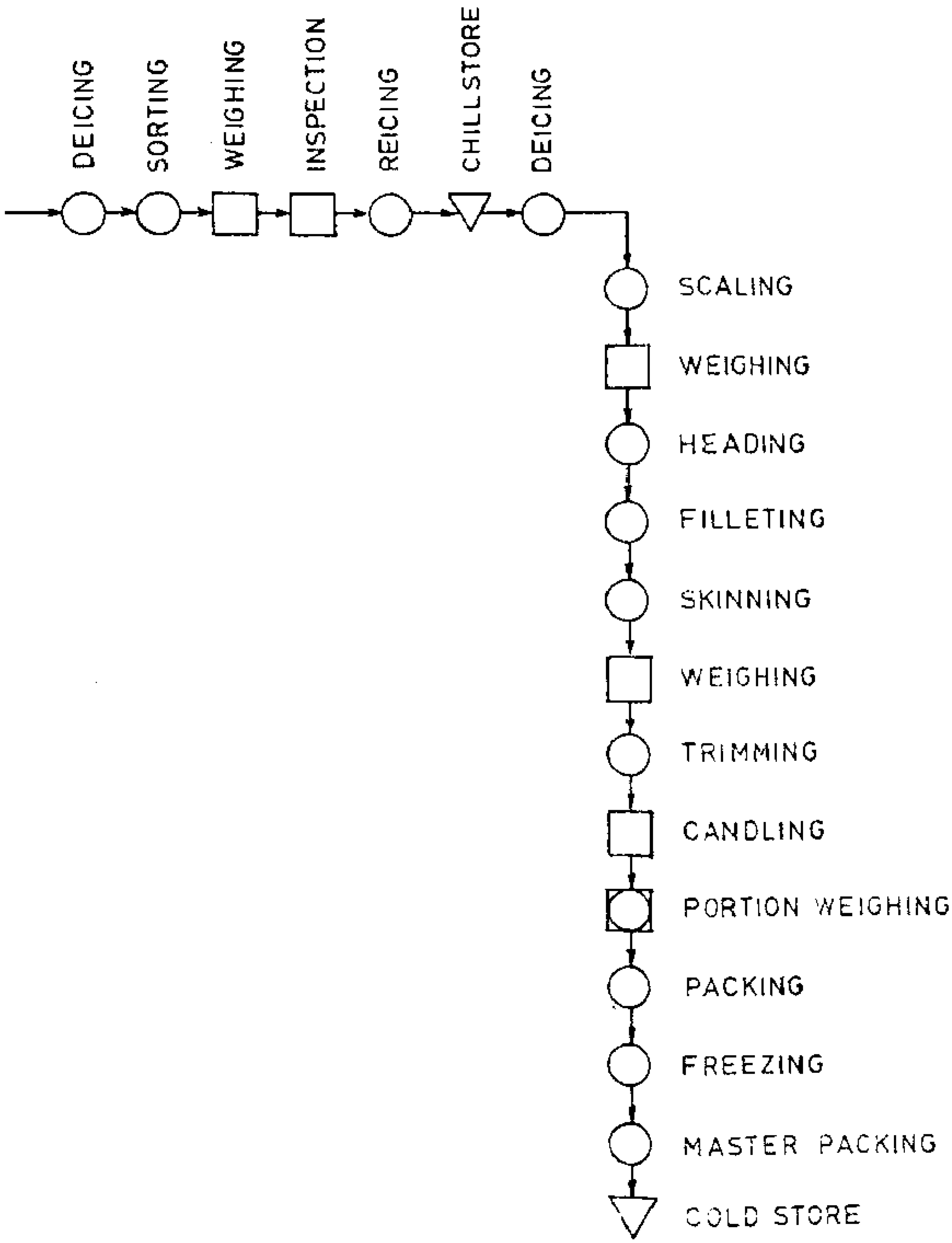


FIGURE 10-G

CONTROL POINTS AND BUFFER - PACIFIC OCEAN PERCH



Processing of Flounders

After inspection and weighing, the sorted and graded fish are transferred to the gutting line (Figure 10-H).

The gutted fish are collected in boxes and are either re-iced and stored in the raw material store or transferred to the heading and filleting machine (Figure 10-I).

After leaving the filleting machine, the fillets are either skinned on a skinning machine, for skinless fillets, or they by-pass the skinning machine as skin-on fillets.

The fillets are transferred in boxes to the trimming tables, where they are trimmed and inspected.

After trimming, the fillets can be either block-frozen or single frozen. The IQF-fillets are portioned, vacuum-packed and packed in masters and transferred to the cold store.

FIGURE 10-H

BASIC PROCESSES - FLOUNDER

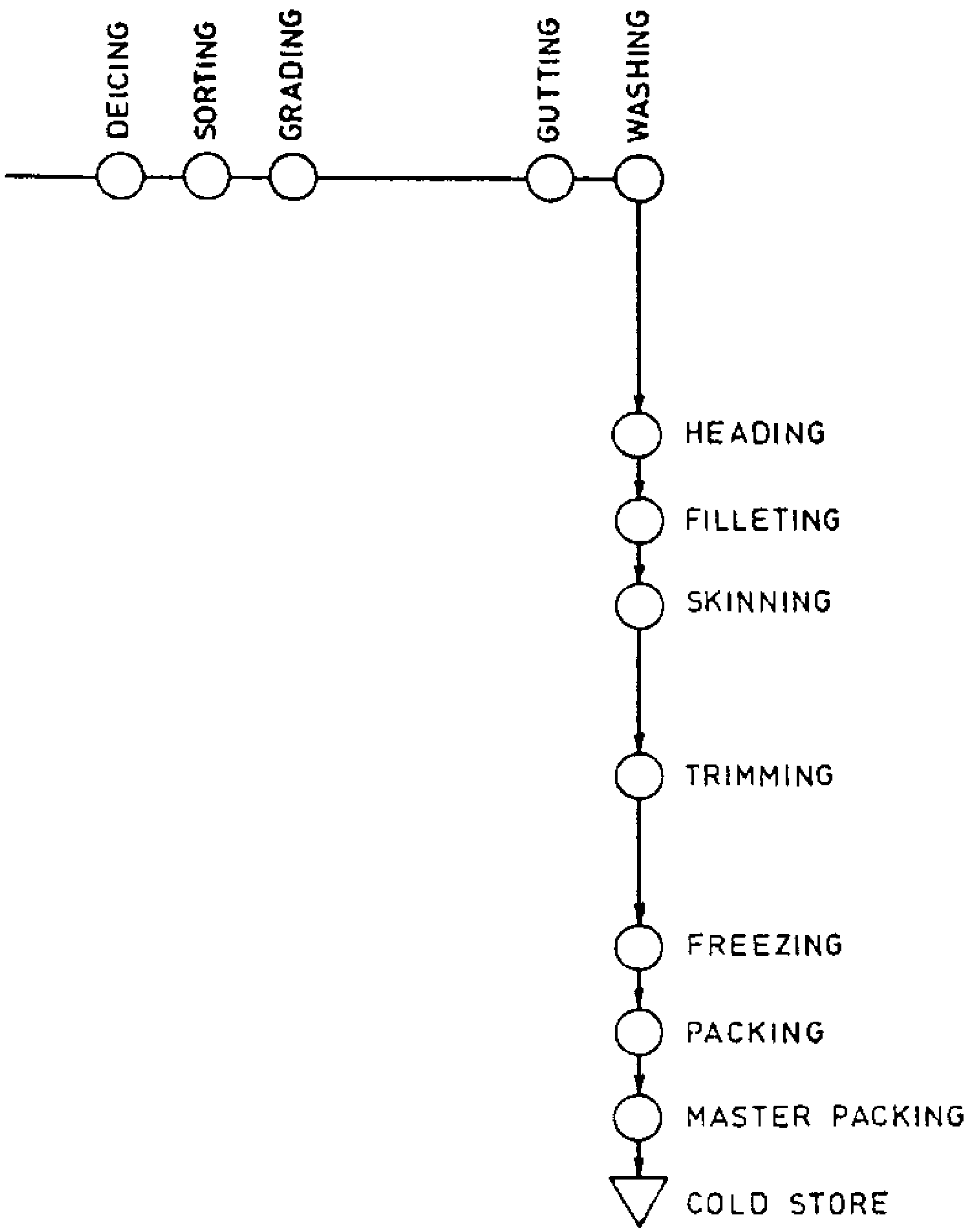
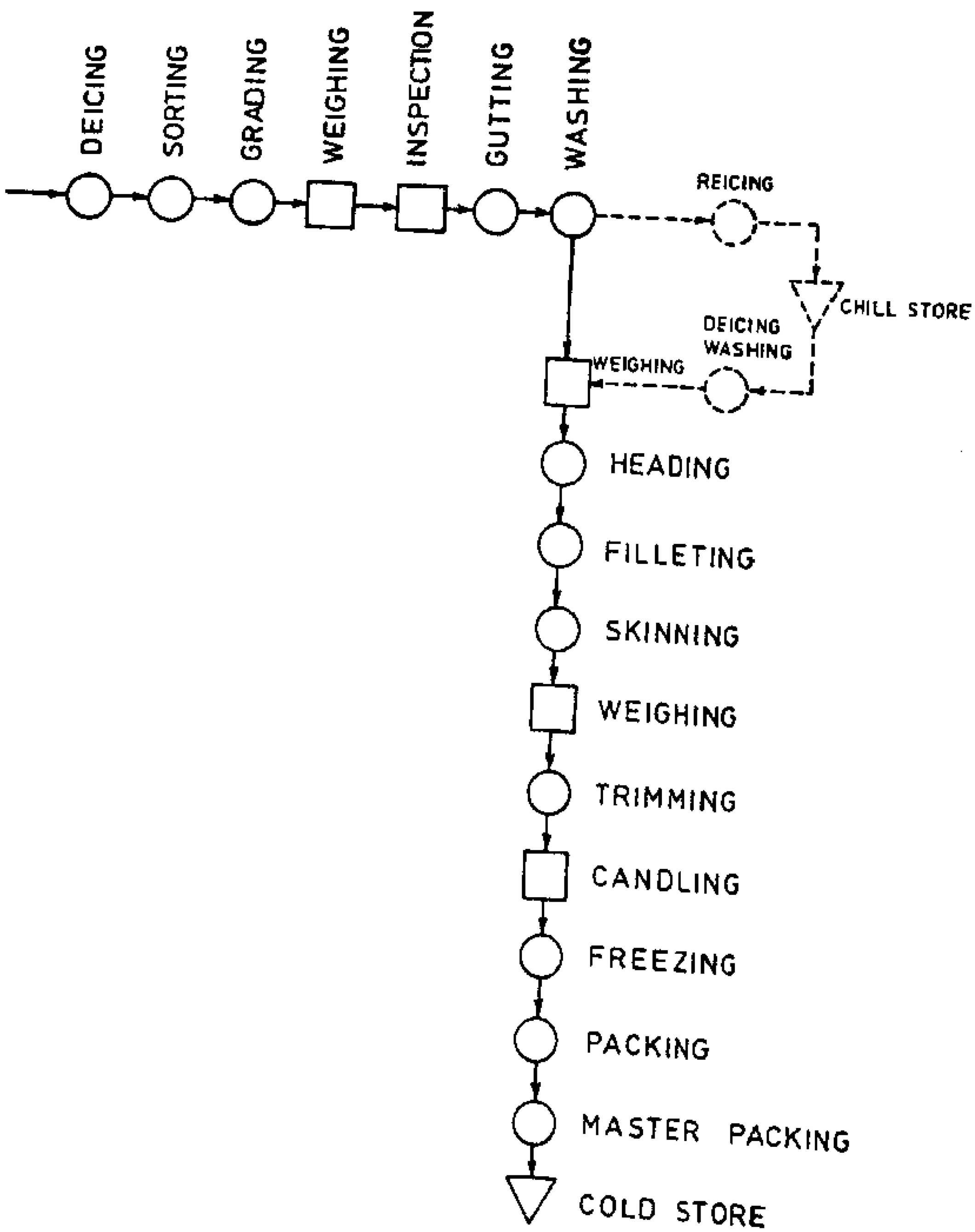


FIGURE 10-I

CONTROL POINTS AND BUFFER - FLOUNDER



PART VI

INDUSTRIALIZATION OF WHITE FISH PROCESSING

CHAPTER 11

PRODUCTION LINES

Kai Kaersgaard

Machines for White Fish Processing

This chapter describes some special purpose machinery available in Europe for grading, gutting, washing, heading, filleting, skinning, freezing, and deboning.

Machines are not always the solution to a production problem; they may be expensive to buy and maintain, and are sometimes less flexible and less productive than a trained worker. Nevertheless, machine-washed fish are better than unwashed fish, machine gutted fish are better than ungutted fish, and a steady fillet yield of 45 percent over long periods may be more economic than the 50 percent achieved by the best hand filleters at the peak of their performance.

Grading Machines

A grading machine for ungutted white fish such as cod and haddock is made by C.F. Wilson & Co. Ltd., Scotland. Its main purpose is to select a size range suitable for a gutting machine by removing all fish that are too large or too small. It uses two pairs of parallel rollers inclined at a small angle and set one above the other. Fish in the required size range fall through the top rollers but are held by the bottom rollers and conveyed to the gutting machine. This machine can handle about 10 metric tons of fish per hour. Power and water consumption is 0.8 hp and 2.6 US gallons per minute. Wilson also makes a machine specially for grading gutted haddocks.

