# The production of surimi and surimi seafood from tropical fish – a landscape view of the industry

**Report to the Certification and Rating Collaboration**

**December 2020**


**Duncan Leadbitter, Fish Matter Pty Ltd**

**Pascal Guenneugues, Future Seafood**

**Jae Park – Jae Park Surimi School**

# Contents

## List of Figures

# Introduction and overview

We have reviewed a considerable amount of publicly available information about the tropical surimi sector. Surimi seafood is not a highly valued product in the West and has thus slipped under the radar of the sustainable seafood movement. Whilst the key fisheries that supply surimi in western countries are certified to the MSC Standard (or in a FIP) this is largely fortuitous as the main avenues for engagement have been via supply chains that supply fillets or breaded products, foods that suit western tastes. Alternative ways of processing the same fish which are more important in Asian countries, in particular surimi, has not been a priority. As such, a major source of pressure for fisheries management reform, especially in tropical developing countries, has not been investigated. Whilst the tropical surimi industry is complex, the general principles of using guided market-based demand, are applicable but new ways of thinking will be required.

Some of the notable findings of our research include:

- The production of tropical surimi is a significant (about 70%) proportion of total global surimi production
- The countries that produce most tropical surimi are China, Vietnam and India, followed by Thailand, Malaysia, Indonesia, Pakistan and Myanmar
- The countries that produce the most surimi seafood products are China, Japan and South Korea.
- The countries that consume the most surimi products are China, Japan and South Korea.
- Surimi can be made from wild capture fish, farmed fish and the trimmings from fish processing (wild and farmed);
- There is a very large number of wild capture species involved as surimi can be manufactured from any species of fish;
- The most commonly used species in tropical surimi are the threadfin breams, croakers, lizardfishes, bigeye snappers, goatfishes, hairtails/ribbonfishes and some small pelagic species such as sardines and flying fishes. Over one hundred species have been recorded.
- Overfishing is a serious and widespread problem in all countries that harvest tropical fish for surimi (if not virtually all other seafood products)
- The main fishery sources for tropical surimi fish are the trawl fisheries which are ubiquitous in Asia. To a lesser degree purse seining and gillnetting are also sources. Only Malaysia and Thailand have made serious efforts to ensure that their trawl fisheries are adequately controlled.
- The tropical multispecies fisheries present some significant challenges for not only fisheries managers but fishery assessment systems and standards which are largely designed around single species approaches. Care needs to be exercised in seeking to impose single species approaches on these fisheries for not only ecological reasons but for social and economic reasons.
- Multispecies trawl fisheries are also multiproduct fisheries. These fisheries can be managed in different ways to optimise yields that suit the objectives set out by fishery stakeholders.
- In any given fishery the same species can be used fresh/frozen, processed (e.g. into surimi) and/or used for fish meal depending on the size, demand and quality of the fish.
- Processing wastes from the surimi sector are commonly used for the production of fishmeal either at the same factory or at dedicated fishmeal factories.
- The production of mixed fish surimi is becoming increasingly common as producers look for ways of extending the use of increasingly scarce high value species such as threadfin breams. There is also surimi made from mixes of species but there is little information available on this;
- Supply chains are very complex. Fish may be transferred to carrier vessels in some countries, the buying arrangements can be complex, there may be mixes of species used in the surimi and the surimi may be traded internationally prior to the making of surimi seafood products.

Chapter 1 provides an introduction to surimi and surimi seafood noting that surimi is a paste made from the muscle tissues of fish which is than processed into a variety of different types of surimi seafood which can be boiled, fried or grilled. The roots of surimi production go back centuries in China and Japan and many Asian countries have their own versions of popular products such as fish balls.

Chapter 2 presents detailed information on the production and trade in tropical surimi and surimi seafood, including information on the industry's development history in producer countries (Pakistan, India, Malaysia, Myanmar, Thailand, Vietnam and China) and the main markets (China, Japan and Korea). Linked to Chapter 2 is Appendix 1 which reviews information on the coldwater surimi sector which is dominated by the Alaska pollock and Pacific whiting fisheries in the US and the key markets of the US, Japan and the EU. There is a considerable degree of interaction between the tropical and cold water sectors which is driven by the availability of fish resources, prices and demand variables, including market interest in sustainable seafood.

In Chapter 3 we explore what is known about the types of species used in tropical surimi. There are at least five families of fish which are commonly used and within these families there are many species. We document over 120 species but this may be an underestimate as there are very few independent studies and the trade does not seem to focus on individual species. We also present information on the nature of the source fisheries including some broadly applicable information on the status of stocks and environmental interactions.

Chapter 4 presents country level information with a particular focus on countries that produce surimi. It brings in some information from Chapter 2 (production and trade data) and Chapter 6 (companies operating) but also reviews what is known about fisheries and supply chain issues, stock status and fisheries management on a country basis.

In Chapter 5 we analyse the available information to look for generic themes across the sector. These may in the form of particular characteristics which need to be considered by CRC members or particular issues that need to be addressed. It should be noted that some country level issues may not be sufficiently widespread across tropical developing countries (or known/documented) to be covered in this section. A case in point is some of the labour issues which have dominated headlines in recent years. One point worth mentioning is that the surimi industry is only one user of fish from the fisheries and the widespread occurrence of overfishing is definitely not the fault of one sector.

In Chapter 6 we both review the results of a survey of surimi and surimi seafood producers and provide a series of suggestions as to how the CRC's members may consider making progress on improving the management of the fisheries that supply fish for surimi production. The overall topics covered include:

**Engaging industry**

There is existing receptivity in some companies to a discussion about sustainability. Not only are some companies experiencing supply shortages which, in some cases, are due to the direct or indirect consequences of poor fisheries management, but others are well aware of the global debate about sustainable fisheries and what this means in terms of opportunities and risks. Some initiatives could include meetings and workshops, establishment of a working group, direct discussions with companies that are already players in the sustainable seafood movement, engaging in industry/community events that are oriented around surimi seafood products – e.g. Kamaboko Road to 1000 (https://www.nikkama.jp/).

