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19004

Distr.
LIMITED

ID/WG.512/2(SPEC.)
29 May 1991

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on the
Fisheries Industry for Asia
and the Pacific Island Countries*

Singapore, 14 - 17 May 1991

HIGH VALUE-ADDED PROCESSED FISH

Background document**

Prepared by

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* Organized by UNIDO in co-operation with ESCAP and Technonet/Asia

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V.91-26402

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1 INTRODUCTION

The fishery sectors of the developing countries of Asia and the Pacific (the Region) play important roles in the economies. The major impact is in terms of employment where marine commercial and artisanal fisheries form the base of household income. Freshwater inland fisheries (including aquaculture) also provides increasing household income and employment opportunity.

Traditionally, the bulk of marine and freshwater output has been marketed and consumed as fresh products, limiting the domestic marketing options to the vicinities of the landing spot areas. Value addition has been a low level applying simple processing activities as salting, sun drying, smoking, mincing, and fermentation, corresponding to the purchasing power of the local consumers.

During the last decades improved fishing technologies as trawling and seining have greatly increased the volumes landed of fin fish and shell fish. Though aquaculture has a long tradition, e.g carp polyculture in China, output from aquaculture has also grown rapidly, especially, in terms of shrimp, mussels and clams. The larger volumes available of species as tuna, sardine, mackerel, pomfret, marine catfish, crustaceans, cephalopods and mussels/-clams, have formed the raw material base for introduction of modern processing as freezing and canning for increased value added generation.

However, it is a general characteristic that only first step processing techniques as block freezing of the raw material (in whole or as fillets) is involved. Relatively simple processes as pre-cooking and seasoning of e.g crustaceans generally is not carried out locally. Only over the last decade second step processing as Individual Quick Freezing (IQF) technologies have been introduced, however, still generally of the raw product. Of cause regional differences exists, e.g. the successful Thai processing industry that markets products of an advanced nature as tuna loins, cooked-/IQF and seasoned preparations and otherwise preserved products and under own brand names.

The block frozen products are marketed in Japan, USA, Europe, Hong Kong and Australia, for further processing into consumer ready products, thus depriving the Region of income from high value added processing.

A new kind of high value products - fresh chilled products - has recently been introduced. Absolute freshness is required and only few species as snappers, marine catfish and cephalopods are exported by air in chilled containers to Japan and Hong Kong.

The group of tropical fish landed represents a vast variety of species with great difference in sizes and chemical composition are generally not processed. If processed then only in smaller quantities by applying street level or small scale artisanal technologies.

This group of species accounts for up to 70 % of the total regional catch and are largely landed as by-catch of the industrial fishery and by artisanal fishery. In either case proper post-harvest treatment (on-vessel and on shore) of these generally low value species is only rarely applied.

This paper focuses some of the technical options available for high value added processing. The technologies discussed include first step processing as fillet, mince and surimi production, however, with a focus on the feasibility second step processing and its derivative consumer ready products. For each technology the quality requirements of raw material are discussed, the process described, potential markets identified (local as international) and issues related to infrastructure requirements and environmental impact are presented. It must be emphasised that the difference between the nations in terms of fishery sector development and economic capacity is substantial and the analyses have to understood as general guidelines.

2 FISH RESOURCES

The output of Asia & Pacific fisheries totalled 44 mio. mt constituting roughly 44 % of the world catch of 98 mio. tons (FAO 1988 figures). Asia accounted for 43% and Oceania barely 1% (see Annex A for statistical details).It is noteworthy that the inland fishery (capture and aquaculture) plays a significant role in Asia where 9 mio. tons were produced, constituting 68 % of the world inland fishery. On comparison the growth of production is almost entirely in the aquaculture sub-sector. Fish culturing thus has become an important part the total production, e.g. in China the culturing of carps, crustaceans and mussels/clams constitutes 40 % of a total catch of 10.6 mio. tons (freshwater culture provided 3.9 mio. tons and marine culture 1.4 mio).

Whereas freshwater fish production including aquaculture is exclusive for the individual countries marine fishery takes place within in the 200 nautic miles EEZs and in the international water outside these. Though the Region has access to major fishery areas the conditions prevailing for marine fishery varies substantially between continental Asian countries and the Pacific nations.

2.1 Asian Nations

The catch taken in the fishing areas of interest to the Region cover 34% of the world fishing area, including: Indian Ocean, Western (no 51); Indian Ocean, Eastern (no 57); Pacific Northwest (no 61); Pacific, Western Central (no 71). The developing nations of Asia accounted for roughly 66% of the Asia total catch taken from these areas. The balance of the Asian catch is taken by major industrial fishing nations including Japan, USSR, Korea R., Taiwan and the USA. Nations such as China has developed a deep sea fleet that operates worldwide including bottom trawling in West-African waters thus increasing the resource base of marine fishing.

Maine catches of the developing countries have traditionally been taken in the shallow water near the coast - the coast shelf fishery is already near the maximum sustainable yields or is over-exploited as in the case of Thailand. Though countries as China, Indonesia, the Philippines and Thailand have established fleets for specialized far distance and even deep sea fisheries most of the landings are still mixed composed of up to 80 species for individual landings. Shrimp by-catch of India e.g. is estimated to be composed of a ratio of shrimp to by-catch of 1 to 10. As the on-ship handling and storage capacity for the by-catch is very scarce this catch is by and large discarded directly, thus not used in its potential for human food.

In fact, the commercially important species with potential for processing include tuna, mackerel, sardine and other small pelagic fatty species as anchovies (up 20-30 % of the annual landings). Smaller quantities of valuable species as pomfrets, sea bass, marine catfish, yellow croaker and snappers are landed see table 2.1 below (FAO 1988 figures).

Table 2.1: Catch of Selected Marine Species ('000 tons)

Country	Pomfret	Catfish	Croaker	Fish nei	Total
China	64		42	1977	3365
India	47	61	157	374	1512
Indonesia	22		26	660	1731
Malaysia	8	8	15	195	610
The Philippines		3		18	1482
Sri Lanka				46	198
Thailand	5	1	13	1026	2601
Vietnam					520
Total	146	73	253	4296	12,019

The group of not elsewhere identified (nei) species make up roughly 1/3. To this group of low value species may be added species as threadfin bream, lizard fish, scads, jacks, emperors and needlefish.

A species of particular concern for the processing of surimi is the Alaska Pollack (caught in the Beering sea and the Northwestern pacific), with an annual catch of 6.5 mio. tons. However, of the Region's countries only China explore this resource by a mere 20.000 tons.

The high degree of variation in catch composition is demonstrated by the case of Thailand with up to 850 different species are landed. The total volumes of low value underutilized species are thus substantial. However, the volumes landed of individual species are insufficient for processing, and the physiological and chemical composition of the mixed landings make processing complicated and requires additional resources spend on sorting and grading.

Raw material more suitable for processing includes the more voluminous low value species (scads, jacks, sardines, mackerels and anchovies). Uniform input is further provided from aquaculture, mostly in terms of valuable species as sea bass, crustaceans and mussel/clams. Various carp species, tilapia, trout and milkfish are generally destined for the local market consumption in fresh form or undergoing low cost processing.

Finally, a source of raw material is the by-product of e.g. the fillet industries, which is difficult to quantify and where quality further may be a limiting factor. The best suited material from this source are belly flaps of white fish for e.g. usable for mince production.

2.2 Pacific Nations

The open sea of the Central Western Pacific is characterised by lower fish productivity compared to the costal area of the Pacific due to the long distances to the nearest continent -the origin of nutrients. The Central Western Pacific is further characterized by water deeps, from where no up-welling do bring nutrition to the photo-tropic zone of the sea.

The total catch of the Pacific in the period 1982 to 88 only accounted for 0.7 to 0.9% of the world total catch (0.8 mio. tons in 1988). Excluding Australia and New Zealand the total catch of the Pacific Nations amounted to 0.18 tons, or 2.2 % of the regional catch.

Another important explanation of the low output for the Pacific nations is the lack of appropriate fleets. The fleets are generally artisanal in nature and the nations generate income from the licencing of fishing rights to trawlers of Japan, South Korea, Taiwan and the USA. Following the establishment of the Forum Fisheries Agency (FFA) more steady income is generated, but still the payments are at a token level compared to the estimated value (USD 600 mio.) of a catch of 6-700,000 tons of tuna in central western Pacific (World Fishing 1990).

Tuna is the commercially most important species caught locally by pole and line or long line technology and, in more rare cases, trawling is practiced e.g. Papua New Guinea. However, the landings of trash fish (nei) are predominant. Of a total landing of 8.1 mio. ton 6.6 mio. tons are trash fish, to this should be added especially scads and jacks.

The raw material exists but the investment in on-ship post-harvest facilities and infrastructures as ice-making plants in combination with the vast sea area involved makes the establishment of an efficient and economic processing industry very difficult. In fact, the existing canning factories in Solomon Islands depend upon the buying of raw material from the licencing nations.