A machine for separating large food fish from smaller fish intended for fish meal production is manufactured by IRAS, Denmark. The fish is lifted into a receiving hopper, where the larger fish is kept back by a coarse grid. A conveyor takes the fish to a separating drum in a uniformly regulated stream; this will separate round as well as flat fish of a certain size from the smaller industrial fish.

Gutting Machines

British, German and Danish machines are available commercially for shipboard gutting of round white fish species such as cod, haddock and whiting. For onshore gutting of fish, more machines are available.

For shipboard gutting the following machines can be mentioned: From Wilson, Shetland ONE 7, TWO 2 and TWO 8; from Kronborg, Denmark, the Jutland Mark III; and from Baader, Germany, the Baader 166. All these machines are fed manually, and the speed at which this can be done largely determines the gutting rate. The Shetland and Jutland machines use a sawtooth type of cut, while the Baader machine uses a circular knife. Livers are broken up and mixed with other offal in the waste from the Shetland and Jutland machines, whereas livers from the Baader 166 usually remain whole and can be separated from the guts afterwards. The standard of gutting in these machines is equal to that of hand gutting of a good standard.

The gutting rate lies between 25 and 45 fishes per minute, in the size range of fish from 10 to 36 inches.

From Baader, the following machines for white fish are also available: Nos. 158, 159 and 162.

Several prototype machines for gutting flatfish species have been tried and demonstrated, but none has yet become available commercially, as far as we know.

Washing Machines

A wide range of washing machines has been manufactured, often to the customer's special requirements, for use on white fish. Two main types have evolved, those which move the fish through a spray, and those which move the fish through a bath. In a Humber washer, the fish are swirled round in an open bath by opposing jets of water for a few minutes before being discharged over a weir.

Spray washers are typically inclined rotating drums filled with an internal spiral and a succession of spray nozzles. The fish are tumbled through the drum by the rotating spiral and the waste water drains away through holes, slits or open meshes in the drum wall.

The drum may be of circular or hexagonal cross section, up to about 120 inches long and 20 to 30 inches in diameter. Commercial models are available from Wilson, Baader, and Arenco.

Typical capacity is about 4 to 10 tons per hour, power supply 1 hp, and water consumption 10 to 50 US gallons per minute. Some models manufactured: from Baader, types 666, 670, and 677; from Arenco, types STR 450, STR 900 and STF.

Heading Machines

Some heading machines accept ungutted fish (actually they are heading and gutting machines), while others accept only gutted white fish. Heading machines usually head the fish by cutting in a semi-circle, V-cut, so that only the head and collar bones are cut off, saving the neck meat. Other machines make a straight cut at various angles and can therefore head practically all types of fish.

Arenco manufactures heading machines for small white fish in the size range 10 to 18 inches (CIV) and for larger fish in the size range 14 to 30 inches (CUB). Baader manufactures heading machines for fish sizes ranging from 12 to 47 inches: models 410, 412, 413, 415, 417, and 423. Models 160 and 161 are both heading and gutting machines. Power consumption ranges from 1 to 4 hp and water consumption between 1 and 7 gallons per minute.

Filleting Machines

Filleting machines are available commercially for a number of species of white fish. Because of the considerable differences in shape and structure between species, and the need to remove the maximum amount of bonefree flesh, filleting machines are usually designed to process only one or two species, and to make only one kind of product; for example, single fillets or block fillets.

Accurate fish measuring mechanisms are essential so that cutters automatically adjust precisely to any size of fish within the range of the machine.

Machines can rarely do better than hand filleters in obtaining maximum yield, but higher output often compensates for slight loss of yield. Some filleting machines take gutted fish with heads on and remove the head in the sequence of operations, but most models require the fish to be headed first.

Arenco manufactures the SFA-4 filleting and skinning machine for small white fish and CUD for larger white fish. Baader manufactures many models for filleting of white fish: for example, model 99 for large fish and models 181, 189, and 190 for smaller fish. Other models for white fish: 121, 183, 187, and 188. For flatfish, models 170 and 175; for perch, 150, 157, and 195.

Skinning Machines

In most types of skinning machines, the tail of a fillet is gripped between knurled rollers and, as the skin is pulled through the rollers, the fillet is separated by an oscillating knife blade. However, on the Trio machine, type FDS, the fillets are conveyed skin uppermost under a rotating refrigerated drum. The skins freeze to the cold surface, a band knife separates flesh from skin, and the skins are subsequently scraped off the drum. On the Baader 50, the fillets are pressed skin downwards on a conveyor belt, and the skins are separated by a band knife, easily adjustable for skin thickness. Other models from Baader are 46, 47, 48, and 51; from Arenco, type CUS-80 for white fish.

Freezers

There are now many different types of freezers available for freezing fish, and freezer operators are often uncertain about which type is best suited to their needs.

Three factors may be initially considered when selecting freezers: (1) financial considerations; (2) logistic considerations; and (3) feasibility.

Financial consideration will take into account both the capital and running cost of the equipment and also likely losses such as product damage and dehydration. Expensive freezers should therefore justify their purchase by giving special benefit and, if these benefits are not worthwhile, they may not need to be considered.

Logistic consideraton should also be taken into account when deciding on a specific type of freezer. A liquid nitrogen freezer (LNF), for instance, may be suitable in every respect for freezing the product, and the high costs of using this method of freezing may be justified. However, if the location of the plant is such that there can be no guaranteed supply of liquid nitrogen, the freezer should not be considered.

Air Blast Freezers

The big advantage of the air blast freezer is its versatility. It can cope with a variety of irregularly shaped products and whenever there is a wide range of shapes and sizes to be frozen, the blast freezer is the best choice. However, because of this versatility, it is often difficult for the buyer to specify precisely the work he expects it to do and, once it is installed, it is all too easy to use it incorrectly and inefficiently.

There are many different designs of air blast freezers, both for batch and continuous operation.

In continuous air blast freezers, the fish move through the freezer, usually entering at one end and leaving at the other. Fish may be moved through the freezer on trucks or trolleys (batch-continuous operation) or they may be loaded on a continuously moving belt or a conveyor (continuous operation).

Batch air blast freezers use pallets, trolleys or shelf arrangements for loading the product. The freezer is fully loaded, and when freezing is complete, the freezer is emptied and reloaded for a further batch freeze.

One type of air blast freezer fluidizes the product with a strong blast of air from below. This type of freezer has not, as yet, had a wide application for fish or fishery products.

Plate Freezers

Plate freezers are the type of freezer most commonly used for freezing fish in industrial countries. Plate freezers do not have the versatility of air blast freezers, and can only be used to freeze regularly-shaped blocks and packages.

Plate freezers can be arranged with the plates horizontal to form a series of shelves and, as the arrangement suggests, they are called horizontal plate freezers (HPF). When the plates are arranged in a vertical plane, they form a series of bins and in this form they are called vertical plate freezers (VPF).

Automatic plate freezers freeze fish in cartons and are a continuous form of the HPF. Automatic plate freezers are specially designed for a processing line, and units with capacities of up to 2 tons per hour are available. Their main advantage is that they save the labor required for the loading and unloading of batch plate freezers. However, when this labor saving is related to the total labor requirements for packing and other operations, the saving is often not significant.

Drum Freezer

The drum freezer is a novel type of continuous contact freezer, which is suitable for a variety of IQF products. The freezer is a rotating drum with pump circulation of a secondary refrigerant used to cool the internal surfaces. The product is placed on the drum and if the product surface is wet, it immediately adheres to the surface of the drum. The drum speed is regulated to give the appropriate freezing time for each product and in completion of one revolution, the frozen product is dislodged by a scraper.

Continuous Freezer with Brine Cooling

This freezer uses a refrigerated brine to cool a conveyor belt made from stainless steel sheet. The product to be frozen is placed on the upper surface of the belt and, as it is conveyed through the freezer, a refrigerated brine is sprayed onto or pumped across the lower surface.

Liquid Nitrogen Freezer

In this freezer, the product is brought into direct contact with the refrigerant. The fish on a stainless steel conveyor belt initially come into contact with a countercurrent flow of nitrogen gas, and as the fish progress through the freezer, the temperature of the cooling gas progressively falls. The remaining heat transfer takes place in a small area below sprays of liquid nitrogen.

Other Freezers

Other types are, for instance, liquid freezant freezers (LFF) which use a specially purified form of R 12; carbon dioxide freezers; and immersion freezers.

Bone Separators

Bone separators separate fish flesh from bones and skin by extruding the flesh mince through a perforated drum. The use of bone separators enables the processor to recover some or all of the 15 percent still remaining of edible flesh on the parts discarded after filleting. Belly flaps, "V" cuttings containing pinbones, and other trimmings in addition to the main frame of the fish, can be processed in a bone separator. Typically a tough elastic belt presses the waste fish into the outside of a perforated stainless steel drum, the flesh is squeezed through the holes into the drum, while bones and skin are scraped off the outside of the drum and discharged to waste. A screw conveyor pushes the flesh through the drum to a collecting point.

Baader manufactures bone separators, models 694 and 695; and Bibun bone separators are manufactured in Japan.

Production Line Examples

In this section some examples of possible production lines will be shown. It is assumed that the raw material arrives at the plant in containers or fish boxes, iced, sorted and ungutted.

In the receiving area, the raw material will be weighed, gutted and re-iced if necessary, and stored in the chill room, where it remains until it is taken out for processing in accordance with the production schedule, or it is transported directly to the processing room for deicing.

The fish is dumped into the deicing and washing machine. An elevator brings it to the conveyor and the fish is transported to the production line proper.

After processing on the production line, the fish are packed, frozen and transferred to the cold store.

Figures for capacity are for maximum capacity.

PACIFIC COD FILLETING LINE

Capacity: 4,500 tons per year
4,500 : 200 = 22.5 t/day
22,500 kg : 8 h = 2,812 kg/h
weight = 1.125 fish/h : 60 = 19 fish/min.

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1. BAADER: (Figure 11-A)

One Heading Machine "BAADER 410"

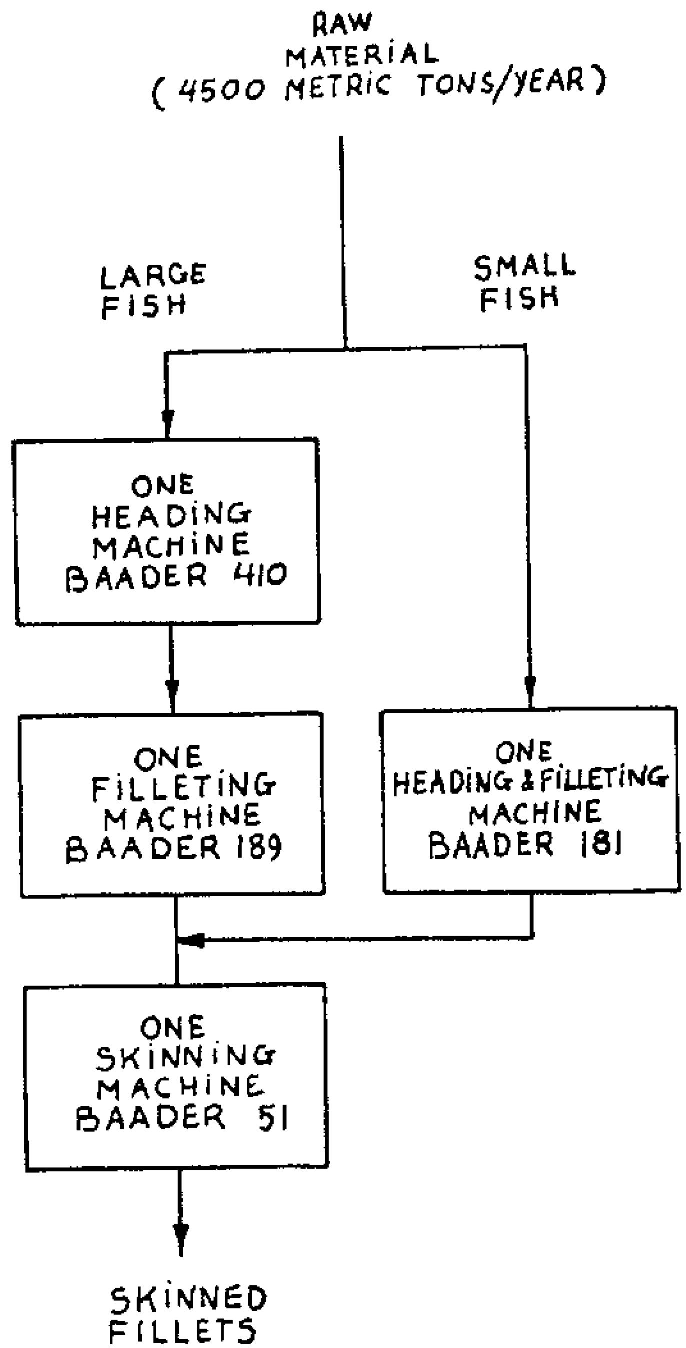
Fish size range	:	17-3/4 - 33-1/2 in
Capacity	:	max 34 fish/min
Operator	:	one person
Power requirement	:	3.7 hp
Water consumption	:	2.6 US gal/min
Net weight	:	2,470 lbs