**Bringing the issues to life in a visual way**

The source fisheries are complex and it is commonly difficult to visualise the consequences of changes in management. However, models such as Ecopath with Ecosim (EwE) can be used to explore the potential consequences of changing inputs (such as numbers of vessels, mesh size changes, days fished, closed seasons etc) so as to better engage non-scientific stakeholders. EwE can also handle economic aspects and so the potential impacts of management changes on industry economics could also be explored.

**Engage related sectors of the industry – find win-win solutions**

There is a close connection between sectors that supply fresh fish, processed fish for human consumption and fish for animal feed (primarily aquaculture). All of these sectors would benefit from better management of the fisheries and options for management and stock rebuilding and win/loss scenarios could be minimised by mixing industry needs with some modelling. For example, the fishmeal sector is engaged at least in some countries and could be further involved in looking at the fisheries as a whole. Declines in the availability of small fish over the short term (if mesh sizes are increased) should be balanced out by increasing stocks and by the increased availability of processing wastes from the surimi sector. Maybe some economic modelling would be useful to bring this aspect into full view by participants.

**Evaluate wider benefits**

Notwithstanding the current interest in labour issues the current standards really only apply to fishery level considerations and do not consider flow through benefits from seafood processing. Large numbers of people employed in surimi production plants will have lost their jobs as a result of poor fisheries management. Encourage the industry to demonstrate the wider benefits in developing countries of the flow-on benefits of better managing all the production from their fisheries and processing them in-country, and how this could help them achieve their SDGs.

**Performance tracking**

The development of an annual 'State of the Industry supplies' report as SFP does for the reduction fisheries would be valuable but this will need to be a move away from the single species approach. The same is also true for Seafood Watch assessments. Possibly a mix of MMSY and indicator species would be the best way forward.

**Develop a workable improvement pathway**

Single species management approaches are generally unworkable and some careful thought needs to be devoted to exploring the intermediate/alternative approaches would be wise, including whether multispecies fisheries could have an assessment tree that allowed species above PRI to carry the MSC label, modelling of the potential consequences of different multispecies approaches may help understand the potential social and economic consequences, undertaking due diligence on the economic and social impacts of seeking MSC certification or moving fisheries into FIPs for which MSC certification was an expected endpoint. A due diligence exercise goes beyond undertaking a Pre-Assessment, changing certification requirements to enable species managed at levels below their individual MSY's to be certified. There may be options with interpretations of MSY which, according to international norms can be modified by ecological, social or economic factors. There may also be avenues in interpreting the MSC requirements for 'stock complexes' and gaining a better understanding of supply chains and how the current single species oriented product composition and traceability systems could be retooled

**Ensure traceability systems are fit for purpose**

Tropical surimi is, arguably, a very different product to anything previously tackled by the sustainable seafood movement. The systems developed over the past two decades are largely designed to work with single species products, which links to the fact that the vast majority of certified fisheries are single species fisheries. There is a need to develop systems that cope better with product mixes. It may be necessary to revisit the tolerance on product mixes, i.e. review the 5% rule.

**Looking ahead to new drivers of sustainable seafood production**

Discuss with the industry about the opportunities for the promotion of sustainable aquaculture as the use of farm-based sources of raw material increases. There may be potential for 'joint ventures' between the sectors that source fish from multispecies fisheries so as to increase the demand for a transition to sustainable use and avoid the potential for one sector to pus sustainability issues on to others.

# Chapter 1 Background and History of the Global Industry

## 1.1 Historical and Cultural Aspects

Surimi literally indicates ground fish meat in Japanese and has been globally accepted as frozen raw fish proteins used for the manufacturing of various surimi seafood. Japan celebrated its 900 years of kamaboko in 2015 and proposed Kamaboko Road 1000 (https://www.nikkama.jp). Surimi was also used centuries ago to make fish balls consumed in soup known as "geng" in Fujian Province (China) and Ground Fish Meat (called Otoshimi in Japan) has also been used in traditional food in Thailand (fish balls called Lok Shin Pla and fried seasoned fish cakes called Pod Man Pla), Vietnam (steamed fish cakes called Cha Ca), Korea (fried fish cakes called Ahmok), Indonesia (otak-otak and pempek), Myanmar and other Asian countries. Fish Protein (from fish mince or surimi) is usually 20 to 30% of the formulation of these products.

The discovery of frozen surimi in Japan in the 60's and the development of the Alaska pollock fishery paved the way for the rapid growth of the Japanese surimi seafood market which reached one million tons by 1970. Fueled by this fast-growing market, surimi production grew through the 1960's via shore-based plants in Hokkaido. In the 1970's Japan launched the first factory trawlers sent to go fishing in the North Pacific Ocean. Surimi production reached 400,000 tons by the mid 1970's.

After Japan, Korea also quickly grew a surimi seafood market in the 1980's. The market reached 300,000 tons in the form of fish cakes and other products and companies built factory trawlers to feed a fast growing surimi seafood industry. By 1989, the output of the Korean vessels reached 60,000MT.

Japanese fishing conglomerates introduced the surimi industry throughout the world in the 1980's and 1990's. After the declaration of the US Exclusive Economic Zone (EEZ) and the 'Americanisation' of the fishing fleets, these companies led the development of the US pollock industry in the form of Joint-Ventures with American investors. In addition, they started production of surimi from Hoki and Southern Blue Whiting on factory trawlers in the South Pacific (New Zealand, Argentina and Chile), initiated the tropical fish surimi industry in Southeast Asia and India, and introduced surimi production technology to the Chilean shore plants operating in the hake, hoki and jack mackerel fisheries.