3 PRODUCTS DERIVED FROM FILLET INDUSTRY

Processing of fish into fish fillets has a long tradition. The original purpose of making fillets was to improve fish preservation by salting or drying. In order to let the salt penetrate the fish flesh or to ensure fast drying it was necessary to open the fish and cut the fillets. The raw material base was "white fish", which means white fleshed fishes such as cod, saithe, haddock and flat fish.

Today, the term fillet refer to a strip of flesh cut to central bone usually skinless. The fillets are cut mechanically under computer control with only limited human manpower involved. The purpose of making fillets has shifted to an orientation towards meeting the increasing demand for consumer ready products. Fillets are easy to prepare both at the level of households for the catering industry and in the fast food industry.

Dependent upon the raw material available and the target markets the output range of products of the basic process are:

- Fresh Fillets,
- Individual Quick Frozen Fillets (IQF),
- Fish Portions
- Formed Fillets (composite fillets), and
- Block Freezing.

Fresh (iced) fillets are for household consumption and the catering industry. The other products are intermediaries often used for further value added processing as described in the following sections.

3.1 Raw Material

The nature of the processing technology requires species with a "good shape", which means that the body must be of elongated regular shape (round and flat fish), without any parts protruding. Fish like gadoids, salmonids, sole, lemon sole, are well suited for cutting fillets. Roughly, 40 species on world basis are used for production of fillets, with a heavy preponderance of species living in cold temperate waters.

In the cold water close to the poles very few species make up the fish stocks, offering a sound raw material basis for an industrialized way of fillet processing. The individual catch in this fishery normally consists of 2-5 different species, easy to classify and grade according to species and size.

Species suitable for fillet production that are accessible in the Indo-Pacific area include, flounder, sole, hake/hoki, lingcod, alaska pollack, whiting (Sillaginidae), marine catfish, redfish, basses, pomfrets, jacks, mullets, tuna, mackerels and shark. Fishing for these species are in general carried out by the developed nations of the area (Japan, Korea, Taiwan, USA, Hong Kong, Australia and New Zealand).

However, countries such as China, India, Indonesia, the Philippines and Thailand have established commercial type tuna trawling fleets. Smaller but still commercially viable volumes of pomfrets, snappers and marine catfish are landed by India, China and Indonesia. Commercial volume catches of pilchard and mackerels are also landed by these countries.

A general problem in utilizing tropical catches for fillet production is the species composition, up to 80 different species in one catch, each in small quantities.

An important consideration related to the fishing technology used is the requirement for freshness of the raw material. In EEC context this implies that the catch has to be kept under iced or frozen condition, i.e. kept at temperatures below +5C. If this condition is not met the process of protein denaturation will start immediately with the formation of histamine as a result. This is particularly critical for the fatty pelagic species as pilchard and mackerel.

There are several ways of meeting the requirement of improved post harvest technology. Modern trawlers, seiners and purse seiners are equipped with insulated Recirculated Sea Water systems, RSW-tanks. However, more simple methods may prove more feasible such as furnishing the vessels with flake ice and pumping facilities for sea water. This ice/sea water mixture is sufficient for the near-coast fishing vessels.

3.2 Fillet Processing and Products

Seen from a processing economy point of view fillet production requires a uniform raw material in terms of size, shape and species. If several different species are processed consecutively the production economy will deteriorate as the sorting and grading will reduce the yield degree.

In addition, a substantial quantity of fish must be available. In modern processing a uniform raw material is acquired by buying the fish bled and iced on board ship, price according to freshness, size and weight. The traditional way of cutting fillets from cod is presented in Diagram 3.1 below (Olafsson 1989).

European and japanese industries use almost entirely machine processing. Only fillet trimming (step F, diagram 3.1), removal of small bones is done by hand using light tables, making it more easy to detect small bone. The bone scanning/detection function is an important part of the quality assurance, as even small bones remaining may result in court trials with demand for economic compensation for damaged health. This is especially the case in the USA, where laws protecting the consumer are very strict.

Optical systems for detection for the remaining bones do exist. Information on the location of the bone in the fillet is fed into a computer, which guides a waterjet cutting machine. While the fillet is passing a conveyer belt the bone is automatically detected and cut out by a thin water jet. The computerized information is further used to cut the fillets in special portions, if so required.

Diagram 3.1: Fillet Processing

Step	Raw Material/ Process	Input/ Additives	Output	Equipment
A	Fresh or bled fish			Hand or machine (preferably at sea)
B	Gutting			Gutting machine
C	Cutting of fillets		Fillets	Fillet machine
D	Skinning			Skinning machine
E	Scanning			Automatic scanner (optic)
F	Trimming			Waterjet (or by hand)
G	Quick freezing			Plate (contact) freezer freezing tunnel
H	Packing	Plastic leaves cartons, boxes		Packaging machine
I	Cold store			Cold store (-25 C)

A crucial part of the freezing operation is to ensure that the core temperature reaches -20 oC before the products leave the continuous freezer. Sufficient capacity of the freezer is important to lower the temperature quickly. Especially, the interval of 0C to -5C needs fast processing (in 2 hours or less) to avoid building up of ice crystals in the fillets.

Ice crystals may during thawing result in loss of water and in a dry and poorly tasting product. Slow freezing may cause the fish proteins to denature resulting in inferior quality.

The output of the filleting industry of the Region is usually in block form, and is an input for further processing in the buying countries.

3.2.1 Individual Quick Frozen Fillets

A grading of the fish is carried out before processing in order to determine the kind of output possible given the species, size and freshness of the raw material. The large and regular size fish of high freshness are used to produce Individual Quick Frozen (IQF) products. The IQF fillets are packed interleaved with plastic leaves and are consumer ready. This product is at best based on white flesh fish.

Fish fillet production, per se, is not a widely applied tradition in South-East Asia. Processing of the many different tropical species makes the efficient application of machines difficult, which implies that hand based operation is necessary.

In the context of waters accessible to the developing nations of the Asia/Pacific nations the gadoid species of the temperate zones are usable for the far distance fleets. Otherwise, only luxury fish as pomfrets, marine catfish and snappers do warrant the application of this technique. Countries as India and Thailand do utilize IQF for fillet production. The IQF technology are most widely used for the production of various high priced products based on shrimp/prawn, cephalopods and mussels/clams.

3.2.2 Composite Fillets

Small size fillets in combination with pieces of fish are formed by mechanic pressing into the shape of a large fillet - a product called composite fillets. For reasons of product presentation the raw material is oriented to produce a shape and structure similar to that of convenient fillets. This process is simple and is an inexpensive way of adding value to residual flesh of luxury species. However, it must be anticipated that most of these products will only reach local large city markets.

3.2.3 Fish Blocks

Smaller, irregular fillets and pieces of fillets from (usually) less fresh fish are used for the production of fish blocks. Following the trimming operation (see step F above) the produce is frozen in frames and packaged in carton boxes before cold storing. The output acts as an intermediary product for further processing.

There is tradition and further scope for the production of fish blocks of cohering fillets. Blocks may be based on more abundant species accessible to the far distance and coastal fleets such as tuna, mackerel and pilchard.

3.2.4 Laminated Blocks

Another type of block frozen product, laminated blocks, is produced on the basis of small and irregular fillets. The fillets and pieces of fillet of sometimes different species are mixed with up to 25 % fish mince and frozen in block.

This technology allows the utilization of the mixed catches of tropical fish. However, it is likely that the processing will be based on hand cutting and trimming due to the irregular character of the raw material. Laminated blocks are intermediary products for further processing.

3.2.5 Battered and Breaded Products

A variety of more value-added products is manufactured on the basis of whole fillets and frozen blocks (ordinary as well as laminated blocks). The most common processing technique applied is the production of battered and breaded products. These products aims at satisfying the increasing market for ready-to-eat convenience products for direct household consumption and the catering and fast food markets. The process involves in general 5 steps.

Diagram 3.2: Battered and Breaded Process

Step	Raw Material/ Process	Input/ Additives	Output	Equipment
A	Frozen or laminated block			
B	Portioning/ forming		Fish portions, fingers, sticks	Blade saw or automatic cutting
C	Predusting	Flour		Preduster
D	Battering	Batter/leavened (tempura) batter		Liquid enrober
E	Frying/heat.	Oil for frying		Continuous fryer or hot air tunnel
F	Re-freezing		Nuggets, burgers comp. fillets, fingers	Freezer
G	Breading	Breading mix, crackers, crumbs		Breading machine
H	Frying/heating	Oil for frying		Continuous fryer or hot air tunnel
I	Re-freezing		Nuggets, burgers comp. fillets,	Freezer

The process lends itself easily to presentation of many different products on the same raw material basis. It can be stopped at various stages.