One Filleting Machine "BAADER 189"

Fish size range	:	16 - 33-1/2 in
Capacity	:	34 fish/min
Operator	:	one person
Power requirement	:	4 hp
Water consumption	:	4 US gal/min
Net weight	:	2,340 lbs

FIGURE 11-A

FILLETING LINE FOR PACIFIC COD - BAADER



One Skinning Machine "BAADER 51"

Belt width	:	16 in
Capacity	:	100 fillets/min
Operator	:	one person
Power requirement	:	2.0 hp
Water consumption	:	2.6 - 3.2 US gal/min
Net weight	:	660 lbs

One Heading and Filleting Machine "BAADER 181"

Fish size range	:	10 - 16 in
Capacity	:	40 fish/min
Operator	:	one person
Power requirement	:	3.0 hp
Water consumption	:	2.9 - 3.4 US gal/min
Net weight	:	1,200 lbs

2. ARENCO: (Figure 11-B)

One Heading Machine "ARENCO CUB"

Fish size range	:	14 - 30 in
Capacity	:	40 fish/min
Operator	:	one person
Power requirement	:	2.7 hp
Water consumption	:	1.3 US gal/min
Net weight	:	440 lbs

One Filleting Machine "ARENCO CUD"

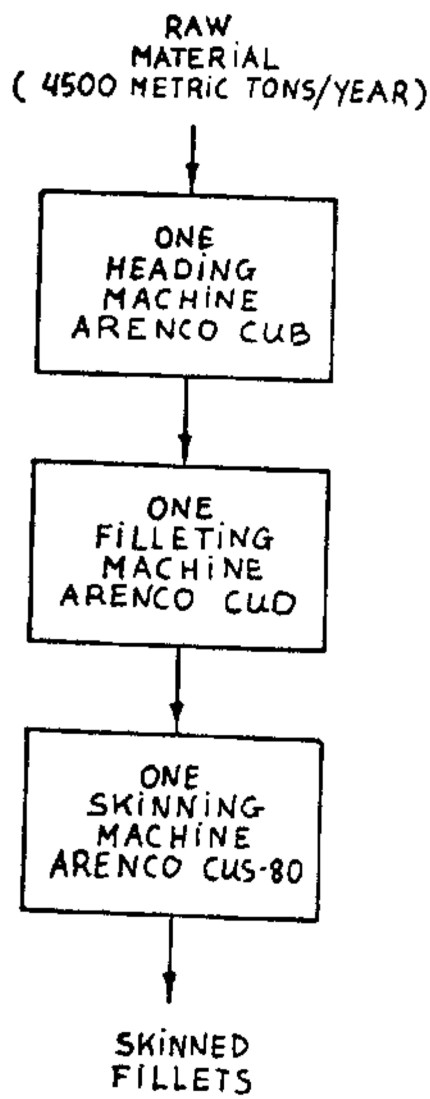
Fish size range	:	14 - 30 in
Capacity	:	40 fish/min
Operator	:	one person
Power requirement	:	2.3 hp
Water consumption	:	2.6 US gal/min
Net weight	:	2,140 lbs

One Skinning Machine "ARENCO CUS-80"

Belt width	:	14 in
Capacity	:	60 - 80 fillets/min
Operator	:	one person
Power requirement	:	2.0 hp
Water consumption	:	5.3 US gal/min
Net weight	:	600 lbs

FIGURE 11-B

FILLETING LINE FOR PACIFIC COD - ARENCO



ALASKA POLLOCK FILLETING LINE

Capacity: 10,000 tons per year
10,000 : 200 = 50 t/day
50,000 kg : 8 h = 6,250 kg/h
6,250 : 0.450 kg average fish weight =
13,900 : 232 fish/min

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1. BAADER: (Figure 11-C)

Seven Heading & Gutting Machines "BAADER 160"

For each machine:

Fish size range	:	14 - 27 in
Capacity	:	40 fish/min
Operators	:	one person
Power requirement	:	2.0 hp
Water consumption	:	6.6 US gal/min
Net weight	:	1,430 lbs

Five Filleting Machines "BAADER 190"

For each machine:

Fish size range	:	13 - 26 in
Capacity	:	55 fish/min
Operators	:	one person
Power requirement	:	6.3 hp
Water consumption	:	10.6 US gal/min
Net weight	:	3,300 lbs

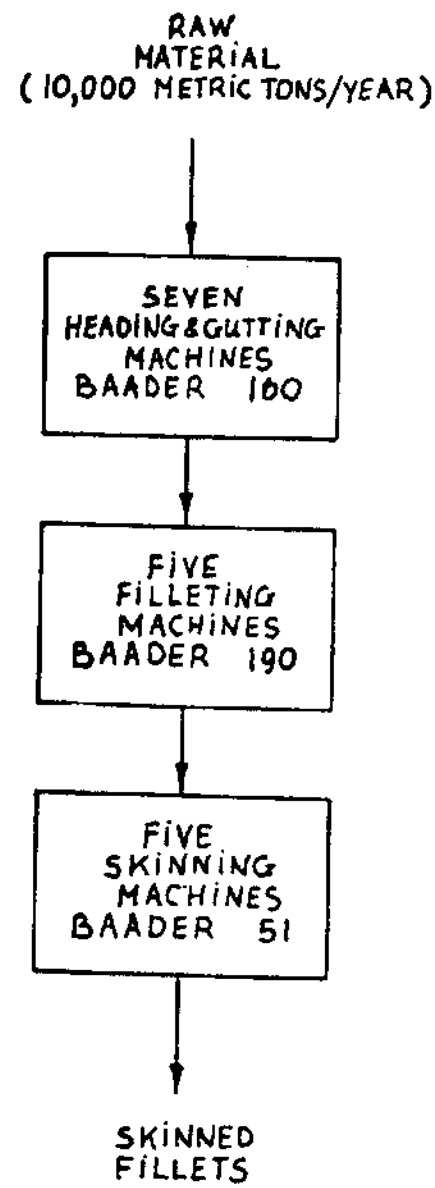
Five Skinning Machines "BAADER 51"

For each machine:

Belt width	:	16 in
Capacity	:	100 fillets/min
Operators	:	none
Power requirement	:	2.0 hp
Water consumption	:	2.6 - 3.2 US gal/min
Net weight	:	660 lbs

FIGURE 11-C

ALASKA POLLOCK FILLETING LINE - BAADER



2. ARENCO: (Figure 11-D)

<u>One Heading Machine "ARENCO CIV"</u>

Fish size range	:	10 - 18 in
Capacity	:	120 fish/min
Operators	:	two persons
Power requirement	:	1 hp
Water consumption	:	5.3 US gal/min
Net weight	:	750 lbs

<u>Two Filleting & Skinning Machines "ARENCO SFA-4"</u>

For each machine:

Fish size range	:	10 - 18 in
Capacity	:	50 - 60 fish/min
Operators	:	one person
Power requirement	:	2.0 hp
Water consumption	:	5.3 US gal/min
Net weight	:	1,210 lbs

3 lines are required.

PACIFIC OCEAN PERCH FILLETING LINE (Figure 11-E)

Capacity: 10,000 tons per year
10,000 : 200 = 50 t/day
50,000 kg : 8 h = 6,250 kg/h
6,250 : 0.7 kg average fish weight =
8,930 fish : 60 min = 150 fish/min

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<u>Four Heading & Filleting Machines "BAADER 150"</u>

For each machine:

Fish size range	:	12 - 22 in
Capacity	:	40 fish/min
Operators	:	two persons
Power requirement	:	5.4 hp
Water consumption	:	7.9 - 10.6 US gal/min
Net weight	:	5,510 lbs

FIGURE 11-D

ALASKA POLLOCK FILLETING LINE - ARENCO

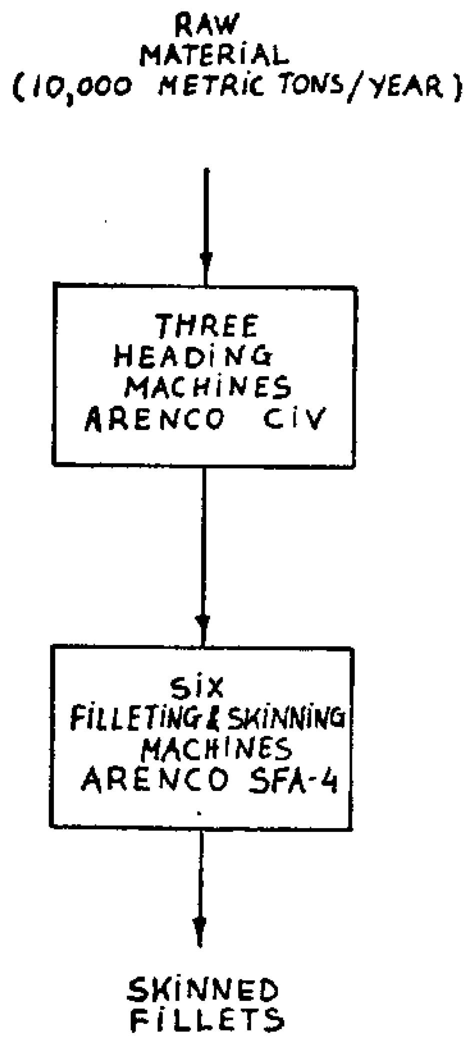
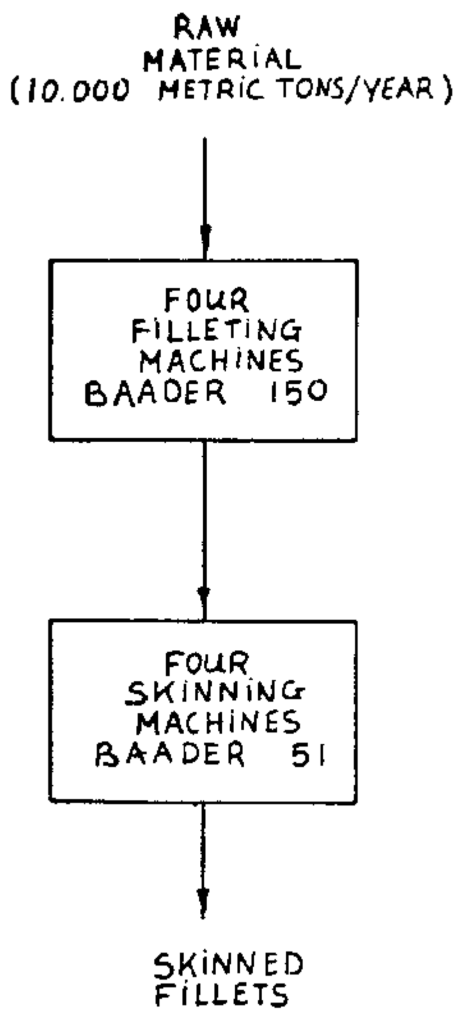


FIGURE 11-E

PACIFIC OCEAN PERCH FILLETING LINE - BAADER



Four Skinning Machines "BAADER 51"

For each machine:

Belt width	:	16 in
Capacity	:	100 fillets/min
Operators	:	none
Power requirement	:	2.0 hp
Water consumption	:	2.6 - 3.2 US gal/min
Net weight	:	660 lbs

FLOUNDER FILLETING LINE (Figure 11-F)

Capacity: 2,000 tons per year
2,000 : 200 = 10 t/day
10,000 kg : 8 h = 1,250 kg/h
1,250 kg : 0.6 kg average fish weight =
2,085 fish : 60 min = 35 fish/min

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One Heading & Filleting Machine "BAADER 175"

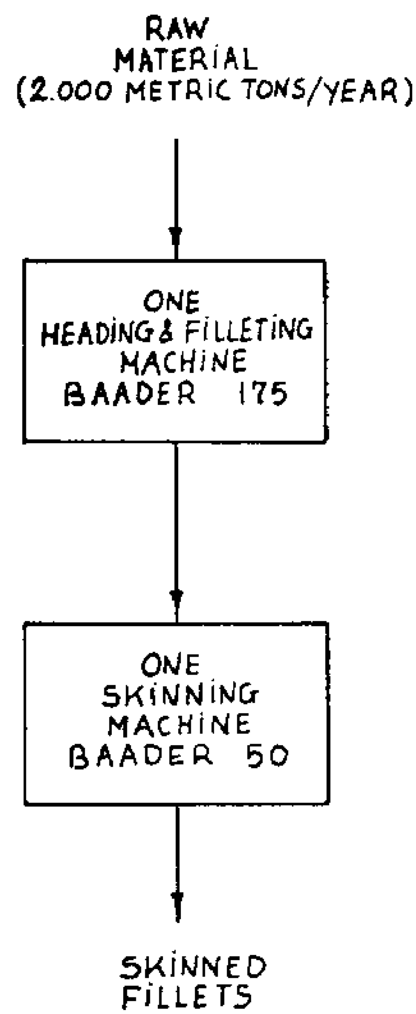
Fish size range	:	12 - 21 in
Capacity	:	40 fish/min
Operators	:	two persons
Power requirement	:	5.4 hp
Water consumption	:	4 US gal/min
Net weight	:	2,769 lbs

One Skinning Machine "BAADER 50"

Fillet size range	:	up to 14 in
Capacity	:	up to 100 fillets/min
Operators	:	two persons
Power requirement	:	2.2 hp
Water consumption	:	4 US gal/min
Net weight	:	990 lbs

FIGURE 11-F

FLOUNDER FILLETING LINE - BAADER



Instead of BAADER and ARENCO skinning machines, a skinning machine from TRIO, Norway, could be used:

<u>One Skinning Machine "TRIO FDS"</u>

Width of belt	:	12 in
Capacity	:	300 fillets/min
Operators	:	one or more persons
Power requirement	:	7.0 hp
Water consumption	:	4.8 US gal/min
Net weight	:	1,980 lbs

CHAPTER 12

PLANT LAY-OUT

Kai Kaersgaard

Processing Areas

Receiving Area

The raw material for processing, iced in boxes or containers, is received in this area for sorting, grading, and inspection.