Japanese companies also introduced surimi products and surimi products technology to the rest of the world through the export market, primarily in the form of crabsticks. In addition to joint ventures in the US, they established joint-ventures and exported the technology in the 1980's to Korea, Taiwan, China, Russia, Southeast Asia, Australia, Europe and South America.

During this period, the Thai industry also showed considerable growth potential. With the support of Japanese technical assistance, the 1980's Thailand became a leading producer and exporter of surimi to Japan and crabsticks to Europe, USA and other markets. The success of the Thai surimi industry stimulated the development of the surimi and surimi seafood industry in the Southeast Asian countries of Malaysia, Singapore, Vietnam and Myanmar while Korea also supported the growth of the surimi industry in Vietnam and Pakistan and Taiwan contributed to building a successful surimi and surimi seafood industry in China.

India developed its surimi industry in the 1990's through partnership with Japanese surimi processors but until today the industry has remained export oriented and failed to develop a domestic market for surimi products.

The Chinese surimi seafood industry started in the 1990's with Korean and Japanese Joint-Ventures in the northern provinces of Shandong and Liaoning to process crabsticks for the growing export markets of

Europe, USA and Russia and later developed the surimi seafood market in Northern China. Fujian Province, with some support for technology from Taiwan, expanded the traditional fish ball market throughout China in the 2000's to create a massive market of a million tons for fish balls, hot pot products and fast food snacks in just a decade while the development of the Chinese fishing industry and later aquaculture supplied the raw material necessary to support this growth.

While the surimi and surimi seafood industry was originally developed throughout the world as joint-ventures with Japan, Korea or Taiwan, within a few years, local processors exerted their independence and developed their domestic markets with products adapted to the local food culture and technology suitable for their environment. The surimi and surimi seafood industry, born in Japan in the 1960's became global in the latter half of the 20th century.

In the western world, the USA was the first to start the surimi seafood industry in the form of crabsticks in the late 1970's and quickly developed this market in the early 1980's. France led the way in Europe in the late 1980's soon followed by Spain and the Baltic Countries. Russia also started surimi seafood factories in the early 1980's but these factories collapsed together with the Soviet system. Nevertheless, these early efforts contributed to the growth of the East European and Russian surimi seafood industry in the 2000's.

The successful and rapid development of the surimi seafood industry globally can be explained by the product characteristics:

- a healthy food protein base of fish origin without bones or skin with an attractive taste and shape
- a versatile product that can be adapted to the local culture and consumer taste
- an exotic curiosity but soon adapted to the local taste, developing with local fish resources
- an affordable source of protein suitable for the mass market
- a product easy to use, precooked in tune with the growing demand for convenience

In many markets, apart from Europe and Russia, the industry has grown or started with raw materials available locally. The growth of the surimi and surimi seafood industry is based on the local development of fisheries.

Alaska pollock (*Gadus chalcogrammus* or *Theragra chalcogramma*), which is the largest white fish biomass in the world, habitats in the North Pacific Ocean, covering from Hokkaido (Japan), Kamchatka (Russia), Alaska (United States), to Vancouver Island (Canada), and further in Sea of Okhotsk, Bering Sea and Gulf of Alaska. Historically this fish has played a major role in the development of surimi and various surimi seafood products and covers approximately one third of the current global surimi production. Tropical species have been utilized for surimi production since 1980s and cover the two thirds (Park et al., 2014).

Two decades (1960-1980) in Japan were the highlight of surimi seafood production as the market extended from its traditional products [kamaboko (steamed), chikuwa (grilled), tempura (fried), and hanpen (boiled)] to fish sausage and crabstick (Figure 1-1). Crabstick was invented in Japan in 1973 and this became a stepping stone for the globalization of surimi seafood. Starting in the early 1980s, the production/consumption of surimi seafood in Japan has declined continuously. However, as the production of crabstick expanded outside Japan (USA in 1981, S Korea in 1982, and France in 1986), the surimi seafood production extended on a global scale.

With the declaration of the 200 mile Exclusive Economic Zone by the United States in 1976 (Figure 1-1), surimi seafood production in Japan started to decline. By the mid-1980s the Japanese surimi industry established the surimi production in Alaska as a US-Japan joint venture. This is how the US surimi industry was established. In addition, several investors began making plans to build American factory trawlers and motherships. Numerous vessels started to make surimi from pollock with the Japanese technical and production head crews in 1988. This combination of growth eventually led to the elimination of any direct foreign fishing in US waters by 1988 (Park et al., 2014).