The above processes are typically carried out in integrated environments of the same company, thus increasing the value-added accruing to the company through a more efficient utilization of the raw material.

The markets for the battered and breaded products have grown considerably over the last decade. Due to the many options of styles and flavorings these markets are found at local, regional and international levels. Outlets are the direct household consumption as well as through the catering industry.

3.3 Infrastructure and Environment

3.3.1 Infrastructure Requirements

In terms of infrastructure requirements the basic process of filleting is the most demanding. Fillet processing requires access to electricity and clean water. Electricity consumption depends upon the number of steps in the production process that are involved and the volume of production. However, electricity supply is not considered to be a problem in South-East Asian countries. Fresh water is utilized for the initial washing of the product. The requirements, however, are limited, which is substantiated by the increase in number of plants in the region over the recent years.

There are no special requirements for battered and breaded products except from ingredients, which are rather simple in nature and readily available.

At the output end - all products are delivered frozen - cold - chains and a reasonable distribution of household and/or catering systems freezers and refrigerators is needed. There will be a certain limit to the marketing options and this should be part of the considerations given when carrying out feasibility assessments.

3.3.2 Environmental Assessment

The fillet process produces solid and liquid wastes. The impact on environment is reduced if the bleeding of the fish takes place on-board ship and the offal is used for further processing into fish meal. In Europe fish for fillet production have to be bled, gutted and iced or frozen to a temperature below +5C from the point of catch. In South-East Asia and the Pacific where similar regulations exist the practices of on-ship post-harvest handling and storing are not always executed according to the rules.

Solid wastes are estimated to equal 35-45% of the raw unbled - weight in the cases of efficient operations where a homogeneous raw material is used. This calculation is based on the recovery and use of meat from the belly flabs and bones through a separation process. The loss is will be in the range 45-60% if the raw material basis is a mixed tropical catch.

Optimal use of the raw material resulting, consequently, in less solid wastes is attainable if the following parameters are given attention:

- uniformity of the fish,
- freshness of the raw material,
- skill of the operators of the filleting machines,
- adjustment of the machines,
- sharpness of the knives, and
- skill of trimming staff.

The main problem of filleting industries in the South-East Asian area is the great number of different species.

Production of derivative products as fish fingers, sticks, nuggets and burgers through the batter and breading processes do not create any significant solid waste problems. In-plant dust pollution problems from the predusters have been resolved by technical improvement of the machinery.

Waste waters are created in 2 parts of the process:

- during fillet cutting and trimming (2 tons per ton fillet), and
- for transportation of offal (4 tons per ton fillet).

Whereas the water for processing is not reusable the transportation water is recirculated in modern installation, thus reducing the volume to be treated.

Waste water is organically contaminated and requires treatment. A widely used technique is the flocculation process:

> an activated sludge method in combination with a dissolved air-flotation method applying metallurgic agents as Al and Fe. This process will make the protein surface for skimming in some cases the skim product may be valorised and sold as a fertilizer. In more modern installations electrolysis is enhancing the protein flocculation (Lee 1985).

3.4 Prospects

Fillet processing is a known technique in South-East Asia, however, the volumes produced of products as IQF fillets is minimal. A major part of the explanation is the local consumer preference for fresh fish products. Limited distribution of marketing infrastructures as household freezers and refrigerators adds to the limitations in local market development.

Another important aspect is that fillet processing is most efficient and economic if the raw material is homogeneous, with a clear preference for regular shaped white flesh fish as round gadoid species or flat fishes. Only the far distance fleets of the Region, e.g. from India and Thailand, are capable of delivering such raw material.

The mixed raw material of the landings makes automatic processing difficult and thus requires a highly skilled staff to assure a reasonable yield and quality.

The production of IQF fish fillets will for marketing reasons be limited to the export markets. Only a limited range of products are suitable for export such as species as pomfrets and marine catfish. The IQF technology is essentially used for products based on shrimp, cephalopods and mussels/clams.

A special type product may have some scope, the composite fillet, as the irregular size and shape of fillets that is often the result from processing tropical species are well suited for this product.

There may be some scope for the processing of fish blocks either in the ordinary form of cohering fillets, or in the form of laminated blocks. Both types are intermediary products, which essentially are used for further processing into battered and breaded products as fish portions, fingers, sticks, nuggets and burgers. The production technology is automated and though sophisticated, it is relatively simple to operate. A local market exists already in the urban centres of the Region.

Final products are frozen and are more easy to distribute through institutional catering such schools, hospitals etc. In fact the products are a highly valuable product both nutritionally and economically on the local markets. Their suitability for the export market is, however, less since the output is not considered luxury type products and hence will have to compete with the large volume producers operating in those markets.

Though, the initial steps of filleting requires electricity and clean water this is not excessive to what is available. Especially, the batter and breading industry poses very little requirements.

In terms of environmental impact solid wastes may be dealt with through fish meal processing. Liquid waste will require at least treatment through flocculation techniques. The batter and breading industry only provides insignificant pollution problems. In general, the entire vertical chain from composite fillet processing, fish and laminated blocks to the battered and breaded final products must be considered ecologically safe. It appears that the vertically integrated operation (that has been established in Thailand recently) may prove a sound model in order to utilize optimally the particular catch composition in the Region and thereby generate more value-added.

4 MINCED FISH PRODUCTS

The production of fish mince, the recovering of fish flesh through deponing and skinning, has a long tradition in South-east Asia. It is still widely practiced as a small scale family based industry, and even as a street level activity.

Modern mince processing technology, whereby the meat separation is carried mechanically, was invented by Japanese researchers in connection with surimi production (see Chapter 5). The technology has found a wide application in other major fish processing nations such as the Nordic countries and USA. The purpose of the process is to make the utilization of the by-products from the filleting industry such as meat from belly flaps, trimmings, heads and bones optimal.

This technology also represents an alterrative method for the valorization of species that are not fit for the fresh fish market, fillet production or other value added production. The output, fish mince, is an intermediary product that is used for the production of laminated blocks, fish balls, roller dried fish, roller dried fish powder, fish noodles, and crackers.

4.1 Raw Material Requirements

Techno1ogically, the production of fish mince may be based on whole fish, fish meat and belly flabs from other processes as fillet production. Raw material thus may also include the by-catch trash fish from shrimp trawling. In Thailand experimental production based on trash fish, threadfin bream (Nemipterus spp.), sardine (Sardinellsa spp.), lizard fish (Synodontodae fam.) and other low-value species generally demonstrated that these species are usable (Phithapol 1988).

However, using trash fish and other small species require a presorting as freshness and good quality is an important criteria for applicability. Sorting of low-value species add to the cost of production.

The general assessment is that the process better than most other modern technologies is suited to the processing of the underutilized raw material available.

4.2 Processing Technology

Fish mince is produced by separating the meat of the gutted and eviscerated fish from the skin and bones. Yields vary with the quality of the raw material available. On the basis of white fleshed gadoid species a mince yield of 18-23 % of the weight of the gutted and filleted fish was achieved (Fiskmassa 1988). In the case of utilizing by-products from the fillet industry, the belly flaps and the meaty head and bones replace the fresh fish. The general steps in the production of fish mince and Roller Dried Fish (RDF) is presented below:

The belt drum separation leaves small pieces of bones and skin in the mince. Washing and straining by a drum screw strainer is necessary to remove the undesired parts.

Following straining (step G, diagram 4.1) several products are possible. By feeding the strained mince into a steam roller dryer a powdered product, RDF, is derived. This product has a high content of protein, 13-17 % depending upon the species used (Phithapol 1988). The powder is easy to transform further (see 4.2.1 below).

The stained mince may be formed into a variety of products. If the mince line is integrated with filleting line products, such as laminated blocks, the derivatives including battered and breaded products are possible. Mince as input to composite fillets is another option.

Diagram 4.1: Fish Mince and Derivatives

Step	Raw Material/ Process	Input/ Additives	Output	Equipment
A	Fresh fish			
B	Gutting/evisce.			Gutter and eviscerator
B	Pre-crushing			Pre-crusher
C	Washing	Fresh water		Washing drum
D	Washing/drain	Fresh water		Mesh belt conveyor
E	Separator	Water		Drum belt separator
F	Sieving/press.	Water		Mesh sieves
G	Straining			Drum screw press strainer
H	Roller drying	Steam	RDF powder	Steam roller dryer
I	Forming		Fish balls, blocks sausage	Former and molds
J	Freezing		Frozen fish mince or balls	Freezer

Products based directly on fish mince are fish balls, which are consumed in various presentations depending upon the cooking method. Mince products as fish balls. fingers, burgers etc. are solely produced for the local market. As they in general are frozen lack of refrigeration equipment limits the distribution to urban markets and the catering industry.