Holding Area (Chill Room)

This is for storage of raw material not to be processed immediately on arrival at the plant; such as gutted fish taken directly from the fishing vessel or fish gutted in the plant.

The fish should be well iced in clean containers and the temperature in the chill room should be 33 to 34°F.

Gutting Area

For gutting of ungutted fish from fishing vessels. Equipment for removal of offal should be in this area.

Area for Washing of Fish

The washing and/or scaling of fish takes place in this area, immediately before the fish go to the filleting lines.

Area for Washing of Boxes and Containers

This area contains machines for washing of boxes and containers used for transportation of fish.

Machine Filleting Area

Here the fish is headed, filleted and skinned in machines. There should be processing lines suitable for both large and small fish. Conveyors for transporting the fish to and from the area and between processing machines should also be in this area.

Manual Filleting Area

Manual filleting lines can be in the same area as the machine filleting lines, but a separate area alongside the machine filleting area is a better choice, because of the noise from the filleting and skinning machines.

Trimming and Packing Area

Here trimming, candling, packing and weighing of fillets takes place. This area must be maintained in a clean condition: adequate lighting, air condition and proper temperature are important factors.

Water for cleaning should be supplied to each trimming table. The trimming, packing and weighing can be done on the same table (parallel line) or on separate tables in series.

Freezing Area

This area contains equipment for the freezing of the finished products.

Area for Washing of Boxes and Freezing Frames

This area is used for washing of fillet boxes, weighing boxes and freezing frames.

Area for Emptying of Frames and Masterpacking

Here emptying of freezing frames takes place, and the finished product is masterpacked. This area could also be used for labeling of the finished product.

Chilling Area for Fillets

It is convenient to have an area for chilling of unfrozen fillets, which for some reason must wait for further processing. The temperature should be 33 to 34°F.

Mincing Area

Minced fish is produced in this area. Since this is a separate process, it should take place in a separate area. Clean and hygienic handling of raw material and product is important.

Cold Storage

Here the frozen product is kept at the proper temperature until shipment. The temperature should be -10°F (-23°C) to -20°F (-29°C), depending on species, type of product and intended time of storage.

Offal Container

Offal containers are used for intermediate storage of fish offal for pet food or fish meal production.

Secondary Areas

Secondary areas have direct access to the processing areas, but are not actually part of the processing lines themselves. These areas are:

- Ice silo
- Ice production
- Foreman room
- Packing material store
- Knife sharpening and store room for knives
- Storage for tools
- Room for refrigerating machinery
- Storage for refrigerants
- Workshops and spare parts
- Chlorination equipment room
- Waste disposal

Additional areas are the following:

- Offices
- Service facilities in the receiving area such as:
  - Toilets
  - Room for changing clothes
  - Cloakroom

- General personnel facilities
  - Entrance
  - Corridors
  - Staircases
  - Cloakrooms
  - Changing room
  - Toilets
  - Cleaning rooms
  - Reception and delivery of working clothes
  - Laundry and drying room
  - First-aid room
  - Canteen
  - Kitchen
  - Food store
- Service facilities for engineers

Further general areas common to most industrial plants

- Boiler room
- Electrometers
- Transformer station
- Air conditioner
- Various store rooms

Planning the Lay-out

Proper Product Flow

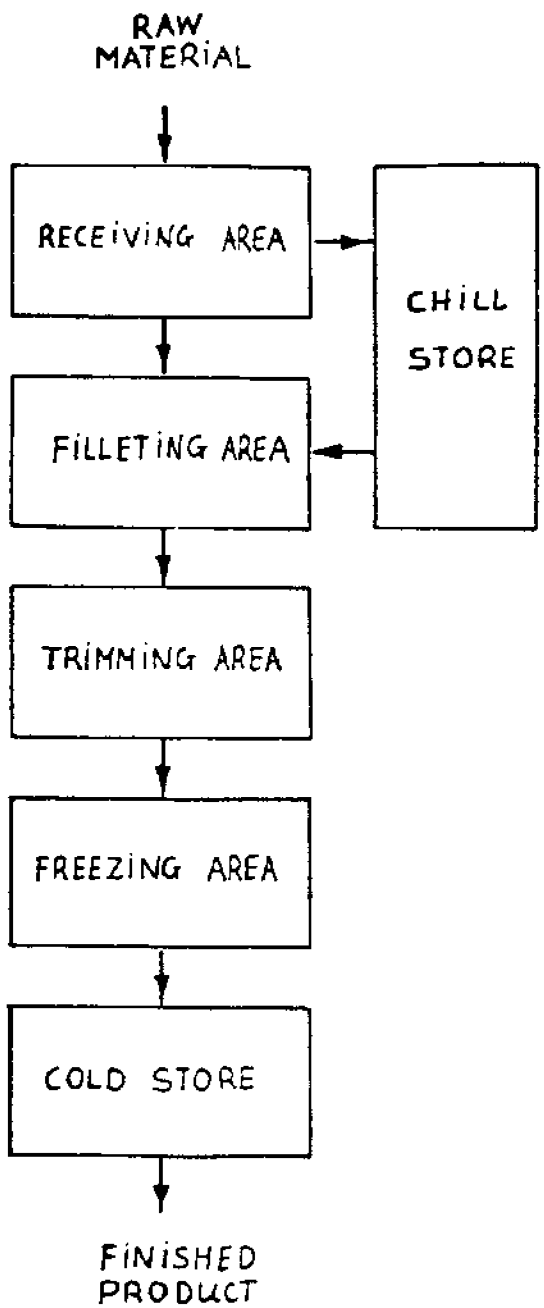
Plants for processing of white fish should be designed and equipped so that all handling and processing can be carried out efficiently. (Figure 12-A)

The fish enter the receiving area first where they are deiced, washed, sorted, graded and inspected. This area should be separate and closed off from other areas. Thereafter, the fish are either processed or sent to the chill store. Before they go to the chill store, they should be reiced, and when drawn from the chill store, they should be deiced and perhaps washed. If they are to be processed at once, they are directed to the filleting area immediately. Therefore, the plant should be designed so that the fish can move from the receiving area directly to either the chill store or the filleting area, and also directly from the chill store to the filleting area.

After heading, filleting and skinning, the fillets go to the trimming and packing area. The filleting and packing area is in fact two separate sections, usually divided by a wall through

FIGURE 12-A

WHITE FISH PROCESSING PRODUCT FLOW THROUGH PLANT



which the fillets are passed. After trimming, weighing, packing and candling, the packed fillets are sent to the freezing area. It is also desirable to have the freezing area separate from the trimming and packaging area. The finished product is masterpacked and transferred to the cold store.

It is important that the fish are processed in as short a time as possible as each delay will increase spoilage. If a delay occurs before the fillets are frozen, they should be chilled in the meantime. At higher temperatures, a delay can have serious effects on the quality of the final product.

The time between moving the product from the freezer and into the cold storage should also be as short as possible, otherwise the product may partially thaw, particularly small (IQF) fillets. Any packaging between freezing and cold storage should be done in premises kept as cool as possible.

There should be no backflow of the product. Once the fish have passed through one processing area, they should not go through that area again, sanitary and hygienic requirements increasing as the product flows from one area to another.

Space Requirements

There are no precise rules for the size of the various processing areas. However, some values gained from experience are mentioned here.

1. Receiving Area

   300 to 600 sq. ft. for the washing machine and 300 to 400 sq. ft. for the scaling machine.

   If manual gutting takes place in the receiving area, one should allow for about 50 sq. ft. for each operator, including conveyors, tables and equipment. For sorting and grading, one can anticipate about the same area as for gutting.

2. Chill Store

   If the fish are iced in boxes, a value of 50 lbs per sq. ft. is often used for each row of boxes. Usually, the height is not more than four rows.

3. Machine Filleting Area

   This area can be about 50 ft. in length and the width will vary depending on the number of lines. One filleting line, consisting of header, filleting machine, and two skinners, will occupy approximately 900 sq. ft.

4. Manual Filleting Area

40 to 50 sq. ft. should be allowed per operator.

5. Trimming & Packing Area

A net area of about 40 sq. ft. per person. For the gross area, including corridors, washing of boxes, processing of roe, etc., one could use a value of 75 to 80 sq. ft.

The ratio of trimming operators and packing operators can be expected to be 2:1 to 3:1.

6. Freezing Area

It can generally be assumed that for a given capacity requirement, the quicker a freezer can freeze the product, the less space is required for the freezer unit. Freezer space is only one factor to be taken into account; space is also required for refrigeration machinery for most freezers; working area, for example, packing, loading and unloading, to release fish from trays and to wash, dry and store these trays. Often, the packing material is stored in this area.

7. Cold Store

The lay-out of a cold store is determined by the type of product, packaging, method of palletization, accessibility required and the equipment used for handling. Passageways should be clearly defined and kept free from obstruction at all times. The floors of large stores are often marked off with a grid and the grid spaces numbered so that the location of goods can be recorded, thus enabling quick retrieval. A 60 percent utilization of the floor space is not unusual, as space is required for passageways and the product should not be stacked directly against the walls or floor. The following space should be left between the floor, walls and ceiling coolers:

Floor - 4 in.; Walls - 8 in.; Ceiling - 20 in.

About 100 lbs/sq. ft. per row can be expected. Pallets can be stacked four to five high, which gives 400 to 500 lbs/sq. ft.

As a rule of thumb, the cold store should be able to accommodate three months' peak production.

In existing plants, it is common that the receiving area and chill store occupy about 20 percent of the total area; filleting, trimming and packing areas, about 20 percent, and the other areas 60 percent of the total plant area.

General Lay-out Examples

The first lay-out (Figure 12-B) shows a plant for white fish processing of raw material of the following composition:

Alaska Pollock	: approx.	10,000 tons/year
Pacific Cod	: approx.	2,000 tons/year
Flounders	: approx.	2,000 tons/year

It is assumed that the raw material arrives at the plant in containers or fish boxes, iced, sorted and ungutted.

1. Equipment for Processing of Flounder

   B 1 1 - Reception Room
   B 2 1 - Buffer Table
   B 3 1 - Treatment Line
   B 4 1 - Elevator with Hopper
   B 5 1 - Heading & Filleting Machine, BAADER 175
   B 6 1 - Skinning Machine, BAADER 50
   B 7 1 - Roller Conveyor
   B 8 1 - Roller Conveyor

2. Equipment for Processing of Pacific Cod

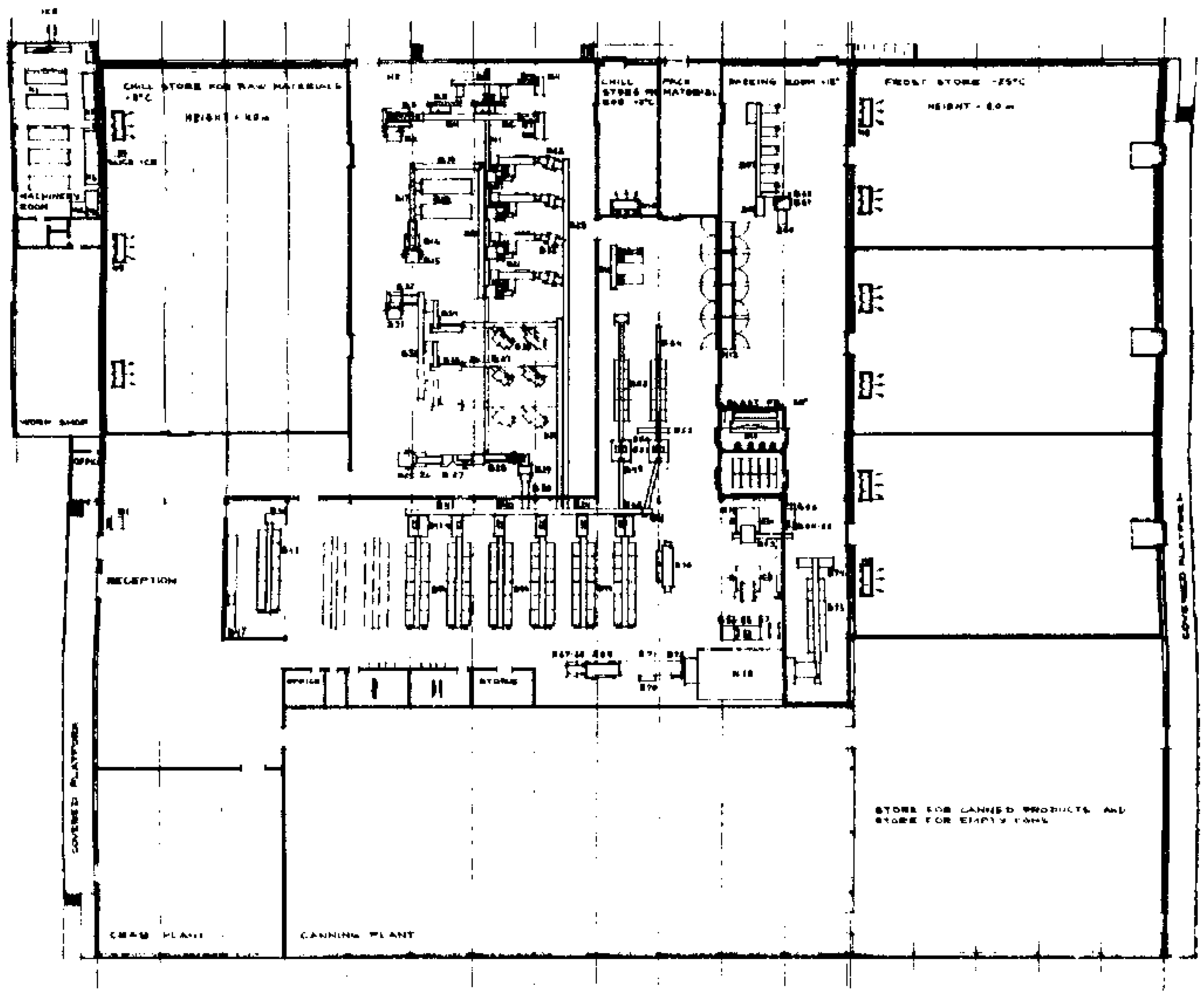
   B 9 1 - Tilt Unit
   B10 1 - Deicing Machine with Elevator
   B11 1 - Heading Machine, ARENCO CUB
   B12 1 - Filleting Machine, ARENCO CUD
   B13 1 - Skinning Machine, ARENCO CUS