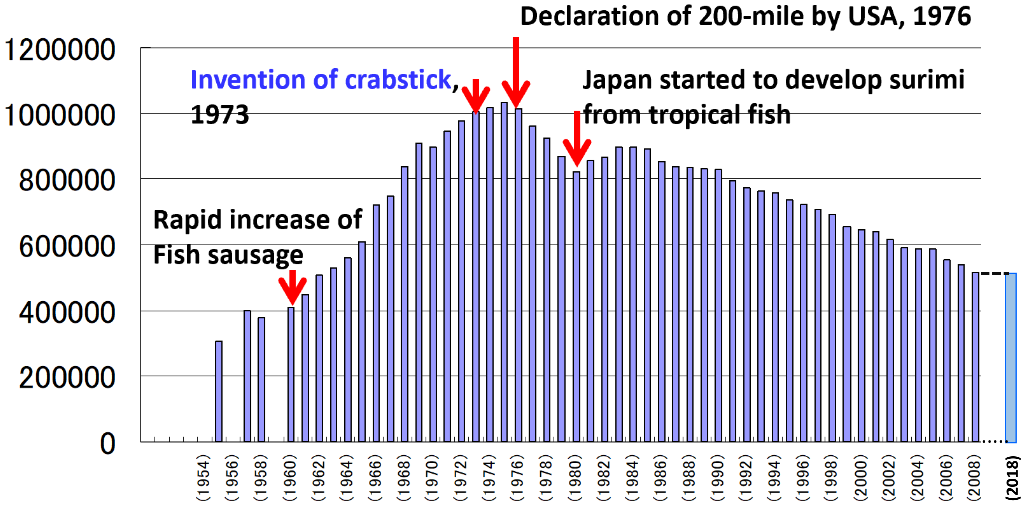



Figure 1.1 Surimi Seafood Production/Consumption (tonnes) in Japan

The global surimi seafood market is led by three leading countries Japan, China, and S Korea. They use more than 70% surimi produced in the world (906,000 tonnes) and produce near 2.5 million tonnes of surimi seafood (Guenneugues, 2019; Chen, 2020) (Figure 1-2). China produces 1.5 million tonnes of finished products with the use of approximately 280,000 tonnes of surimi. There are so many different types of fish balls or other balls. As they are often made by combining pork/chicken/surimi in various ratios, the usage rate of surimi is approximately 20% in the majority of fish balls. Because seasoned ground meats are often coated using surimi seafood paste as skin before heat treatments, the quantity of surimi usage is low. But it is known some gourmet products are made with high grade surimi.

When it comes to tropical surimi, over 120 different species are harvested and utilized for surimi production by SE Asian countries, India, Pakistan, and China. Among various tropical fish used for surimi production, threadfin bream, lizardfish, big eye snapper and goatfish comprise more than 90% of all raw materials. Fish size is so small probably due to overfishing as a result of poor fishery management.

Thailand has been a leading country for surimi and crabstick production in SE Asia with both volume and technology. It was in 1979 when the first commercial surimi was manufactured in Thailand by Apitoon. Since Nissui and Apitoon signed the contract to develop surimi in 1980, good quality surimi started to be manufactured in Thailand and the surimi business has grown year after year, with an increase in the number of surimi manufacturers. The highest surimi production volume in Thailand (approximately 160,000 tonnes) was in 2003. With the depletion of resources, it is now stabilized at around 60,000 tonnes a year.

India started surimi production when Hindustan Lever Limited (HLL) signed a MOU with Shinto Corporation (Japan) and commercial production commenced in late 1995. Simultaneously, in 1995, Gadre Marine Exports started surimi operations in Ratnagiri with technical assistance from Daerim (South Korea). Now Gadre owns HLL's surimi operations and is the largest surimi maker and only one surimi seafood manufacturer in India (Park et al., 2014).

Other countries like China, Vietnam, Indonesia, and Malaysia also started the surimi production from marine species in 1990s. They have positioned their role as a solid surimi exporter. Details will be discussed in other chapters.

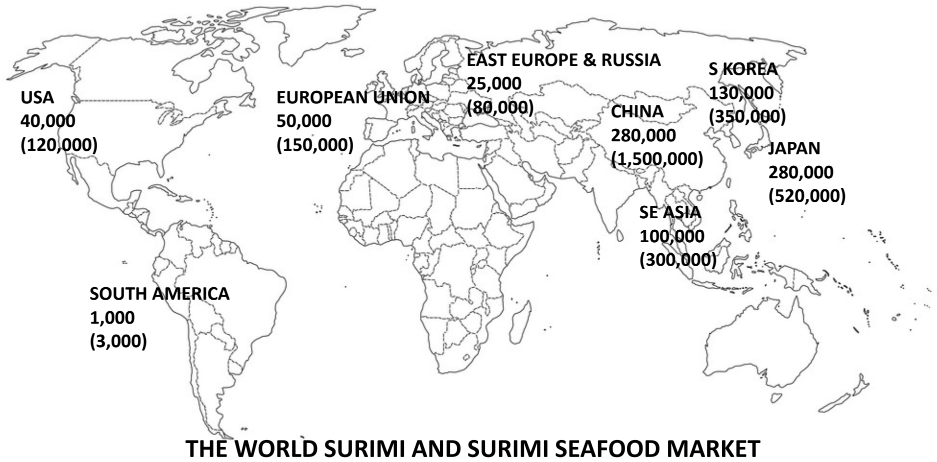



Figure 1.2 Global surimi market per surimi usage and surimi seafood production (Guenneugues, 2019; Chen, 2020; Zhou, 2020)

## 1.2 How is surimi made?

Surimi is refined as fish myofibrillar proteins isolated through various processing steps including harvesting, offloading, sorting, heading, gutting, deboning/mincing, washing/dewatering, refining, screw pressing, and stabilized with cryoprotectants before forming blocks, freezing, metal detection, boxing and pelletizing. Each processing step affects the quality and production yield (quantity) of surimi. Temperature and time control during postharvest, processing, and storage is a key element to keep the quality of surimi good and longer. Effective removal of guts, sarcoplasmic proteins, stroma proteins, and lipids through deboning, washing, and refining are also important to achieve the quality of surimi at the highest condition.