4.2.1 RDF based Products

A favorable feature of the RDF product is its final from as a powder, which by itself opens a wider ranged market as the infrastructure requirements are less. Derivative products include:

- Curry/fish soup mix, where RDF replace dried powder produced on cooked and ground fresh fish,
- Nam-prik products (powder of paste of fresh fish), where RDF also replaces other fish based inputs in ready mixes or ready-to-eat products.

RDF has been accepted as a well tasting product, however, the competition is not on quality but on price. RDF has a production cost roughly 4 times that of street level products based on the same species or trash fish. Other options that have been tested include the production of fish noodles and fish crackers (see below).

4.2.2 Fish Noodles

A promising product is fish noodles. The basic idea is to enrich the traditional noodle, where the nutritional value essentially is linked to the carbohydrates. The wheat dough is mixed with RDF, kneaded, roller pressed, thread, steamed, oven dried and packaged and, preferably, kept chilled. It is possible to use fish mince as a replacement for RDF.

The result is a product with high protein and fibre contents. In order to test the nutritious effect of fish noodles these were offered to school children with nutritional problems in Malaysia. Though the final results of the testing program are not yet known the intermediary results are promising. Thus the product has good potentials as a protein source even in remote areas.

Without attempting to quantify the market, products of this nature are well suited to the local conditions of South-East Asia as their distribution only poses little requirements on infrastructure. Another favorable feature is that the final product, the fish noodle, may be prepared in even very local kitchens.

4.2.3 Fish Crackers

Fish crackers is the modern name for a traditional Malaysian product called keropok. Originally, the keropok requires manually deboned fish meat as an input. The meat is mixed with sago and/or tapioca flour, salt, sugar, water and fish mince and formed into cylindrical rods. The rods are boiled, cooled, sliced and sun dried. The output usually has a high moisture content as it is sold by weight in the coastal rural areas.

The modern mechanized process was developed to improve the quality of the hand made product, where fish quality, sun drying of the slices, and the high moisture content are detrimental to the quality and do result in a short keeping time. Modern technology thus allows for the use of more low value species and assures a controlled process resulting in an output with a lower moisture content.

At the technical level an important step is the mixing of the ingredients into a homogeneous dough. The dough is stuffed mechanically into a casing, steamed, cooled/ chilled, sliced, oven dried, (sometimes fried) and packaged. The crackers are fried in hot oil by the consumer, whereby the slices expand into a low-density porous product (Yean 1986). It is possible to use RDF as a complementary input to this process.

The product has a good keeping time. Due to the fact the consumer ready product is dried it is possible to reach in-land markets thus making a quality fish protein source available. In the coastal zones marketing may face price competition as the traditional method is cheaper, however, for a low quality product. Export of keropok is not likely as it is a Malaysian specialty.

4.3 Infrastructure and Environment

4.3.1 Infrastructure Requirements

The infrastructure requirements are modest as the processing of fish mince is designed to be a sideline activity to other processes as filleting and block frozen products. Clean water is needed. The volumes vary with the species used as fatty fish - the major part of by-catches and coastal fisheries - require more water for the washing. Water consumption is estimated to be in the range of 3-5 tons per ton mince produced.

Electricity requirements are modest, however, depending upon the output wanted and the scale of production. The production of e.g. RDF requires some energy means for the production of steam for drying of the RDF. It stands to reason that RDF production should be carried out in an integrated environment whereby energy use may be optimised through efficient recycling systems. Small scale production of mince is possible using an electrically-driven 100 kg per hour input drum deboner, based on a 250 watts (1/3 horsepower) gearmotor (Bligh 1988). Units of that size are easy to erect and designed for simple operation and maintenance.

Mince products as laminated blocks and composite fillets require freezer or refrigerator installation. However, as the mince is used in integrated environments the facilities are available. Products as RDF and its derivatives, ready-to-eat soups, fish powders, fish noodles and fish crackers do not require any special infrastructures. In fact, the powder form and good keeping quality makes it easy to distribute to in-land markets for further processing at local facilities into noodles or crackers.

4.3.2 Environmental Assessment

Fish mince production results in solid and liquid wastes. The amount of solid waste depends on the raw material used. In the case of the utilization of by-products from the filleting of white fish a maximum of 34 % waste is produced (on the basis of raw weight). Solid waste of this nature is usable for fish meal and oil production.

In the case of the a heterogeneous raw material as the shrimp by-catch and tropical coastal landings the yield vary much more depending among other things on the fat content of the species used. In addition, sorting is needed in order to utilize only quality fish from the landings. Experimental trials indicate that the solid waste may be in the range from 30-70 % (Phithakpol 1988): 30 % (lizard fish, threadfin bream), 50 % (sardine), and 70 % (trash fish). It may be advisable to apply the small scale operation for such species.

The volume of solid wastes from further processing into fish balls, RDF powders, noodles and crackers is quite limited and with insignificant environmental impact.

Waste water from mince production may vary considerably depending upon the species involved. As the water will be organically contaminated treatment by at least flocculation is necessary (see 3.4.2). Dispersion of smaller production units along the coast line may prove more ecologically safe as the volumes of waste water will be relatively small and thus not detrimental to the shallow brackish waters - the breeding grounds of shell fish.

4.4 Prospects

The production of fish mince appears to be a promising method for the processing of filleting by-product and for underutilized species. However, when the production is based on the latter (typically the heterogeneous tropical catch or shrimp by-catch) care must be shown to sort and utilize only fish of a suitable quality. Mince production may lead either to direct marketable products as composite fillets, fish balls, sausages, and burgers or to intermediary products as laminated blocks, RDF powder, and derived products as ready-to-eat meals, fish noodles and crackers.

Fish mince production is most feasible, technically as economically, when the input is homogeneous. As this rarely is the case in the Region mince used as an intermediary for products as laminated blocks and composite fillets should be carried out in large scale integrated operations.

For mince production on the basis of coastal fisheries it may be better to use small scale deboning units as these can be located near to the raw material supply.

It should be noted that all output produced are oriented towards the local markets. As the derivative products (fish ball, soup mixes, noodles and crackers) use mince or RDF as a replacement for the traditional use of fresh hand deboned or sun dried fish competition at the coastal market will be in terms of price rather than quality, with a factor of 4 or 3 to 1 in favour of traditional street level processed products.

However, the higher protein content and the much improved keeping quality of the mechanically produced mince and RDF powder makes the catering market a very interesting option, especially, the institutional share of that market such as schools and hospitals. It is possible to supply even remote areas with a much needed protein source to balance to nutritional quality of the daily meals. The fact that RDF powder do not require any special marketing infrastructure makes it possible to reach the local in-land markets. Further processing into noodles and crackers may take place these locations creatring in a potentially strong market.

Ecologically, the production of the mince itself produces wastes, especially, waste water that needs treatment. A way of reducing the negative environmental impact would be to base the mince production on small scale units on the coast line.

There is no significant environmental impact from the production of derivative products such as noodles and crackers and it may offer alternative employment opportunities and an incentive for value added production in rural area.

5 SURIMI BASED PRODUCTS

Kamaboko manufacturing, the utilization of thoroughly washed deboned and skinned fish meat for the production of fish cake, is an old tradition in Japan. Records indicate that the term "kamaboko" existed in year 1155 (Okada 1985). Today kamaboko is a generic term for products based on mechanically deboned fish meat.

The original way of producing kamaboko was based on small scale family type enterprises up to the end of World War II. Utilization of less attractive white meat fish species that had only limited value on the fresh fish markets formed the raw material supply.

With the emergence of improved trawling techniques and capacity for icing the catch the raw material base was substantially increased. Factories were receiving acceptable quality raw materials and were more free to choose their location nearer the large city markets. However, dependency on day-to-day catches were prevalent and batch production remained the only way.

A hallmark in the kamaboko tradition was the introduction of the fish sausage. The sausage industry was based on frozen red meat fish species such as tuna, marlin, shark and even whale meat. Thus the factories were able to schedule the activities and to run continuous productions. The output was a low priced product with a high level of fish protein content. The product, in fact, had an image of western style food and became quite popular in the overall city populations.

Sausages were produced by grinding the fish meat with fat, species were added and the whole thing was wrapped in synthetic film casing (polyvinylidine chlorides). Retort sterilization further assured a product with a long shelf life independent of temperature conditions. The casing offers good protection against bacterial attacks.

Market demand for fresh/iced fish caused a raw material supply - problem for the Kamaboko industry. Also the output, the kamaboko (fish paste) with a high degree of elasticity had a relatively short durability even in frozen condition (Tanikawa, 1971). Rating criteria includes colour (the whiter the better) and elasticity (Kammuri 1984). The Kamaboko industry was modernized along the same line as sausage industry by the introduction of more advanced equipment. Traditional family based operations were taken over by large scale industrial enterprises.

An important break for the Kamaboko industry came with the innovation of frozen "surimi". The Surimi technique was invented during a research program aimed at identifying a value added utilization of the abundant species Alaska Pollack (Theragra chalcogramma) off Hokkaido.