3. Equipment for Processing of Alaska Pollock

   B14 1 - Tilt Unit
   B15 1 - Deicing Machine with Elevator
   B16 1 - Band Conveyor
   B17 2 - Heading Machine, ARENCO CIV
   B18 2 - Band Conveyors
   B19 2 - Band Conveyors
   B20 4 - Band Conveyors

FIGURE 12-B

GENERAL PLANT LAY-OUT FOR WHITE FISH PROCESSING - 1



B21 4 - Filleting & Skinning Machines, ARENCO SFA-4
B22 1 - Band Conveyor
B23 1 - Band Conveyor
B24 1 - Roller Conveyor

The second lay-out (Figure 12-C) shows a fish processing plant for the processing of raw material of the following composition:

Pacific ocean perch	:	10,000 tons/year
Alaska pollock	:	10,000 tons/year
Pacific cod	:	2,000 tons/year
Herring	:	2,000 tons/year
Halibut	:	500 tons/year

1. Equipment for Processing of Pacific Ocean Perch

B15 1 - Tilt Unit
B16 1 - Deicing Machine with Elevator
B17 1 - Band Conveyor
B18 2 - Scaling & Washing Machines
B19 1 - Band Elevator
B20 1 - Band Conveyor
B21 4 - Heading & Filleting Machines, BAADER 150
B22 4 - Skinning Machines, BAADER 51
B23 1 - Band Conveyor
B24 1 - Band Conveyor

2. Equipment for Processing of Pacific Cod

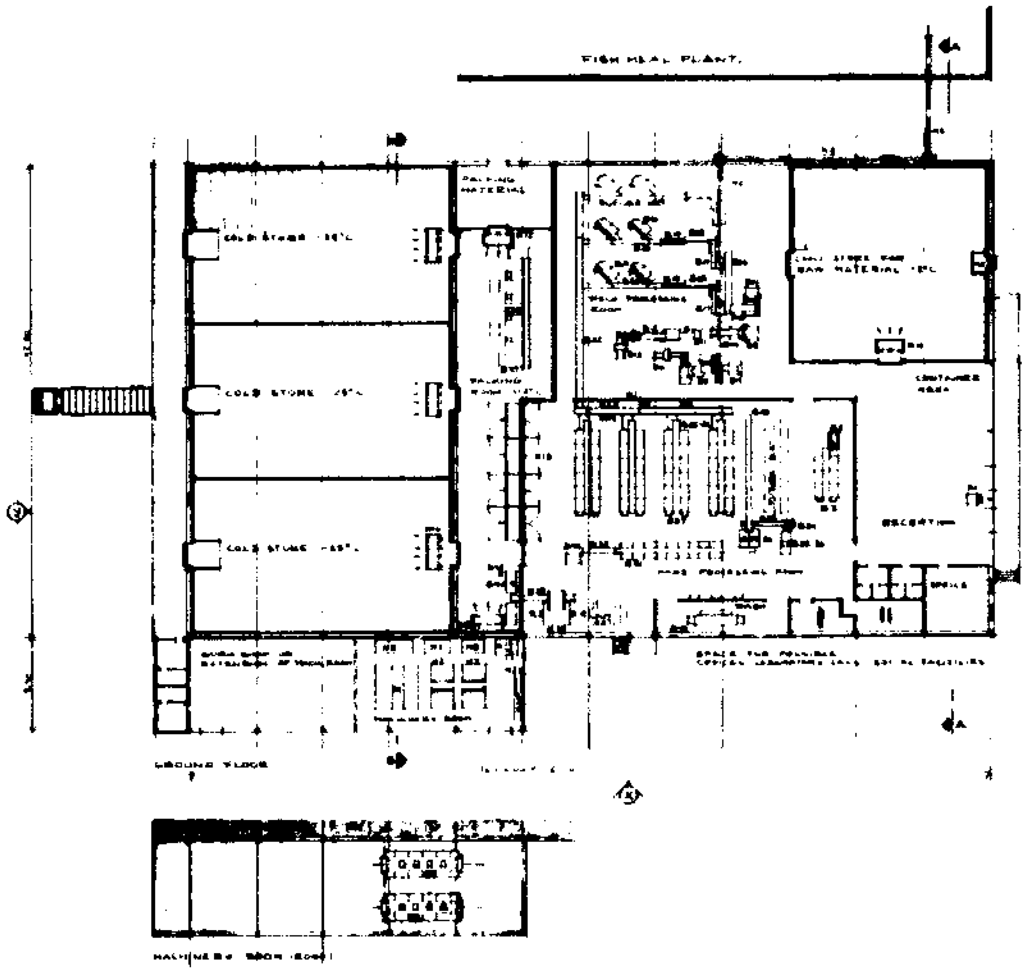
B25 1 - Tilt Unit
B26 1 - Deicing Machine with Elevator
B27 1 - Heading Machine, ARENCO CUB
B28 1 - Filleting Machine, ARENCO CUD
B29 1 - Skinning Machine, ARENCO CUS
B30 1 - Roller Conveyor

3. Equipment for Processing of Alaska Pollock

B31 1 - Tilt Unit
B32 1 - Deicing Machine with Elevator
B33 1 - Band Conveyor
B34 2 - Heading Machines, ARENCO CIV
B35 2 - Band Conveyors
B36 2 - Band Elevators
B37 4 - Band Conveyors
B38 4 - Filleting & Skinning Machines, ARENCO SFA-4
B39 1 - Band Conveyor
B40 1 - Band Conveyor
B41 1 - Roller Conveyor

FIGURE 12-C

GENERAL PLANT LAY-OUT FOR WHITE FISH PROCESSING - 2



Construction

White fish processing plants should be specially designed for their purpose. The plant and surrounding area should be kept free from objectionable odors, smoke, dust, or other forms of contamination.

The buildings should be well constructed and kept in good repair, and they should be sufficiently large to accommodate the equipment and personnel without crowding. The design and construction should be such as to prevent the entry and harboring of insects, birds, or other vermin, as well as to permit ready and adequate cleaning.

The food handling area should be completely separate from any part of the premises used as living quarters.

Areas around the plant should be well drained, and the slope to the drainage lines not less than 2:100. It is wise to locate the plant so as to permit later extensions without any undue difficulty.

Floors should be hard surfaced, non-absorbent, with adequate draining facilities. They should be non-slip, without crevices, and they should slope evenly and sufficiently for liquids to drain off to trapped outlets fitted with removable grills. Suitable and adequate drainage facilities are essential for removal of liquid or semiliquid wastes from the plant, and they should be designed to cope with the maximum flow of liquid. Except for open drains, drainage lines carrying waste effluent should be properly vented, their internal diameter should be four inches, and, if required, they should run to a catch basin for removal of solid waste material. The slope of the floors should be at least 1 to 1.5:100 in the receiving area, 1.5:100 in the filleting area, and 1:100 in toilets and cloakrooms.

Internal walls should be smooth, waterproof, resistant to fracture, of light color and readily cleanable. Acceptable materials for finishing walls inside are cement render, ceramic tiles, various kinds of corrosion-resistant metallic sheeting such as stainless steel or aluminum alloys, and a variety of non-metallic sheeting.

Window sills should be limited to a minimum size. They should slope inwardly at an angle of 45° to prevent storage of miscellaneous objects or accumulation of dust, and they should be placed at least 3 feet above the floor.

All doors through which fish or fish products are moved should be sufficiently wide and of a self-closing type or furnished with an effective air screen. Ceilings should be at least 10 feet in height and should be of smooth, waterproof, light-colored finish.

The premises should be well ventilated to prevent excessive heat, condensation and contamination through obnoxious odors, dust, vapor or smoke. The air should be changed 15 times per hour in the toilets, 10 times per hour in the filleting and trimming areas and 5 times per hour in cloakrooms. Ventilation openings should be screened and, if necessary, equipped with proper air filters. The temperature in the filleting areas should not rise above 64°F.

Good illumination should be provided, and it should not alter colors. The following have been recommended (1 lux = 0.09 foot candles):

40 lux outside
150 lux in the cold store
300 lux for packing material room, corridors, refrigerating machine room and receiving and gutting area
500 lux in the filleting area, trimming area and toilets
1500 lux for candling

The color, for example, could be a cool white.

The design of the cold store should take into account the size of intended production, the type of fish and fish products, the intended time of storage and the optimal temperature requirements. As a rule of thumb, the cold store should be able to hold products from three months' production, and the temperature should not be higher than -13°F. The recommended storage temperature in the U.K. is -22°F.

A good vapor seal is required on the outside surfaces of the cold store. The inflow of outside air into the cold store should be minimized as much as possible, and where a cold store door has to be opened frequently, the flow of air through the door should be restricted by the use of an airlock chamber, a cold air curtain, self-closing shutters, or some other similar device. If a cold store has more than one entrance, only one door should be open at a time; otherwise air currents may greatly increase the inflow of warm outside air.

The temperature difference between the product and the air temperature should be minimal, with low circulation in order to avoid product dehydration. Provisions should also be made for effective and regular defrosting of the cold storage facility. Freezers should also be fitted with an inside alarm system in order to properly monitor temperature fluctuation.

An ample supply of cold water should be available at numerous points throughout the premises at all times during working hours. All water available for use in those parts of establishments where fish is received, held and processed should be potable water or clean sea water. It should be supplied at a pressure greater than 20 to 30 lb/sq. in. Water for cleaning purposes should preferably be supplied at a pressure of 70 lb/sq. in. When inplant chlorination of water is used, a solution of free Cl_2 of 5 to 10 ppm can be used. For cleaning after processing, 50 ppm can be used.

It is recommended to use a number of water taps instead of long water hoses. Also use reels for the water hoses. The taps for hot and cold water should be of different colors. Hot water for hand washing should be about 110°F, and for cleaning purposes 160°F.

Adequate and conveniently located toilet facilities should be provided. The following formula could be used as a guideline in assessing the adequacy of toilet facilities in relation to the number of employees.

1 to 9 employees :	1 toilet
10 to 24 employees :	2 toilets
25 to 49 employees :	3 toilets
50 to 100 employees :	5 toilets

Add one toilet more for every 30 employees more than 100.

Hygienic Operating Requirements

Fish, because of its highly perishable nature, requires strict adherence to specific hygienic requirements which should become part of the daily operational routine of the plant.

All surfaces which come in contact with fish should be hosed down with cold or hot potable water or clean sea water as frequently as necessary to ensure cleanliness. Suitable cleaning and disinfecting agents, together with manual or mechanical scrubbing, can be used to assist in achieving the desired objective. The surfaces should then be rinsed thoroughly afterwards.

Filleting and cutting surfaces should be cleaned frequently. If they are not thoroughly scrubbed and disinfected, at least at the end of each working day, there may be a serious day-to-day carryover of microbial contamination.

If individual offal containers are used close to a processing line instead of the flumes or chutes connected to a common line, they should be located in such a way that there is no possibility of splash-back.

All machines used for gutting, washing, filleting, skinning, or similar operations should be thoroughly cleaned, disinfected and rinsed during rest or meal breaks and before resumption of production following other work stoppages. The machines should be inspected before processing begins, and all trapped or accumulated product should be removed periodically throughout the working day.

Removal of solid, semi-solid or liquid wastes from fish unloading, holding and processing areas should be on a continuous or almost continuous basis, using water and/or appropriate equipment so that these areas are kept clean and there is no danger of contaminating the product.