Even though there is the history of surimi over 900 years, modern surimi production started in 1960 when Japanese scientists (Kyosuke Nishiya and Fumio Takeda) at Hokkaido Fishery Research Center discovered the effective role of sugar as a cryoprotectant (Suzuki, 2010). Sugar was found to inhibit the protein denaturation during freezing/frozen storage. This discovery is the first corner stone for global surimi production by shifting fresh surimi to frozen surimi. Eight percent of sugar was introduced first for the surimi production from pollock, but 4% was replaced later by sorbitol as 8% sugar was too sweet. A mixture (50/50) of sodium tripolyphosphate (STPP) and tetrasodium pyrophosphate (TSPP) was used at 0.3%. However, for the tropical surimi, only 6% sugar and 0.2% phosphate mixture have been used. The difference was due to the different thermal stability of species (cold water fish vs. warm water species). Tropical fish possesses higher thermal stability and they are much stable against temperature-induced denaturation. How the use of two phosphates (STPP and TSPP) mixture in frozen surimi was initiated is not clear. Since the Ph of these two phosphates are 9.8 and 10.2, respectively, at 1% solution and tripolyphosphate can be easily changed to pyrophosphate, either one should do the job similarly as a pH adjuster, chelating agent for metal ions, and inhibitor for trimethylamine-N-oxide demethylase (TMAOase). As for the inhibition of TMAOase, which induces texture toughening during the frozen storage of gadoid fish, TSPP worked better than STPP for lizardfish (Benjakul et al., 2004) while STPP worked slightly better than TSPP for Alaska Pollock (Lee et al., 2017).

Surimi production yield in a commercial scale has been changed dramatically for the last 35 years since the beginning of surimi production from both cold water and warm water species. Surimi production methods for both cold water and warm water species are more or less the same except one distinctive difference in heading and gutting. Cold water species (Alaska pollock, Pacific whiting, Southern blue whiting, Hoki, and

Northern blue whiting) are headed and gutted mechanically while all tropical fish are handled manually. The size of tropical fish is too small to be handled mechanically.

Since 1984, with the first surimi production in the United States, a total of 17 land-based surimi plants were built and, as of 2020, only 8 plants currently produce surimi from either pollock or Pacific whiting in North America. A total of 28 vessels were built or remodeled to produce surimi from pollock and Pacific whiting since 1988 and, as of 2020, only 14 vessels remain for surimi production.

In the early stage of surimi production (1985-1995), the production yield was about 12-15%. Then it increased to 20-25% in the next 7 years (1995- 2002), 25-30% between 2000-2010, and then 30-40% in the last 10 years (2010-2020) depending on the species used and processing uniqueness of individual manufacturers. This incredible yield increase in the United States was made through the adequate fishery management for pollock and whiting and the industry's efforts in adapting decanter technology and other mechanical innovations for fish cutting (Park et al., 2014). Decanter technology introduced in the mid-1990s was expanded to the entire industry by 2000. Decanter centrifuge can collect almost all insoluble particles from surimi wash water. Depending on the quality of recovered meat, it can be added to medium or low grade surimi. This recovered meat can also be packed alone as recovery grade surimi and made a significant contribution to the yield increase (Park et al., 2014). Scalp cutter by American Seafoods Company and Toyo V-cutter by UniSea also made a significant contribution to yield improvement as the new devices retain more meat. It is interesting to review the change of fish portions that enter the deboning machine. It has evolved from skinless fillets to skin-on fillets and then to butterfly-shaped H&G fish (Park et al., 2014) in land-based plants in an effort to recover more meat from fish.

With the American Fishery Act of 1998, the Olympic style fisheries management was shifted to ITQ (Individually transferrable quota) and it made a significant impact on the full utilization of landed fish in the United States. With the development of the Pacific whiting surimi industry in 1991-1992 in Oregon, Oregon State University Seafood Lab found the significant change of protein contents in Pacific whiting muscle tissue as the fishing season goes along. As a result, the fishing season opening for Pacific whiting was delayed from April 15 to May 15, resulting in the yield increase. Team efforts together with the government, industry, and academia made Alaska pollock and Pacific whiting the most sustainable fisheries.

A couple of efforts have been made in developing surimi from non-traditional species in the last 20 years. The first one is commercial production of surimi from jack mackerel in Chile. It also utilized the decanter technology to dewater washed mince instead of using a conventional screw press. Even though small-scale surimi production from pelagic fish (horse mackerel, sardine, or scad) was made in Japan using the conventional method, making surimi in a large scale from jack mackerel in Chile was quite fascinated and developed its market primarily in the crabstick industry of Europe and Russia. Once its production volume reached over 40,000 tonnes. But, after the 2014 tsunami the drastic reduction in fishing quota in Chile killed the production. There is a recent effort in making surimi from mackerel or sardine in Vietnam and Thailand.

The second effort is to make surimi from aquaculture fish. The large-scale production started in Hubei Province, China more than 10 years ago using silver carp. Its production volume was 70,000 tonnes in 2019 (Chen, 2020). All silver carp surimi, made from live fish and possessed good gel texture and whiteness, is popularly utilized in China by mixing it with low grade sea fish surimi like ribbon fish surimi. Vietnam is now following the same pattern with pangasius (Vietnamese catfish). As its aquaculture industry has grown to 1.5 million tonnes/year. Over 1 million tonnes of raw materials (pangasius whole fish and/or by-products from fillet processing) are potentially available to generate 150,000 to 200,000 tonnes of surimi annually.

Sustainable fishery management in tropical fisheries, compared to United States, is quite low. However, in the last few years, a few countries (Thailand, India, and others) started to enforce fishing bans. Details will be discussed in other chapters.

## 1.3 What products are made using surimi and how they are used?

Using surimi blocks, any forms of gel-like products can be made with various processing methods. Japan is proudly recognized its 900 years of history. However, China might have started to produce surimi seafood before Japan. According to the book Sheng Ji Zong Lu, the Chinese fish ball is believed to have originated during the Qin dynasty (BC 221-207). However, Chinese literatures first recorded the fish ball in 1111-1118 (Liu, 2012).