Today Surimi is the most important raw material supply for the Kamboko industry and, naturally, for the derivative products including also the sausage industry.

5.1 Raw Material Requirements

Freshness of the raw material is an essential parameter for the quality of the output as the process of protein denaturation starts even under iced conditions and will take place during freezing and cold store.

Most of the surumi is today produced on factory ships. These ships are equipped with units for desalinization of sea-water, surimi production and fish meal plants. The USA alone has close to 20 factory ships with an estimated production in 1989 of 231 mio. lb uncooked product weight (Vondriska 1989). It is estimated that 50-55% of the world production of surimi is produced on vessel (Lee, 1984). In factory ship processing the backbones and belly flaps are usually removed before final deboning requiring fewer washing cycles (down to 1 cycle in the best cases). Shore based production requires more cycles, 3-5 cycles.

The single most important species for surimi production, Alaska Pollack, accounts for 90% of the commercial production. Alaska Pollack has good chemical properties for surimi production and the annual stock yield available is estimated to be in the order of magnitude of 2 mio. tons. However, in recent years the Alaska Pollack fishery has declined due to over fishing thus urging the industry to identify other suitable species.

The ideal characteristics of alternative fish to be used would be an abundant low-value white fleshed pelagic or mezo-pelagic species with good gelling capacity. Attempts at using species as sardine (pilchard), sand eel, mackerel, herring and capeline have been made. Small pelagic species such as sardine and mackerel are abundantly available and would volumewise provide an attractive raw material source for tropical countries. However, the high content of fat, myoglobin, sacroplasmic protein and dark muscle makes them less attractive for surimi production requiring alterations in the production process:

- a meat separator (rotary freezer or pressure shower) to remove mechanically dark muscle, skin and subcutaneous fat, and collect the ordinary muscle,
- washing with $NaHCO_3$, and
- a super decanter for improved fat/oil removal

before the repeated washing of the mince (Putro 1989).

Sardine as a base for surimi production has been attempted amongst other in Morocco. Though the process is technically viable the output still is grayish. A source of the difficulties is the substandard quality of the raw material, where poor on-vessel handling and storage practices result in damaged raw material. Finally, markets for the second grade output are not easy to find.

Shrimp trawl by-catch as: Coral fish (Caesio spp), Dorab (Chirocentrus dorab), Bigeye snapper (Priacanthus spp), Threadfin bream (Nimipterus spp), Small snapper (Lutjanus spp), Glassfish (Pentapiron longimanus), Lizard fish (Saurida spp), Croaker (Pennahia spp), have gel forming capacity and are being used also for surimi production (Putro 1989). However, the output is not a homogeneous paste thus attracting lower prices.

An additional constraint is the composition of the by-catch. These species are generally low-value not suitable for the fresh fish market. Their highly irregular sizes and difference in chemical properties make sorting and grading an imperative. The by-catch may be iced or frozen in up to 5 days before arriving at the shore based processing plant. Less freshness and general chemical characteristics further decrease the gel forming capacity.

The quality of the output is less than that based on fresh fish factory ship processing. A certain number of the alternative species are red meated and the colour of the output is reddish or brownish. The final texture of the surimi is not all homogeneous and is less elastic. The surimi produced of this kind of raw material is second grade not applicable for export, but is only usable as binders in derivative products for the local markets (fish sausages and fish balls).

Though it is technically possible to process a large variety of species into surimi it is generally noted that the output products may be of secondary quality attracting correspondingly lower prices. In order to increase output quality investments in factory vessels may be necessary and still the problem of access to suitable volumes of homogeneous fish species would remain difficult and costly for Pacific and even Asian developing countries. Probably the best hopes are for the utilization of small lean fishes from by-catches.

5.2 The Surimi Process

The surimi industry is able to utilize fresh/iced and frozen fish as raw material. The major steps in a typical modern production of Surimi are shown in Diagram 5.1, However, variation occurs depending upon the raw material available and the wanted output.

Following mechanical deheading and gutting the crucial part of the process is the repeated washing and rinsing of the fish mince (step C). This process removes undesired substances (inorganic ions, low molecular organic compounds, residual black skin, scales) and enzymes along with water-soluble proteins and oils. Removing the water soluble proteins will slow the process of protein denaturation by the break down of trimethylamine oxide TMAO.

DIAGRAM 5.1 SURIMI PROCESSING

STEP	RAW MATERIAL/ PROCESS	INPUT/ ADDITIVES	OUTPUT	EQUIPMENT
A	Fresh or frozen fish			
B	Deheading/ cutting	Salt water		Gutting machine
C	Deboning/ separation		Fish mince (meat/flesh)	Drum belt separator
D	Washing/ rinsing rep.	Fresh water (evt. 0.01-0.3% NaCl)		Washing drum/ rotary screen rinser
E	Dehydration			Decanter/ screw press
F	Straining			Strainer/ rotary sieves
G	Blending/ kreading	Cryoprotectants sucrose 4% sorbitol 4% polyphos. 0.2%	Surimi	Silent cutter kneader
H	Freezing			Plate freezer
I	Packaging			Packing machine
J	Cold store (- 20-25C)			Cold store

The washed mince product is dehydrated by screw presses and is screened from remaining skin and bone residues. Cryoprotectants are added (a mixture of sucrose and sorbitol) according to the needs of the further uses and the degree of sweetness desired. The output is a colour- and odorless stabilized fish paste with a high level of myofibrillar protein (actomyosin) and an elastic texture which is plate frozen, packed and stored. The durability in frozen condition is 1 year or more without the loss of water binding capacity or elasticity.

An attempt at identifying average yields on the basis of raw fish of the gadoid species of the north Atlantic indicates that the resulting output, frozen surimi, is around 11%, however, with an important filet output of 30% and roughly 5% second grade fish mince (Fiskmassa,1988). Results on the basis of Alaska Pollack (north Pacific) indicates surimi yields in the range of 22-32%, however, without any filet production (Lee, 1985).

The Surimi process results in a frozen intermediary product with a durability of more than 1 year and the right properties for:

- Kamaboko production (chikuwa, fried surimi, hanpen, datemaki),
- Application as a binder (for products as shumai, croquettes, artificial fish egg, fish sausages, fish balls),
- Production of seafood analogues (extruded products as crap sticks, scallop adductor muscle, crap flakes, fabricated shrimp),
- Fabricated meats (ham, hamburger).

The major characteristics of the derivative products are described below.

5.2.1 Fish Sausage

Fish sausage production is based on frozen surimi. However, the surimi quality required is not necessarily 1st. grade as it is used mainly in its capacity as a binder. The thawed surimi is s kneaded/ground and mixed with among other things colour agents, various flavorings and even fish and whale, and meat red meat mince. Technology requirements for this production are only moderate, see diagram 5.2.

Fish sausage is storable under ambient temperature conditions and has a long shelf life. Other products of that family are fish meat ham where chunks of fish and red meat are mixed with the surimi. A similar product is fish meat hamburger, where the meat chunks are smaller. Fish sausage is a low priced product which is sold mainly through supermarkets in major cities of Asia. These products have not gained markets outside Asia.

DIAGRAM 5.2 FISH SAUSAGE PROCESSING

STEP	RAW MATERIAL/ PROCESS	INPUT/ ADDITIVES	OUTPUT	EQUIPMENT
A	Frozen surimi			
B	Thawing			Thawing device
C	Kneading/ grinding	Water and Spices, flavouring salt, starch, fat colour agents	Kneaded surimi	Kneader, silent cutter
D	Packing in plastic	Plastic tubes (film sheet)		Packaging machine
E	Heating	Hot water		Retort (for rotation)
F	Cooling	Cold water		Retort
G	Drying/ examination			Dryer
H	Packaging	Plastic film	Fish sausage	Packing machine

5.2.2 Other Binder Products

The binding capacity of surimi is utilized in other products as:

- Shumai: minced meat and vegetables wrapped in a thin wheat dough and steamed,
- Croquettes,
- Imitation herring egg: the capeline roe and surimi powder is mixed and shaped,
- Fish balls: minced fish meat mixed with surimi.

These products are relatively low priced and have gained popularity in Asian countries. The main outlets are supermarkets.
In Thailand fish balls (or "Lukchin pla") is quite popular as a way of altering the daily fish dishes. These are kamaboko style fish gels mixed with minced fish meat.

The surimi used in the fish ball industry is produced on local factories, The quality of that surimi is of second grade, i.e. not exportable. In 1985 the Thai fish ball industry counted approximately 100 factories with a capacity for 5 mio. balls per day with an equivalent annual raw fish supply of 12,500 tons (Yamprayoon 1985). The best quality fish balls is produced from yellowtail (Serolia spp.) and spanish mackerel (Scomber japonicus) yielding a high priced product. The major share (and low price end) of the fish ball market is based on ribbon fish, big eye, eel, barracuda, threadfin bream and shark.