Cleaning of vehicles, together with receptacles and other such equipment, should be planned to a regular routine.

Operating Practices

Handling of Fish Before Freezing

The need for careful and rapid handling of fresh fish and the reasons for maintaining chill temperature have already been mentioned.

Preparatory operations leading to the finished product and the freezing operations should be so timed as to permit expeditious handling of consecutive batches in production within the time and temperature range that will prevent deterioration and spoilage and will allow for proper freezing.

If the fish is known to be highly parasitized, it pays to fillet and candle a few which are picked at random in order to decide whether to proceed with the processing. The presence of parasites in fish or fish products is highly objectionable to the majority of the consuming public.

It must be stressed that placing quantities of fish in a chill room does not remove the need for adequate icing. Chill rooms are designed to maintain a chill temperature and to keep already cool fish from warming up.

Fish temperatures may rise during packaging. Temperatures of 50°F and above are not unusual in processing factories, and the spoilage rate will increase if the fish are held too long at these higher temperatures.

Freezing of Fish

Freezing and frozen storage cannot improve the quality of fish. At best, the process maintains the fish in much the same condition as it was immediately before freezing. It is, therefore, essential that the raw material be as fresh as possible.

Some of the most important things to remember when freezing the fish are the following:

1. Freezing should be fast enough to prevent development of adverse quality changes in the product.

2. In vertical plate freezers, fish should be carefully packed between the plates so that there are as few air spaces as possible.

3. Defrost heating of vertical plate freezers should be just long enough to loosen the frozen blocks for unloading.

4. In horizontal plate freezers, fish and fish products should be packed in trays or other forms to produce uniform and compact blocks.

5. Air-blast freezers should be loaded in such a way that there is always a sufficient flow of cold air around the product.

6. In brine freezing, there should be rapid circulation of the cooling medium, and the ratio of fish to brine should be carefully controlled.

7. Freezing processes should be allowed to run the full allotted time to ensure their completion.

8. Frequent checks should be made of refrigerant pressures and temperatures and accurate records maintained.

Freezing should never be carried out by placing unfrozen or partially frozen products in a cold store. If frozen in a cold store, the fish will suffer serious quality losses due to an extremely slow freezing rate. Unfrozen fish may also warm up other products already in the store.

Double Freezing

Double freezing means freezing a product, thawing or partly thawing it, and refreezing it. This practice is often necessary for the production of some frozen fish products made from fish previously frozen and stored in bulk. What must be remembered is that even quick freezing results in quality changes in the fish and double freezing will, therefore, result in further changes. Consequently, only fish that were initially very fresh could be subjected to double freezing and still conform to good quality standards. Fish frozen quickly at sea immediately after catching, for instance, would be suitable for this purpose.

Packaging

The quality of frozen fish and fish products will decline rapidly during storage and distribution if they are not adequately protected against the effects of dehydration and oxidation as well as against physical damage and contamination by foreign matter.

There are many factors to consider when designing packages for frozen fish products. It is important that the product be presented in a package that is attractive to the buyer and which is convenient to handle. Labels should be printed clearly and must comply with the labelling laws of the country in which the product is marketed. In addition, packages of frozen fish products should bear clear indications as to how they should be kept from the time they are bought at the retailer to the time of their use.

Many types of flexible wrapping and packaging materials are available, usually in several grades and thicknesses. These include various types of vegetable parchments and treated papers, aluminum foil and films of regenerated cellulose, polyethylene, polyester, polyamide and polypropylene.

These materials differ considerably in their cost and in their ability to exclude water vapor and gases. Some can be sealed by heat while others require the use of adhesives. They also differ in their physical properties at low temperatures and in their suitability for mechanical wrapping.

Some important things to consider are:

1. Packaging materials should not contaminate the product in any way.

2. Packaging materials should not unduly increase the time required for freezing.

3. Packages should have low water vapor permeability.

4. Packages should have low permeability to gases and odors.

5. Packaging materials should be sufficiently strong and durable to withstand stresses during processing, handling, storage and distribution.

6. Packages should be impermeable to fats and oils.

7. Packaging materials should not stick to the wet or frozen surface of the product.

Storage

The recommended storage temperature for all fish products in the U.K. is -22°F. It has been calculated that under specific conditions, the total cost of operating a cold store at -22°F is only four percent higher than when operating at -4°F although the corresponding percentage increase in running costs will be higher.

Factors limiting storage life are:

1. protein changes
2. fat changes
3. color changes
4. dehydration changes.

The important factors to be kept in mind when designing and operating a cold store are:

1. low temperature
2. uniform temperature
3. steady temperature
4. good air distribution
5. minimum rate of air circulation
6. minimum heat ingress.

Control Programs

Process Control

Process control can be the controlling of yield, capacity, and quality at different stages of the processing.

Yield

Yield is controlled by weighing the product at some process control points; for example, weighing of raw material purchased, raw material drawn from storage, as well as weighing the finished product entering and leaving the cold store and before and after unit operations of interest.

To be able to estimate optimum yield, a skilled filleter can fillet some fish chosen at random, and the yield obtained can be used as a reference.

Capacity

Capacity can also be controlled by weighing. A reference for the capacity in manual operations can be decided, as above, by a skilled operator. High capacity can result in lower yield, and high yield can result in low capacity. It is, therefore, important to find some way of controlling the process in order to achieve optimum performance. In many European countries, accord or bonus systems are employed for that purpose.

Quality

Inspection of raw material quality takes place in the receiving area, and the quality of the finished product can be judged in the trimming area.

Sanitary Control

It is desirable that one single individual be in charge of the cleanup crew. A permanent cleaning and disinfecting schedule should be drawn up to ensure that all parts of the establishment are cleaned appropriately and that critical areas, equipment and material are designated for daily cleaning and disinfection or more frequently if required.

Laboratory Control

In addition to any control by the official agency having jurisdiction, it is desirable that each fish processing and freezing plant, in its own interest, should have access to laboratory control to establish the hygienic quality of the products processed.

The extent and type of such control will vary with the food product as well as the needs of management. Such control should reject all foods that are unfit for human consumption.

Analytical procedures used should follow recognized standard methods in order that the results may be readily interpreted.

CHAPTER 13

INTEGRATED RAW MATERIAL UTILIZATION

Kai Kaersgaard

Introduction

Let us first consider some of the principal elements involved in maximizing the return on investment made in a white fish processing facility:

- sales price for the products
- raw material prices
- costs of operation
- production yield.

Sales Price

The sales price is largely set by the market, although it may also be influenced by the location of the plant.

Raw Material Prices

The prices of raw materials or cost of goods sold are also, generally speaking, dictated by the mechanics of the market, but also are dependent on what the fishermen must be paid in order to make the occupation of fishing attractive to them.

Costs of Operation

Operation costs include:

- labor costs
- utility costs
- packing materials
- sales and administration costs
- capital costs.

Production Yield

The production yield is the ratio between the quantity of final products sold and the quantity of raw material acquired;

that is, how effective the factory utilizes the raw material it acquires.

When examining these principal elements in relation to a given plant and with a given market strategy, it becomes clear that the operating costs and the production yield are the decisive factors in any efforts toward achieving the best return on investment.

The objectives of this chapter are to analyze the production and products which can be produced.

In addition, means of increasing the yield and its sensitivity to the overall profit picture will be examined.

Finally, we shall review a series of possible buffer productions or alternatives that may be considered feasible to put into effect when the landings are larger than the normal production capacity.

Utilization of Pacific Cod, Alaska Pollock, Pacific Ocean Perch, and Flounder

(Figures 13-A, B, C, D, E, F, G, H, and I)

The following diagrams illustrate some of the most important utilizations and productions of the fish species dealt with here. The finished products are mainly aimed at the commodity and bulk markets.