Various types of surimi seafood are manufactured commonly for use in either frying, grilling, steaming, or boiling in water. Fish balls are very popular in China and SE Asia and this product form is probably the number one product in the world by volume. Surimi seafood paste is shaped into a ball with or without being mixed with other ground meats before being heated (warm water followed by hot water). Fried fish cake (known as tempura in Japan and ahmook in South Korea) is the number one popular item in Japan and South Korea and more than 250,000 tonnes are consumed each year per country. Fried fish cake is not like other fried foods when it comes to fat content. It contains only 2-3% fat while other fried foods possess a relatively high fat content (French fries 18% fat, fried chicken 14-15% fat, and fried fish 11-12% fat). According to the US FDA, fried fish cake can be categorized as low fat food (less than 3% fat). Supawang et al. (2019) reported that low fat content in fried fish cake is because fish protein's gelling (film-forming) properties and high hydrophilic properties of sugar and/or sorbitol which are included in surimi as a cryoprotectant. Consumer education should be made globally to tell how healthy fried fish cake is.

The third most popular surimi seafood is crabstick (crab-flavoured surimi seafood) that covers the widest range in the world from Japan, South Korea, USA, Europe, Russia, South East Asia, China, and South America. Globally more than 400,000 tonnes are consumed (Figure 1-2). Crabstick is produced in continuous processing when paste is extruded as a thin sheet, cooked under steam or on heated drum, fiberizing, bundling, cutting, packaging, metal detection, pasteurizing, chilling/freezing, and boxing.

Grilling is not a common heating process for surimi seafood. However, chikuwa is made when the surimi paste is rolled over the metal stick before being broiled under a gas or electric grill.

In the case of the crabstick, when it was invented in Japan and relocated to its first overseas production in the USA, a standard crabstick recipe contains 60-65% surimi, 20-25% water/ice, 3-6% starch, 1-2% egg white, and others (1.5-1.8% salt, 2-3% sugar, 1-2% crab extract/flavourings). As surimi supply was limited in 1991-1992, a significant amount of surimi was removed and replaced by other ingredients. The surimi grade used in the production of crabstick has also been down from high grades (SA and FA) to mid (A, KA) – low (RA, RB) grades for the last 30 years. Globally the surimi grade used for crabstick productions is A, KA, and RA/RB, while SA and FA are used in the premium products (steamed kamaboko and others) in Japan. The quantity (%) of surimi used in the current crabstick production is probably 25-40% while Japan keeps its original percentage 60% in most products. As the large portion of fish balls produced in China are made with a mixture of meat (core) and surimi (surface), only 280,000 tonnes of surimi was estimated to be used for the production of 1.5 million tonnes of surimi seafood (Figure 1-2). The surimi content in fish balls in China is approximately 20% as surimi paste mostly coats seasoned ground meat.

Considering the surimi production yield (30-40%) discussed above and the usage level of surimi in the surimi seafood (20% in China, 25-40% in other countries, and 54% in Japan) (Figure 1-2), 1 kg of fish can be converted to roughly 1 kg of surimi seafood.

Based on the surimi production yield (30-40%), roughly 60-70% is lost as a solid waste (45-55%) and soluble discharge (15%). Most of the solid waste generated in surimi factories is utilized as fishmeal. Fish oil is separated and used as a fuel. Two leading surimi makers in the United States refine their pollock oil as a food grade and sell fish oil capsules. Another surimi company utilize fish skin and refiner discharge to make fish collagen. Oregon State University has done quite a work in utilizing pollock bone from surimi production and demonstrated the inclusion of submicro pollock bone in surimi enhanced the gel strength significantly as free calcium ions was released and activated transglutaminase (Yin and Park, 2015). Further studies are under progress to determine the bioavailability of submicro pollock fish bone as a calcium supplement.

## 1.4 Summary

Despite over 900 years of surimi history, the globalization of surimi beyond Japan and Asia started when the role of sugar as a cryoprotectant was discovered 60 years ago and the crabstick was invented 47 years ago. In the United States, surimi production yield has increased significantly from 12-15% to 35-40% for the last 35 years through the combined efforts made by government, industry, and academia in a way to enhance the sustainability of two fisheries (Alaska pollock and Pacific whiting). However, in the area of tropical fisheries, a special effort is highly needed for a sustainable future. The production of surimi using pelagic fish and freshwater/aquaculture fish must play a significant role in meeting a continuous and large demand for surimi particularly in Asia.

A variety of finished products made using surimi as a major ingredient cover the global market with the estimated volume at over 2.5 million tonnes. They are well accepted as local specialty cuisines/appetizers. As today's consumers have become more health-conscious than ever, the health benefits of surimi seafood must be emphasized with the addition of omega-3 oil and/or fishbone-based calcium. In addition, it needs to be addressed how healthy fried fishcake (over 500,000 tonnes are consumed globally) is with its typical fat content only at 2-3%.

# Chapter 2 - Surimi resources and markets

In this chapter we provide information about the tropical surimi sector, including the production of surimi and surimi seafood. We also provide some information about the use of small pelagic species which may be sourced from tropical or cooler waters and also information about the growing use of farmed fish (almost totally freshwater fish). There is a lot of interaction between the tropical and cold water sectors and so we include material on the cold water sector in Appendix 1. Finally, there is also interaction between the surimi sector and other sectors (such as fishmeal) which we discuss prior to making some commentary on what may be options for the industry in terms of sustainable sourcing in the future.

## 2.1 - Characteristics of the surimi industry

Almost any type of fish (and cuttlefishes) to manufacture surimi. Alaska pollock, which is the world's largest single species, white fish resource, is still the reference for the surimi industry in Japan and in western countries even though its production volume was surpassed by tropical fish surimi production in the early 2000's and represents today less than one quarter of the world surimi production.

With the exception of surimi produced from Pacific Whiting caught in the US, the production of surimi from other cold water white fish (initiated by Japan in the 80's) has decreased considerably and now represents only 1% of the global surimi production.