Similar products are marketed in Malaysia and Indonesia.

5.2.3 Kamaboko Products

Though kamaboko is a generic term for products based on stabilized frozen surimi a particular group of products are labelled kamaboko (or Japanese fish cake). The characteristics of kamaboko products are:

- a high degree of elasticity (good water binding capacity),
- a chewable mouthfeel,
- and whiteness.

The major market is Japan, however, markets also are found in Hong Kong and other ASEAN countries.

Due to the strict consumer preferences kamaboko production is based on Alaska pollack surimi, which has the right water binding capacity and whiteness. The general production steps as indicated in Diagram 5.3.

DIAGRAM 5.3 KAMABOKO PROCESSING AND PRODUCTS

STEP	RAW MATERIAL/ PROCESS	INPUT/ ADDITIVES	OUTPUT	EQUIPMENT
A	Frozen surimi			
B	Thawing			Thawing device
C	Kneading/ grinding	Monosodium gl. water, starch, rarely spices fish meat	Kneaded surimi	Kneader, silent cutter
D	Suwari (gel setting)		Fish gel	Wooden board, hemicylinders
E	Steaming	Steam	Kamaboko	Steamer (basket)

A variety of products are made on this basis. The major difference is the way of heating and the kind of additional raw materials, e.g.:

Product	Heating method	Additional input
Chikuwa	Iron bar	
Agemono	Frying (hot oil)	Minced fish meat
Hanpen	Hot water	Shark meat (extra kneading)

Technology requirements are not excessive but a sound knowledge of consumers preferences is essential in the choice of production process. The price levels of output vary according to the quality and grade of ingredients.

5.2.4 Extruded Products

A group of products that has gained increasing attention in the international markets are based on the extrusion of surimi. The best known and produced types are the so-called seafood analogues and the fabricated meats. The basic principle is described in diagram 5.4.

DIAGRAM 5.4 EXTRUDED PRODUCTS (FABRICATED CRAB LEGS, SHRIMP, MEAT)

STEP	RAW MATERIAL/ PROCESS	INPUT/ ADDITIVES	OUTPUT	EQUIPMENT
A	Frozen surimi			
B	Thawing			Thawing device
C	Kneading/ grinding	Water, egg white, flavouring (crab) salt, starch	Kneaded surimi	Kneader, silent cutter
D	Extruding		Extruded surimi	Extruder
E	Heat/gel-set.	Gas/steam/gas	Surimi gel sheet	Heat setting unit
F	Cutting		"Noodle" strips	Strip cutter
G	Folding		Surimi rope	Rope folder
H	Mixing with colored surimi	Colored extruded surimi paste		Wrapper
I	Cooking	Steam		Steam cooker
J	Cooling/drying			Cooling dryer
K	Packaging		Fibrous surimi (crap legs etc.)	Packing machine

5.2.4.1 Seafood Analogues

The output of the extrusion process is a fibrous product which has a texture quite different from the kamaboko. It resembles to a large degree the target luxury type products as crab legs, crab flakes, shrimp and lobster. Careful selection of flavorings and colour agents assures that the products in fact are very close to their targets.

Seafood analogues are produced in Japan, Korea, USA and Europe. It is estimated that the world production in 1990 is in the range of 400-450,000 tons, with Japan as the leading producer accounting for 300-350,000 tons (Murphy 1991). The major producer in Europe is France where factory vessels are producing frozen surimi on the basis of gadoid species. However, the production is still in its infancy and European seafood analogue producers have to import the frozen surimi from Japan and the USA.

A market survey indicates that the overall consumption in Europe was 19,450 tons (1989) with an expected growth to 40,000 tons in 1992. Surimi based products face the problems of technical barriers to trade as certain flavouring and colouring agents are prohibited in human food products.

In the longer term the general trend towards a higher level of consciousness of health and nutrition relations may turn the consumer more toward fresh natural seafood than to the imitation products. Also the fact that the surimi products marketed in Europe are considered highly price elastic may put a limit to future growth.

The USA market has had its most impressive growth in the 1980s and the annual increases are now levelling out. The present level of annual consumption is estimated at 65-70.000 tons per year (no statistics are kept on surimi), with expected growth trends of 8-10% per annum.

Among the most important price determining factors is the raw material supply situation. As seafood analogues require top grade frozen surimi the principal raw material source thus is the Alaska pollack stock found within and outside the Japan, USSR and USA EEZs of the north Pacific and the Beering Sea. Over fishing is a problem limiting the catch to a seasonal venture and with the highly capital intensive fishery/factory ship technology the price hikes on frozen surimi thus are transferred to the fabricated seafood industry and, finally, to the consumer.

To support future growth in the seafood analogues industries it will be necessary to identify new suitable species for raw material. As indicated earlier such species may be found essentially among the small lean gadoid species. However, these species do have more economic potential in terms of fillet products and fish mince (Fiskmassa 1988). In fact, leaving only minor parts of the fish in volume term to surimi production. It is questionable whether the capital intensive production is warranted on a rater slim raw material basis.

5.2.4.2 Fabricated Meat

The production process of fabricated meats resembles that of seafood analogues. However, in the production of the surimi a slow freezing technology is used. This process allows the forming of ice crystals in the surimi paste and the thawing process thus leaves tiny crates in the block. Thawed and kneaded surimi is extruded and mixed with flavorings including tuna, pork extract etc. and extruded. The final products are a composite molds sometimes further mixed with fibrous surimi. The products have a meat like texture showing a blend of coloured and white surimi that is close to e.g. ham.

The markets for these products are difficult to quantify as the main market is the USA, where detailed statistics are not kept. In Europe fabricated meat products are not yet introduced.

5.2.4.3 Snacks

Technologically, the most simple way of utilizing surimi is for the production of various snack products. The surimi is thawed, kneaded with starch and various flavorings and cut into the form and shape wanted and dried usually in a micro-owen. The production technique thus is simple and not costly, however, the market prospects are not yet investigated. Products of this nature are typically produced for the very local markets. They are based on second grade surimi and are low priced.

5.3 Infrastructure and Environment

5.3.1 Infrastructure Requirements

The production of frozen surimi requires infrastructures in terms of availability substantial amounts of fresh water and electricity. Whereas the electricity requirements are easily met as a mere 110 kWh per ton surimi is required. This is not likely to pose difficulties in countries as China, Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, and Thailand.

However, the major infrastructure problem is related to the provision of fresh water of drinking/processing quality for the onshore production of surimi. Clean drinking water is essential due to the need for repeated washing/rinsing of the fish mince. It is estimated that the conventional production of 1 tons of surimi requires 20 tons of fresh water (Kaeg 1985).

As these requirements do have a substantial cost attached and in general are difficult to meet in most places experiments in recent years have been conducted with the aim of reducing the water requirements. A method has been developed in Alaska whereby the washing water is mixed with the fish mince under turbulent conditions in a retention cell allowing longer contact between water and mince. Water requirements this way have been reduced to 6 tons water per tons surimi produced (Fiskmassa 1988).

However, the water requirement must still be considered excessive as fresh drinking water supply typically is a problem in major city areas of ASEAN countries. The competition for water supplies thus is not favorable to surimi production.

Given the high capital costs of modern factory vessels, long travel distances to get to areas with large volume of homogeneous applicable species, it is not advisable that ASEAN members, Vietnam, China or the Pacific nation will choose the strategy of first grade surimi production. In this context it should be noted that the Korean surimi production is competitive not due to improved technology or lower capital costs but due to lower wages.

It appears more interesting to pursue the strategy of utilizing the better part of by-catches for the production of lower grade surimi that then would enter the processing lines of derivative products (sausages, fish balls etc.). However, due to the heterogeneous composition of raw material the input/output relations may be even less than 10 to 1 indicating a higher level of water consumption per ton surimi.

From an infrastructure point of view it may prove even more advantageous to aim solely at a few derivative products such as the production of fish ball products and sausages. In this case the surimi may be imported frozen and the local value added contribution would be the production of the fish minces to be mixed in with the surimi. The power and water requirements are modest and markets are nearby. However, careful consideration must be given to the market potentials before new investments are made.

5.3.2 Environmental Concerns

The major environmental concerns are related to the substantial production of organic wastes in terms of solids and liquids. In the best case (i.e. where the raw fish is used also for filets as well as surimi production as in the Scandinavian countries) the input/output relations are as follows:

Input:			
	Raw fish		100 %
Output:			
	Whole gutted fish (78 %)		
	Filet	31 %	
	First grade mince (20 %) equal to a surimi production of	11 %	
	Second grade fish mince	5 %	47 %
Solid Waste:			53 %

The total solid waste is roughly 50% (Fiskmassa 1988). Based on Alaska pollack the solid waste accounts for to 68-78% (Lee 1985). However, using factory ship processing where fish meal plants usually are part of the design reduces the solid waste problem.