FIGURE 13-A

PACIFIC COD - PRODUCTION 1

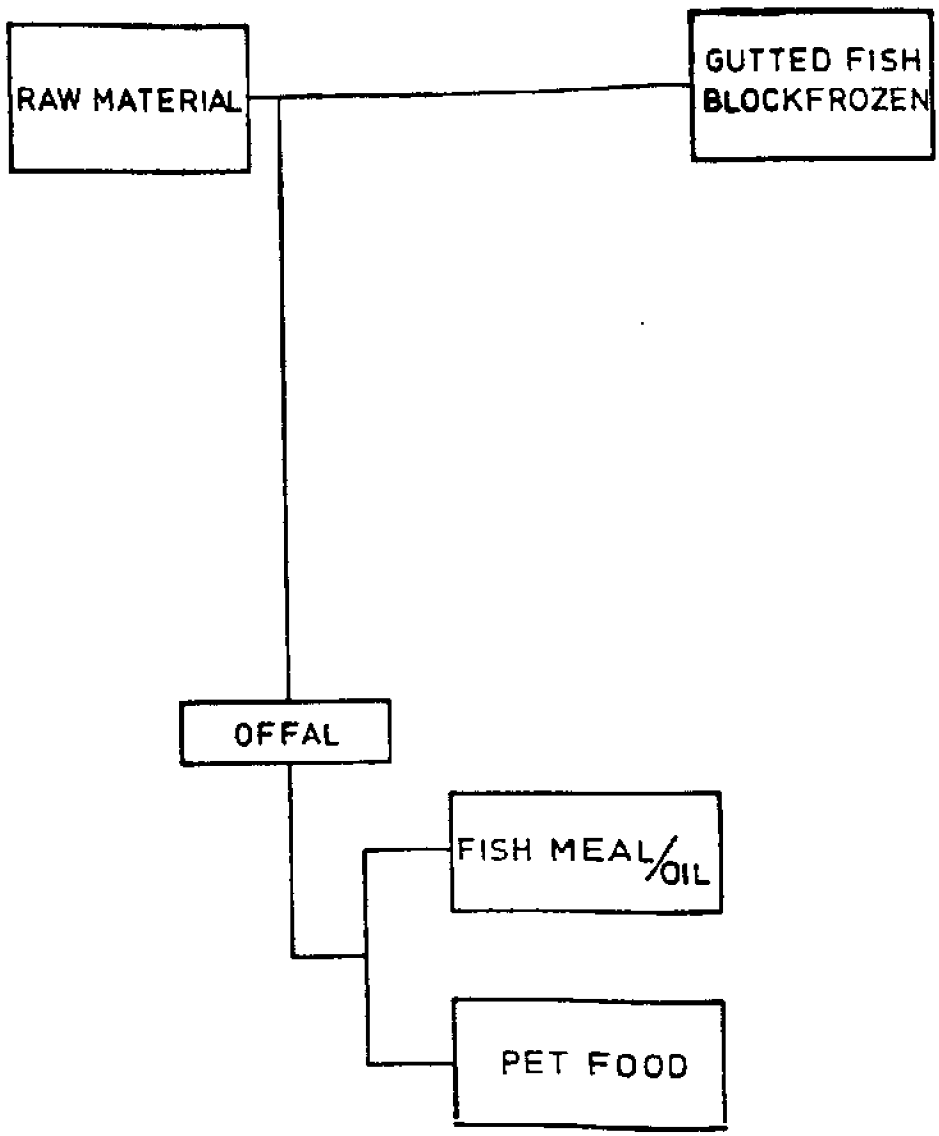


FIGURE 13-B

PACIFIC COD - PRODUCTION 2

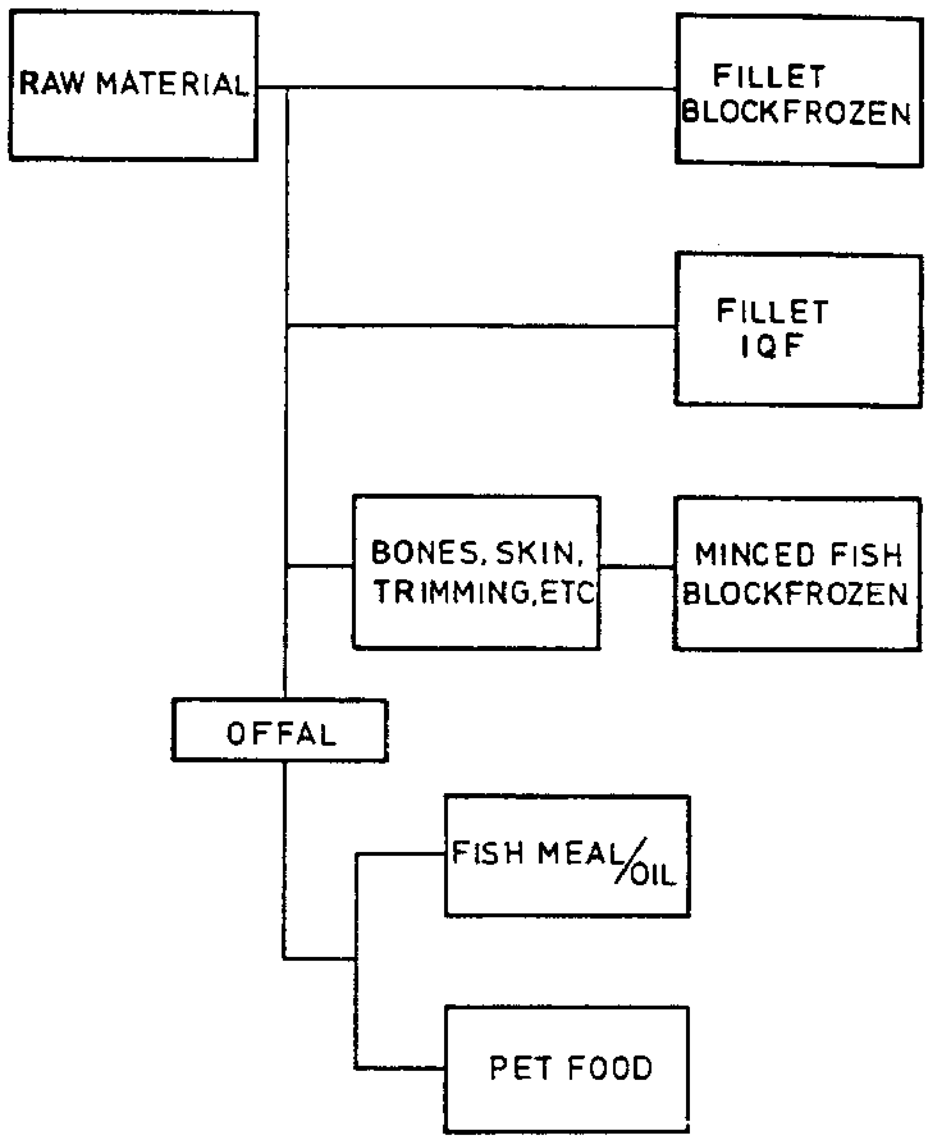
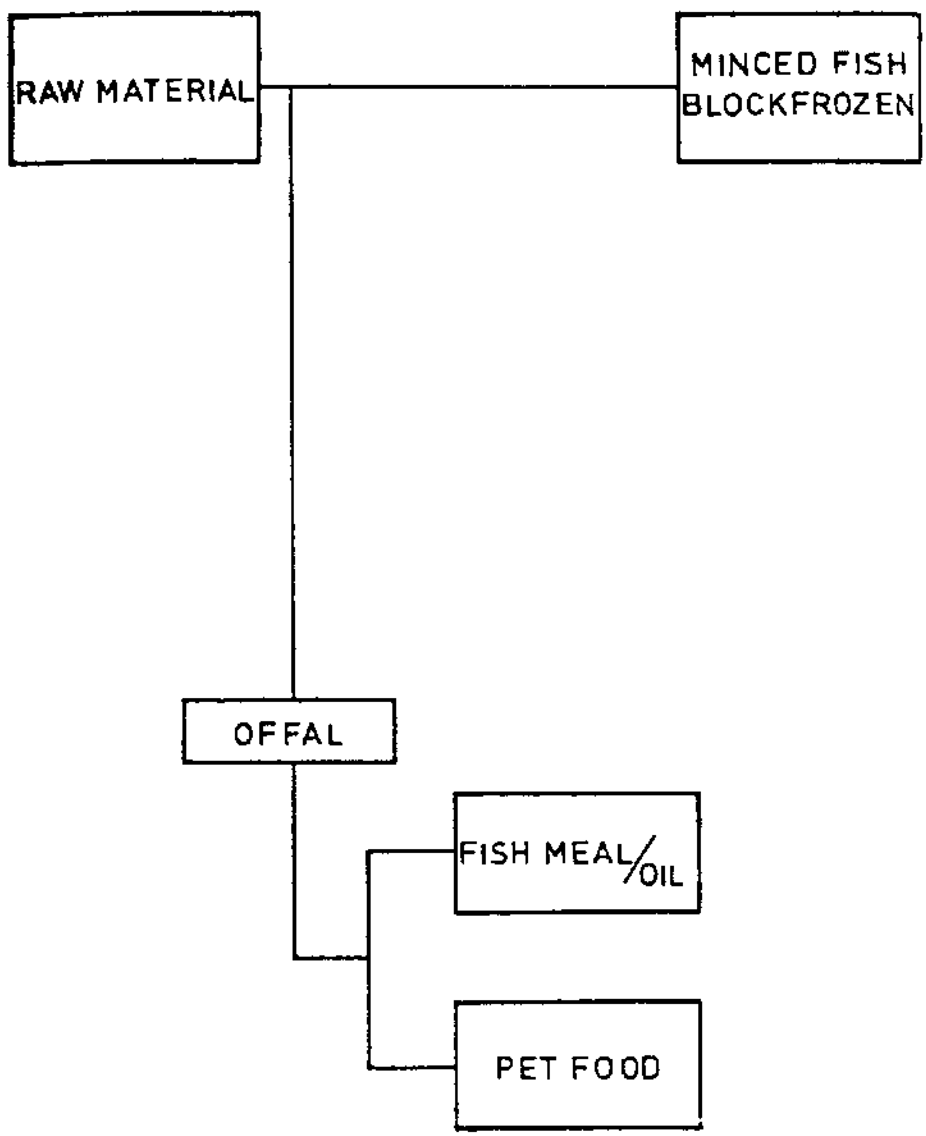