Tropical fish in Southeast Asia have become the largest fish resource for surimi production and represent about 70% of the global surimi production.  The industry utilizes resources that were once called "trash fish" and used for fish meal production.  This term has been applied to a wide variety of fish species of relatively low commercial value (compared to table fish) that are too small (20 to 100g) for table consumption but big enough to be hand-cut by cheap labour in Asia.

While threadfin breams (itoyori)(Nemipteridae) were the main raw material used in tropical fish surimi production in the first years of the industry in the 1980's, this species group has, over time, become a lower portion of the fish supply throughout Southeast Asia as a result of the increased volume of other species available for surimi processing as well as the depletion of their stocks resulting from overfishing. This also applies to the other demersal species: big eye snappers (kintokidai)(Priacanthidae), croakers (Sciaenidae), lizard fishes (Sauridae) and ribbon fish (Trichuridae).  Nowadays, in addition to these demersal species is a growing number of small pelagic species such as flying fish, mackerel, scad, sardines and anchovies, which are commonly referred to as "dark fish".  Pelagic species are increasing in volume as a raw material used for surimi production particularly in larger processing countries, Vietnam and China.

Silver Carp was the first aquaculture fish used for commercial surimi production in China in the late 2000's as a substitute for itoyori or sea bream (Sparidae).  The production of surimi from this fish reached 70,000 MT in 2019.  Panga (Pangasius) is also a growing resource in Vietnam for the production of surimi, mainly from the trimmings of filleting factories and less frequently from whole fish.

Surimi is not one product but a multitude of products obtained from a variety of fish species that may be processed as single species or mixed together.   Through the surimi process different grades are obtained with a gradient of quality attributes that are both functional (the ability to bind water and other ingredients and form a gel with a firm and elastic texture during the cooking process) and organoleptic (neutral pleasant taste and odor, light colour, absence of residual pieces of skin, bones and scales).

The different qualities of surimi respond to the demand for different raw materials suitable to process different products for different markets, as follows:

- expensive high grade surimi obtained for white fish fillet that gives a gel of very firm and elastic texture, white colour, neutral taste and smell is used in high value products such kamaboko in Japan, imitation baby eels (angulas) in Spain, high quality crabstick in various markets or a shell of a purse filled with a base of fish roe in China.

- cheap low grade surimi processed from mix fish, a raw material with lower water binding ability that will a soft gel of darker colour, sometimes with rather strong fishy taste and smell used to process fried fish cakes and sold as a street food.

In this aspect it would be wrong to believe that one surimi can fit all markets. Each product has its own characteristics adapted to its usage and market. In the surimi industry, consumer demand determines the product quality and the raw material required but, in turn, the availability of this raw material also often determines the characteristics of the products and as such shapes the market.

One example is the usage of jack mackerel surimi to substitute for Alaska pollock for crabstick production in Europe and Russia in the period 2000-2008. This surimi production, successfully developed in Chile, was fueled by the fast growing crabstick market in Europe and Russia. The cheap price of this raw material, as compared to Alaska pollock, was attractive enough for the processors to ignore the slightly greyish colour that was hardly noticeable by new consumers.

Another example is the development of the fish ball market in China which is based on a combination of low gel dark mixed fish or ribbon fish surimi and higher quality white surimi from silver carp. The colossal growth of this market would probably not have happened, at least not in such volume, if the product had been using Alaska pollock surimi that was twice as expensive.

History has shown that despite variation in production and demand the surimi products markets are quite sensitive to price as much as the product quality. During periods of increased costs for the raw material, the processors of the finished products may be forced to increase the price of their products or reduce the percentage of surimi in their formulations with results in a lower quality product. In both cases the result is an immediate decrease in consumption.

Even though surimi is a product traded globally, the development of the surimi industry in a particular area often creates an opportunity that results in the development of a local surimi seafood industry. This is particularly true in Southeast Asia.

### 2.1.1 Raw materials used for surimi production

The raw material used to process surimi may be:

1 - a species used for another application that tends to give better return to the processor but is nevertheless used for surimi because of production constraints. One example is the hake and hoki fisheries in Chile before regulation ended the system of “Olympic Quota”, a fishery management system which put no limits on the numbers of vessels but only the total catch which resulted in a race to fish and a short-term production of large volumes, resulting in lower prices. Since the revenues of the processor depended primarily on the amount of fish caught and processed until closure of the fishery, surimi was a means to process a large amount of fish in a short period of time. When the regulation was changed to Individual Quota Allocation this gave the processor the necessary time to manage the catch to process the product that provided the best revenue and so 100% of the fish moved to fillet production. An Olympic Quota is also used to some extent in the Alaska pollock fishery. During ‘A season’, when the focus is to maximize processing while the roe is at maturity, (the roe constitutes a major income for the processor) priority is given to surimi for using the meat, as this increases the speed of processing as compared to the time taken to process fillets.

2 - a fish resource that can be used for higher value utilization but at times of high landings does not find sufficient market or sufficient processing capacity to absorb the supply and can thus be made available for the surimi processors at a lower price.

3 - a fish resource that has been previously used to process fish meal and found a better value when processed into surimi. The typical example is the "trash fish" used for tropical fish surimi production in Southeast Asia. At the beginning of the industry, this catch, which was a "by-catch" of higher value fish caught by trawling in the multispecies fisheries of Southeast Asia. The surimi industry had several consequences, sometimes with complicated effects:

- it removed a large volume of raw material from the fish meal industry and initially resulted in supplying a lower quality raw material for fish meal production. But soon the fishing fleets started to use ice to preserve the fish quality for use in surimi production and increase the value of the catch, which also resulted in delivering better quality raw material for fish meal, in some cases.
- over time the increased revenues of the fishing vessels allowed them to go to new fishing grounds further away from their port and this resulted in a large increase of the fishing fleets and the catch, a large portion of which was not suitable for surimi production. Since the surimi industry releases back 35 to 50% of the fish weight to the fish meal industry, the development of the surimi industry in some Southeast Asian countries also resulted in a development of the fish meal industry.
- the substitution of whole fish by "fish waste" from the surimi factory resulted in raw material with lower protein content (from 60% for whole fish down to 50% in average for surimi waste) … but the price of this waste is adjusted to compensate the protein level (the price of surimi waste is generally less than 50% of the price of the whole fish used for fish meal) and for a bonus, the surimi waste always has very low levels of TVN (Total Volatile Nitrogen -a measure of the quality of the fish used for fish meal) which may increase the value of other fish meal through the blending process.