There are no estimates available of the solid wastes from surimi production based on shrimp by-catch or from small pelagic species and the fatty fish (sardines, horse mackerel etc.). However, due to the difference in fish sizes of the by-catch wastes are most likely larger in volume terms. Due to the more thorough washing required for the small pelagic solid wastes are probably larger also for these species. In the case of by-catch of the attempts at utilizing underutilized species as sardine and horse mackerels the solid waste production will require simultaneous fish meal production. If such facilities are not available a major problem with solid wastes will prevail.

It is noted that the fish meal produced on the basis of the above wastes is not a first quality product as the input is not homogeneous. Thus, in an assessment of the possibilities of putting a value on the solid wastes only low prices products are possible. Given the present depressed market trend for the average Chile 65% fish meal it is highly questionable whether such productions are economically feasible.

Liquid wastes:

In the case of factory ship production waste waters are directly disposed of and environmental impact is dismal due to the waters deeps and currents. On-shore processing will lead to the discharge of uncleaned waste water in costal zones. As a part of the disintegration process bacterial growth is created under high level of oxygen consumption. The reduced levels of oxygen remaining available in these shallow waters is a condition detrimental to the fauna - i.e. damaging the fish fry survival of the brackish water breeding grounds.

Depending upon the raw material used and the level of technology applied on-shore production of surimi will produce 10 to 20 times the raw material weight in terms of organically contaminated water. The contamination is quite severe as the concentration of e.g. proteins is very high. It is estimated that at least 1/3 of the proteins of the deboned meat are washed out (Lee 1985). In addition, more normal effluent as blood and fat and oils are also washed out, which especially in the context of small pelagic species may add considerably to the level of contamination.

The most commonly practiced way of handling waste water is by an activated sludge method sometimes in combination with a dissolved air-flotation method (see 3.3.2). The present trend in international environmental protection laws and regulations will pass the requirements for further cleaning onto the industry thus calling for more efficient cleaning techniques with associated higher capital and operating cost requirements.

From an environmental point of view it would seem more feasible to aim at the production of surimi derived products. Most of the productions only have limited environmental consequences compared to the production of frozen surimi. Along this line of thinking the better option may be fish ball and sausage types of products. The input/output ratios would definitely improve thereby reducing solid and liquid wastes.

5.4 Prospects

In an overall evaluation of the potential of surimi production and/or the production of surimi based products the following aspects are important:

- A suitability of raw material
- B economic feasibility for producing the raw material
- C capital intensive productions (surimi per se, extruded fish products)
- D accessible markets of derivative products (fish balls, sausages, seafood analogues and other imitations)

E   infrastructure and environment
F   nutritional value

As surimi originally was invented to offer the japanese kamaboko industry a stable raw material supply functional aspects such as water binding (gel-formation) capacity, a chewable mouthfeel and whiteness are essential. Aside from a limited number of species available with this characteristic surimi quality is further a function of the freshness of the raw material, which is why factory ship processing is ideal. Only few species such as the Alaska pollack meet these criteria. However, the stock is gradually being depleted by Japanese, Korean, US and Canadian factory ships and feeder trawlers. Other suitable species include gadoids and certain flat fishes. However, the economic potential of these species are better explored in terms of fillet production.

Ideally, the aim of the Region would be to utilize abundant low-value fish species for the production. These species should not have any important competitive processing options as e.g. fillet production. For the Region's members the more abundant species are the small fatty pelagic as sardines and mackerels. It is technologically possible to make surimi of these species, however, only by introducing additional capital intensive methods. Though many experiments with such species have taken place only the lean white species will yield the first grade product.

The utilization of by-catch especially from shrimp trawling is complicated as it is a heterogeneous mixture both in size and chemical characteristics. Surimi products on this base are second grade and not exportable thus only attracting low prices.

An additional constraint is that these landings require an on-shore production facility placing strains on infrastructures as water supply and electricity. Whereas electricity supply may be overcome supple of clean fresh water is a major issue. In a very rough estimate the input/output ratio of by-catch to surimi would probably be 20 to 1 and due to the heterogeneous nature of the raw material. The fresh water requirement would also be in the order of 20 to 1. Alternative uses of the by-catch may yield better ratios and also the fresh water could be better used as drinking water supply in stead of producing only second grade products attracting relatively low prices.

Environmentally, the production process results in high levels of solid wastes, up to 80% of the raw material weight. It is thus imperative that the solids are transformed preferable into fish meals. However, the heterogeneous composition of the wastes do make the production of high grade meals difficult. In fact, attempts at valorizing the wastes may result in low price meals without commercial viability.

The organically contaminated waste waters pose another major ecologic danger as at least 1/3 of the myoglobin protein are washed out together with fat, oils, and dark muscle fibre. The degree of contamination and the large volume of waste water requires extraordinary investments in water treatment facilities if today demands for ecologically clean and dischargeable liquids are to be met.

From a raw material point of view and considering the infrastructure and environmental impact too it is thus questionable whether surimi production, per se, is a sound way of development for the Region's countries. It appears reasonable that this highly capital intensive production should be left to developed countries located nearer the major raw material source, the Alaska pollack of the North Pacific and the Beering Strait. Without the local production of high grade frozen surimi the high priced extruded products as crab legs and fabricated meat become economically difficult as they will have to be based on imported surimi. Such productions are more safe if handled in the consuming countries where production with greater ease can adapt to consumer preferences.

However, there may be some scope for the production of second grade surimi. It must then be targeted to meet the requirements of the production of locally marketed derived products such as fish balls and sausages. Finally, it appears in general to be a waste of protein for human consumption to wash away 1/3 in order to allow the production of fish paste that requires enrichment to attain a reasonable degree of nutritional value.

ANNEX A: DETAILED STATISTICS

Table 1: Nominal catches by Continents

Numbers include fished and farmed marine and freshwater fishes, crustaceans, mollusks, squids and other invertebrate on which production can be based.

Country	1982 mt	1983 mt	1984 mt	1985 mt	1986 mt	1987 mt	1988 mt
Africa:							
Inland catches	1,412,200	1,431,400	1,538,400	1,553,500	1,679,300	1,752,700	1,802,200
Marine catches	2,521,700	2,797,900	2,584,400	2,714,900	2,928,700	3,570,800	3,508,100
Africa total	3,933,900	4,229,300	4,122,800	4,268,400	4,608,000	5,323,500	5,310,300
America North							
Inland catches	205,800	307,700	433,900	443,300	484,400	572,100	563,700
Marine catches	7,087,500	7,022,900	7,504,800	7,933,500	8,143,200	9,058,500	9,004,200
A. North Total:	7,293,300	7,330,600	7,938,700	8,376,800	8,627,600	9,630,600	9,567,900
America South:							
Inland catches	313,900	328,100	337,400	327,900	361,100	385,100	367,500
Marine catches	9,145,100	7,243,500	10,039,100	11,478,900	13,615,000	11,584,300	14,044,700
A. South Total:	9,459,000	7,571,600	10,376,500	11,806,800	13,976,100	11,969,400	14,412,200
Asia:							
Inland catches	5,306,400	5,888,200	6,401,300	7,020,700	7,840,300	8,556,200	9,187,600
Marine catches	27,871,900	29,192,100	30,627,400	30,701,200	32,883,300	33,334,900	34,413,600
Asia Total:	33,178,300	35,080,300	37,028,700	37,721,900	40,723,600	41,891,100	43,601,200
Europe:							
Inland catches	403,300	401,300	413,000	429,600	459,700	449,300	483,900
Marine catches	11,937,500	12,400,500	12,712,700	12,514,800	12,265,700	12,185,300	12,390,500
Europe Total:	12,340,800	12,801,800	13,125,700	12,944,400	12,725,400	12,634,600	12,874,400
Oceania:							
Inland catches	17,100	17,800	20,000	20,500	20,500	22,800	24,200
Marine catches	516,400	567,100	614,400	595,400	670,800	782,900	863,100
Oceania Total:	533,500	584,900	634,400	615,900	691,300	805,700	887,300
USSR:							
Inland catches	837,500	856,400	881,500	905,600	926,900	988,400	995,600
Marine catches	9,153,200	8,960,200	9,711,400	9,617,200	10,333,000	10,171,200	10,336,500
USSR Total:	9,990,700	9,816,600	10,592,900	10,522,800	11,259,900	11,159,600	11,332,100
World:							
Inland catches	8,496,200	9,230,900	10,025,500	10,701,100	11,772,200	12,726,600	13,424,700
Marine catches	68,233,300	68,184,200	73,794,200	75,555,900	80,839,700	80,687,900	84,560,700
World Total:	76,729,500	77,415,100	83,819,700	86,257,000	92,611,900	93,414,500	97,985,400

Source: FAO Yearbook Fishery statistics, 1988

ANNEX A

Table 2: Nominal catches by ASIA and OCEANIA

Numbers include fished and farmed marine and freshwater fishes, crustaceans, mollusks, squids and other invertebrate on which production can be based.