FIGURE 13-C

PACIFIC COD - PRODUCTION 3



UTILIZATION OF ROE AND LIVER

FIGURE 13-D

FLOUNDER (FLATFISH) - PRODUCTION 1

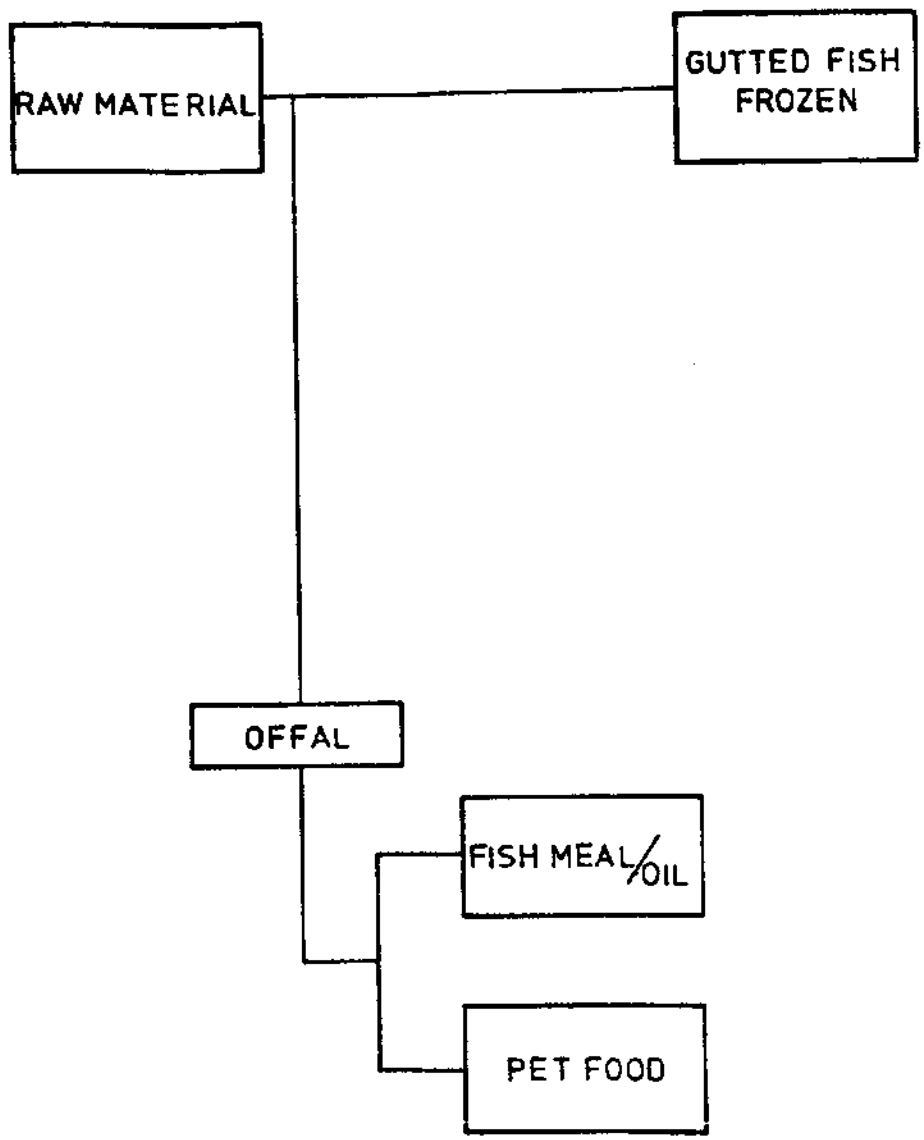


FIGURE 13-E

FLOUNDER (FLATFISH) - PRODUCTION 2

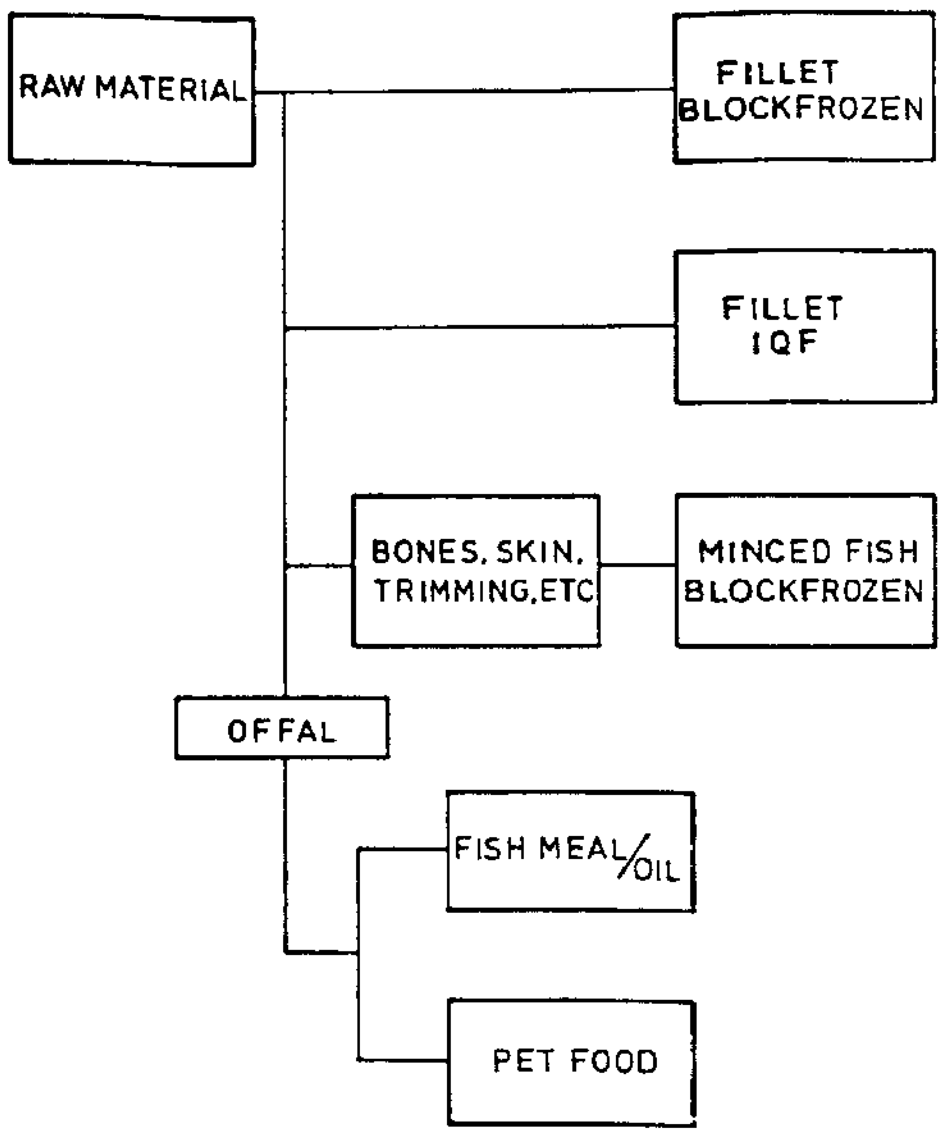


FIGURE 13-F

ALASKA POLLOCK - PRODUCTION 1

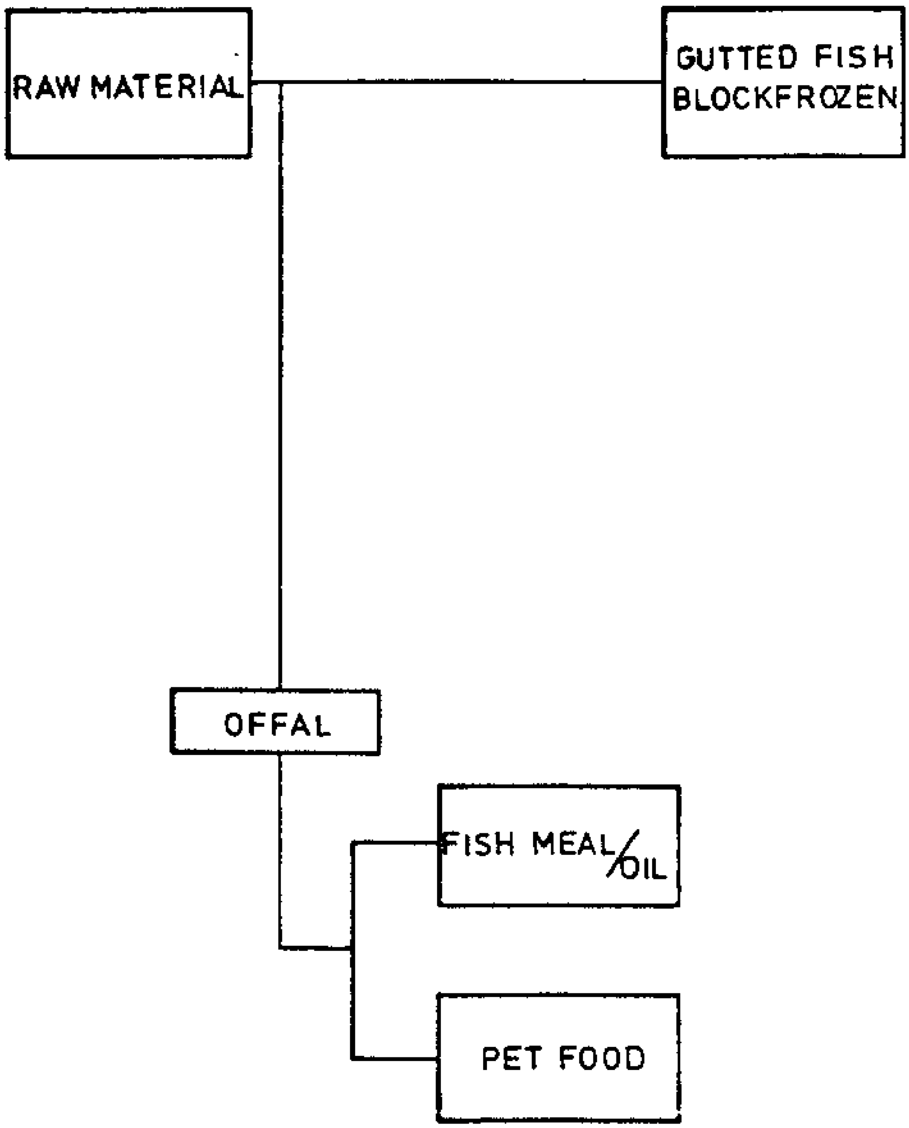


FIGURE 13-G

ALASKA POLLOCK - PRODUCTION 2

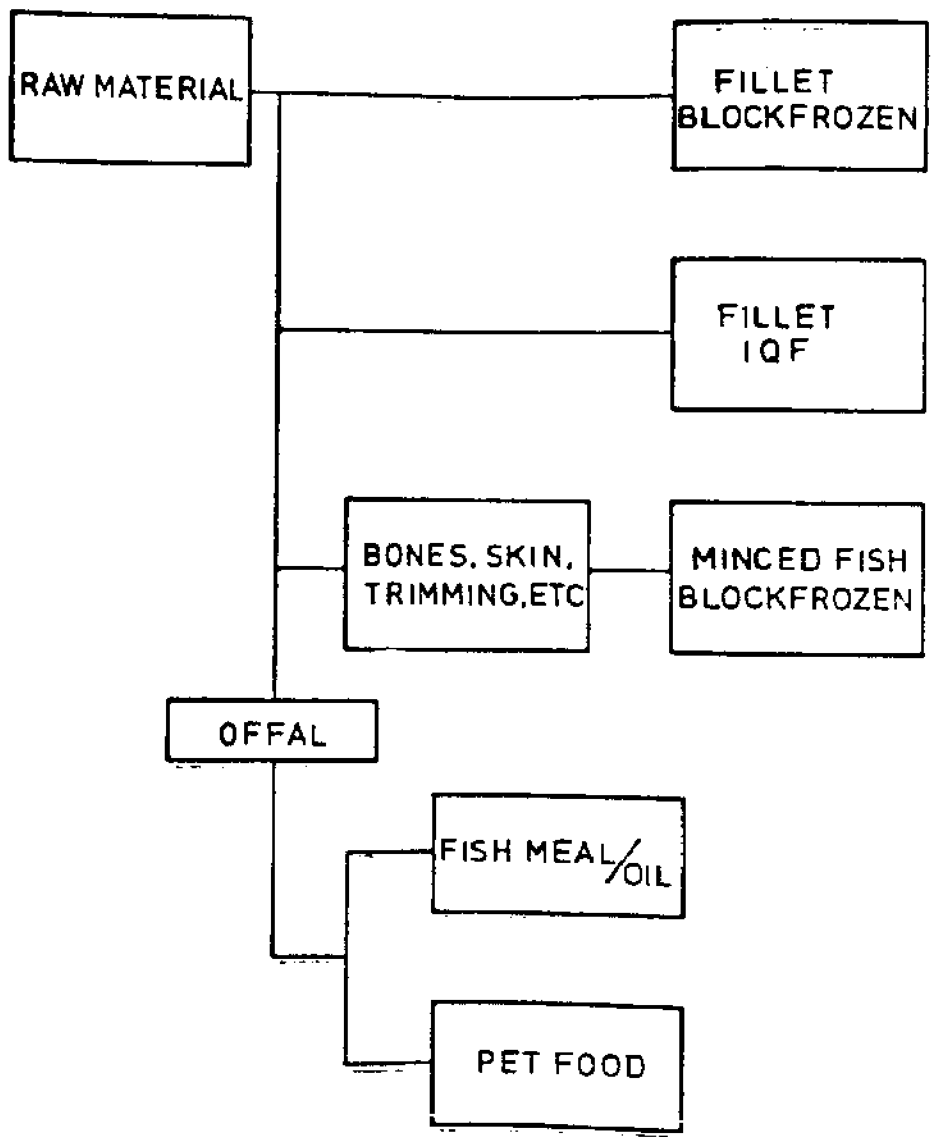
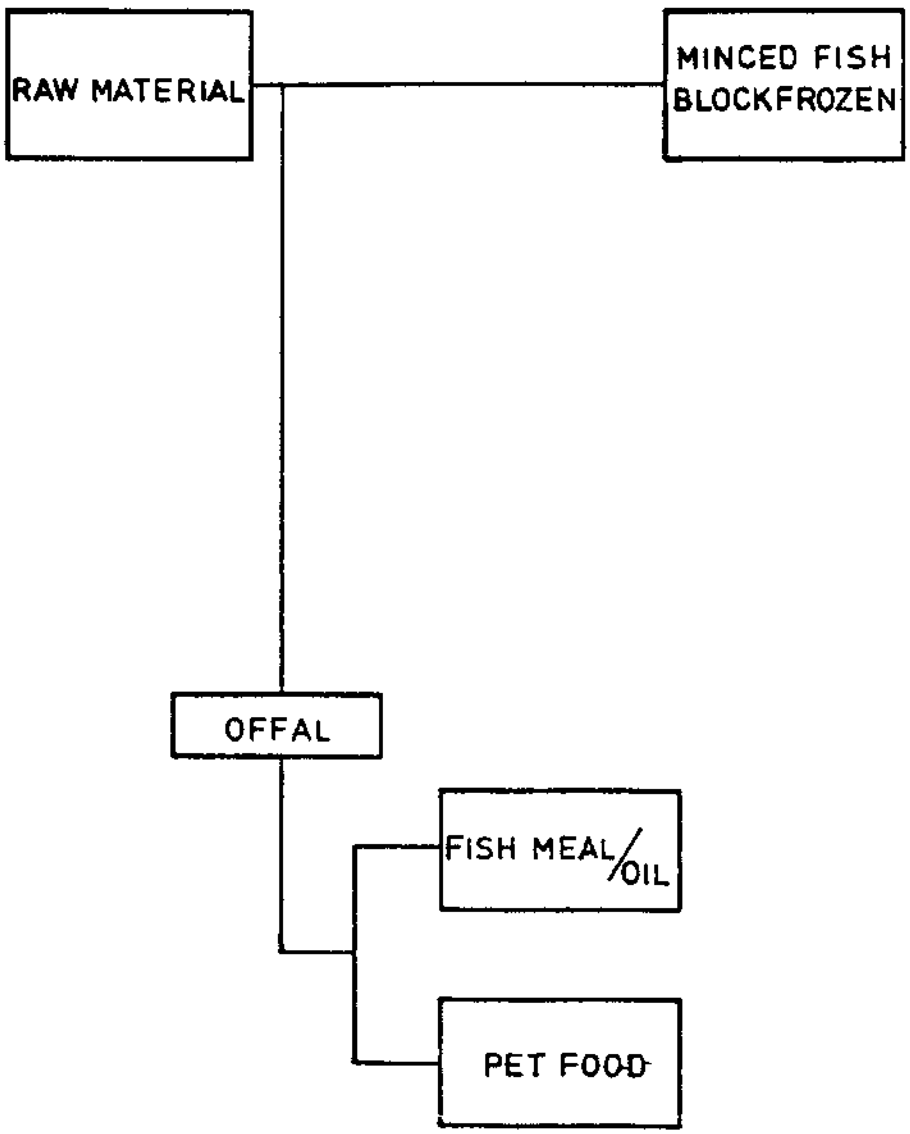


FIGURE 13-H

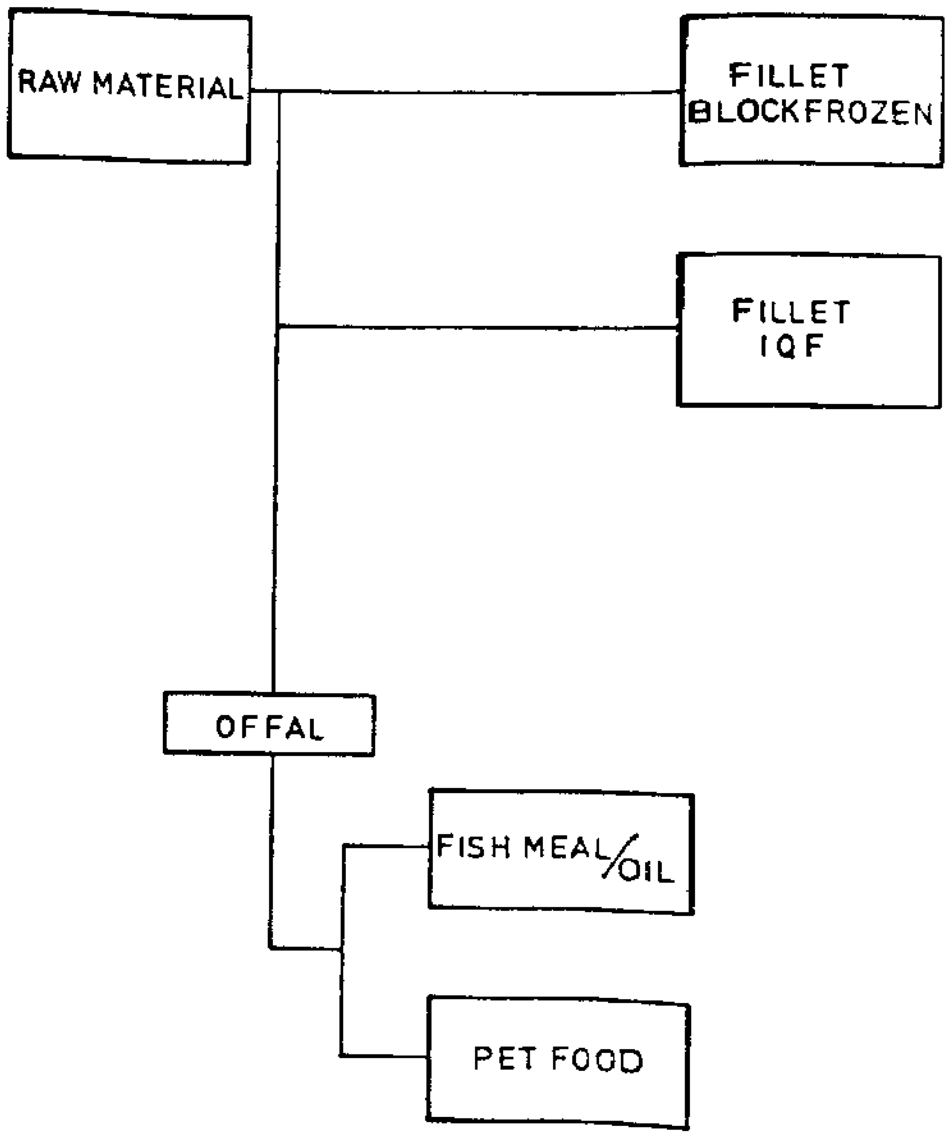
ALASKA POLLOCK - PRODUCTION 3



UTILIZATION OF ROE AND LIVER

FIGURE 13-I

PACIFIC OCEAN PERCH - PRODUCTION 1



Increase of Yield

Production yields may be increased by:

1. Better Raw Material Quality

   It is easier to treat raw material of high quality, and a greater part of quality fish can also be used for high-priced products.

2. Size Grading

   This process ensures that the size of the fish to be treated corresponds to the limits of the machines of the treatment line.

3. Machine Selection

   The machine selected must be adequately suited for the specific production.

4. Machine Adjustment

   Greater efficiency may be achieved by adjusting the machine to operate within narrower limits than those for which it is originally designed.

5. Training of Labor

   Well-trained operators make a considerable contribution to higher yield.

6. Process Control

   Establishing proper process control functions facilitates continuous adjustments of the production for maximum yield recovery.

Yield recovery may also be increased by improved labor policies such as:

- adequate supervision and control
- increased training
- incentive pay based on capacity, yield and quality.