Country	1982 mt	1983 mt	1984 mt	1985 mt	1986 mt	1987 mt	1988 mt
Asia:							
Inland catches	5,306,400	5,888,200	6,401,300	7,020,700	7,840,300	8,556,200	9,187,600
in % of W.inland	62	64	64	66	67	67	68
Marine catches	27,871,900	29,192,100	30,627,400	30,701,200	32,883,300	33,334,900	34,413,600
in % of W.Marine	41	43	42	40	41	41	41
Asia Total:	33,178,300	35,080,300	37,028,700	37,721,900	40,723,600	41,891,100	43,601,200
In % of W.Total	43	45	44	43	44	45	44
Oceania:							
Inland catches	17,100	17,800	20,000	20,500	20,500	22,800	24,200
in % of W.Inland	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Marine catches	516,400	567,100	614,400	595,400	670,800	782,900	863,100
in % of W.Marine	0.8	0.8	0.8	0.8	0.8	1.0	1.0
Oceania Total:	533,500	584,900	634,400	615,900	691,300	805,700	887,300
In % of W.Total	0.7	0.8	0.8	0.7	0.7	0.9	0.9
World:							
Inland catches	8,496,200	9,230,900	10,025,500	10,701,100	11,772,200	12,726,600	13,424,700
Marine catches	68,233,300	68,184,200	73,794,200	76,555,900	80,839,700	80,687,900	84,560,700
World Total:	76,729,500	77,415,100	83,819,700	87,257,000	92,611,900	93,414,500	97,985,400

Source: FAO Yearbook Fishery statistics, 1988

Table 3: Nominal catches by 10 major fishing countries - ASIA -
Numbers include fished and farmed marine fishes, freshwater fishes, crustaceans, mollusks, squids and other invertebrate on which production can be based.

Country	1982 mt	1983 mt	1984 mt	1985 mt	1986 mt	1987 mt	1988 mt
Japan	10,826,542	11,254,722	12,021,004	11,408,883	11,976,274	11,848,582	11,896,935
China	4,926,683	5,213,261	5,926,793	6,778,819	8,000,063	9,346,222	10,358,678
India	2,367,049	2,508,587	2,864,495	2,826,057	2,923,210	2,907,775	3,145,650
Korea R.	2,280,821	2,400,387	2,477,080	2,650,031	3,103,468	2,876,367	2,727,059
Indonesia	1,982,159	2,204,872	2,251,896	2,332,686	2,457,082	2,584,970	2,703,260
Thailand	2,120,133	2,260,024	2,134,846	2,225,114	2,536,335	2,200,953	2,350,000
Philippines	1,786,790	1,973,141	1,933,706	1,864,990	1,916,347	1,988,718	2,041,920
Vietnam	661,208	757,138	776,308	808,010	824,743	871,404	874,000
Bangladesh	686,000	726,587	756,013	775,631	796,910	817,003	828,598
Malaysia	682,069	740,689	669,592	639,385	620,614	611,862	604,128
Total:	27,637,385	29,298,719	31,142,141	31,670,221	34,534,432	35,441,994	36,926,100
Total region:	33,162,435	35,080,285	37,028,731	37,721,936	40,723,558	41,891,081	43,601,129
Countries in %	83	84	84	84	85	85	85

Source: FAO Yearbook Fishery statistics, 1988.

Table 4: Nominal catches by 10 major fishing countries - PACIFIC - 1991.03.25

Numbers include fished and farmed marine fishes, freshwater fishes, crustaceans, mollusks, squids and other invertebrate on which production can be based.

Country	1982 mt	1983 mt	1984 mt	1985 mt	1986 mt	1987 mt	1988 mt
New Zealand	239,740	282,063	322,499	304,750	345,174	430,705	503,265
Australia	166,408	169,241	169,373	160,993	180,305	199,907	201,709
Solomon Is.	32,782	47,296	48,853	44,029	55,412	44,541	54,830
Kiribati	19,540	24,212	25,906	29,565	33,585	43,868	37,725
Fiji	28,017	27,838	27,909	27,626	27,002	35,266	38,347
Papua N Guinea	9,204	15,541	17,774	25,480	24,981	25,563	25,554
New Caledonia	2,880	1,276	3,349	2,694	4,006	4,797	3,683
Samoa	4,020	3,820	3,720	3,641	3,700	3,400	3,500
Vanuatu	2,715	2,470	2,920	3,527	3,205	3,249	3,249
Tonga	2,100	2,200	2,330	2,500	2,730	2,719	2,678
Total:	507,406	575,957	624,633	604,805	680,100	794,015	874,540
Total Region:	515,649	584,904	634,382	615,863	691,350	805,722	887,294
Countries in %:	98	98	98	98	98	99	99

Source: FAO Yearbook Fishery statistics, 1988

ANNEX A

Table 5: Catches of Selected Species in Regional Areas ('000 mt)

Species (region)/FAO Area	51	57	61	67	71	Total
Giant sea perch		6			14	20
(region)		6			13	19
Flatfish	10	7	176	154	5	352
(region)	10	1			3	14
Alaska pollack			5107	1397		6504
(region)				20		20
Bombay duck	96	2			14	112
(region)	96	2			14	112
Sea catfish	48	34	5		47	134
(region)	33	34	5		46	118
Lizardfish	6	6	12		25	49
(region)	5	6			24	35
Demersal percom.	33	1	5	12		51
(region)	8			11		19
Groupers nei	5	3			15	23
(region)		3			15	18
Bigeys nei		2	12	17		31
(region)		2		17		19
Silago whitings		5			14	19
(region)		1			13	14
Snappers nei		5			32	37
(region)		5			32	37
Fusiliers		3			33	36
(region)		3			33	36
Snappers, jobfishe	9	1	11		25	46
(region)		1			25	26
Threadfin breams	1	11	25		78	115
(region)		11			78	89
Yellow croakers			65			65
(region)			42			42
Croakers, drums	142	53	61		35	291
(region)	125	53			32	210
Emperors	41	2			16	59
(region)		2			16	18
Red mullets	1				26	27
(region)					26	26
Goatfishes	12	10	2		7	31
(region)	12	10			7	29
Needlefish		2			36	38
(region)		2			36	38
Barracudas	10	9			25	44
(region)		9			25	34
Mullets nei	12	19			39	70
(region)	6	19			39	64
Threadfins	4	11			20	35
(region)	3	11			20	34
Scads	3	21	256		319	599
(region)		21	251		319	591
Jacks, crevalles	31	22	1		21	75
(region)	6	22			21	49
Indian oil sardine	238	48				286
(region)	215	48				263
Bali sardine		8			55	63
(region)		8			55	63
Sardinellas	22	24			185	231
(region)		24			185	209
Rainbow sardine		2			47	49
(region)		2			47	49
Stolephorus anch.	7	37			226	270
(region)		37			226	263
Anchovies nei	60	22			54	136
(region)	55	22			54	131
Clupoids	104	24	107		13	248
(region)	35	8			13	56
Wolf-herring	11	16			20	47
(region)	11	16			20	47
Spanish mackerel	62	24			54	140
(region)	10	24			54	88
King mackerel	8	12			6	26
(region)	7	12			6	25

ANNEX A

Table 5 (cont'd)

Species (region)/FAO Area	51	57	61	67	71	Total	
Seerfishes	7	7	4		28	46	
(region)		7			28	35	
Bullet tuna	8	9	25		109	151	
(region)	4	9			108	121	
Kawakawa	32	13	4		86	135	
(region)	17	13			86	116	
Skipjack tuna	182	13	161	3	619	978	
(region)	15	13			263	291	
Longtail tuna	40	2	7		36	85	
(region)		1			36	37	
Albacore	18	11	22	6	12	69	
(region)					4	4	
Yellowfin tuna	170	13	41		193	417	
(region)	7	8			124	139	
Bigeye tuna	41	9	13		14	77	
(region)					1	1	
Tuna-like fishes	25	33	27		111	196	
(region)	2	32			104	138	
Hairtail	2	3	531		5	541	
(region)		3	366		5	374	
Chub mackerel			1138			1138	
(region)			241			241	
Indian mackerel	12	84			184	280	
(region)		84			184	268	
Sharks, rays, skat	60	55	55	2	42	214	
(region)	47	44			41	132	
Marine fishes nei	528	1052	4742	58	1736	8116	37%
(region)	186	1049	3661		1710	6606	59%
Total	2003	1827	12538	1730	4146	21908	
(region)	984	1759	4650	132	4012	11201	

Source: FAO. Yearbook 1988 (vol. 66), Rome 1990

FAO Fishery Areas: Indian Ocean, Western (no 51); Indian Ocean, Eastern (no 57); Pacific Northwest (no 61); Pacific, Western Central (no 71).

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