Further detail on the links between the surimi sector and other sectors can be found in Section 2.8.

4 – A by-product of the filleting industry: surimi may be processed from the frames, the trimmings, the belly flaps, the scalp … any meat that can be recovered after filleting. The pollock fillet industry in the US, the pangas industry in Vietnam are some examples. As long as the volume of "by-product" is large enough, the surimi industry offers the opportunity to increase the value from the raw material. This high efficiency in resource recovery is also applied to maximize the yield in surimi processed from the whole fish. In addition to meat recovery in the cutting process, it is also possible to recover protein lost in the next step of the surimi process, namely the washing process. Typically, 25 to 30% of the protein from the fish mince recovered by the meat separator is "lost" in the washing process and 3 to 5% in the refining process. New technology developments combined with other improvements in the process may allow to improve surimi yields from tropical fish up to 50% and sometimes higher depending on the fish species. Under the pressure of increasing cost of the raw material, the tropical fish surimi industry has substantially improved the conversion yields. While yields of 25-30% were the standard a few years ago, most of the industry works today in the range of 35 to 40%, allowing it to produce more surimi from the same amount of fish and improve the overall economics .

As a global trend, the increasing demand for fish fillets and the limited resources available for table fish tends to divert the white fish supply away from the surimi industry which must look for alternative raw material, learn to use new species of lower quality (lower functionality, darker colour) and maximize recovery to remain profitable in a very competitive environment.

### 2.1.2 Differences between cold water and tropical production

Even though the process is fundamentally the same, there number of differences in the economics of the cold water white fish and the tropical fish surimi industry.

For the cold water surimi industry:

- It is capital intensive and highly mechanized.
- The fisheries are well managed and raw material is allocated by quota for most of the industry which gives some security on the supply
- The surimi processor usually owns or has some control over fish availability
- The competition is limited to a small number of participants who share the resource of a fishery

This combination if attributes allows for a long-term business strategy.

In comparison, for tropical surimi production:

- The investment is about, 5 to 10 times lower than for the cold-water surimi industry. Many surimi factories in Southeast Asia were started with a budget of 2 to 3 million dollars.
- The industry is labour intensive but labour costs are low. A surimi factory usually employs several hundred workers for fish cutting and for processing. It is often the main source of income for the population in areas of low development.
- The raw material cost is high and the supply unpredictable. It varies continuously in terms of volume, cost, species, etc. It is practically impossible to make business plans that can be implemented. It represents the largest portion of the product cost and its variability brings a lot of uncertainty to the economics of the industry.
- The fishery management is poor or non-existent, sustainability is an issue for most if not all of the countries in Southeast Asia
- The competition is open with no barriers to new participants which results in low profitability and does not give incentive for investment
- The processor has usually no control or low control on the resource. The supply chains are complex and usually managed by fish brokers who finance the fishing boats. The price of fish may vary widely, as much as 20 to 30% within a few months or weeks depending on the supply.

As such the tropical surimi industry is in continuous mutation due to the changes occurring in the fishing industry, the increasing consumption of fish and fish products, changes in the fish supply resulting from natural variations of the fish biomass or from commercial fishing, changes in fishing regulations, etc.

The development of the surimi production and market in Southeast Asia and China in the years 2000-2020 largely contributed to the growth of the fishing industry at the cost of depleting many of the fishing grounds of their demersal species. Besides the problem of sustainability that urgently needs to be addressed, climate change will pose new challenges in the coming years.

The key words for the twenty-first century are “fisheries management” and “sustainable fisheries.” There has been increased emphasis on stock assessment, reduction of fisheries by-catch, conservation of the resource and maximum utilization of what is harvested, as well as an emphasis on ecological issues.

Global surimi production doubled from 500,000 MT in the late 80’s to nearly 1 million tonnes fueled by the production of tropical fish surimi in South-East Asia and China.

Surimi is a source of fish protein which offers many possibilities to make any kind of products of various forms, tastes and texture and its markets have grown naturally for an affordable, nutritious, healthy, convenience food. The surimi market which grew in the past years at the cost of depleting fishing grounds in Southeast Asia will need to find new resources to fuel its growth in the next decades and/or work with partners and governments to bring in good fisheries management and rebuild stocks.

## 2.2 - Global surimi production and markets

Pollock surimi is processed in Alaska (200,000 MT) and Japan (30,000 MT). The other main resource of white fish used to process surimi is Pacific Whiting in the US Pacific North West (40,000 MT) while the production of southern blue whiting and hoki in Argentina has declined to 8,000 MT and Northern Blue Whiting to 3,000 MT. Appendix 1 provides a detailed overview of the cold water sector.

Tropical surimi production is estimated at around 650,000 tonnes, the main production being in China (230,000 tonnes), Vietnam (180,000 MT), India (110,000 tonnes), Thailand (60,000 tonnes), Indonesia (30,000 tonnes), Malaysia (20,000 tonnes), Pakistan (5,000 tonnes) and Myanmar (2,000 tonnes). Figure X provides an overview of the general location of production and markets across both the cold and tropical sectors.

In addition to the fisheries, aquaculture fish have started to be processed into surimi in China during the last decade and silver carp represents today a production of 70,000 tonnes of surimi.

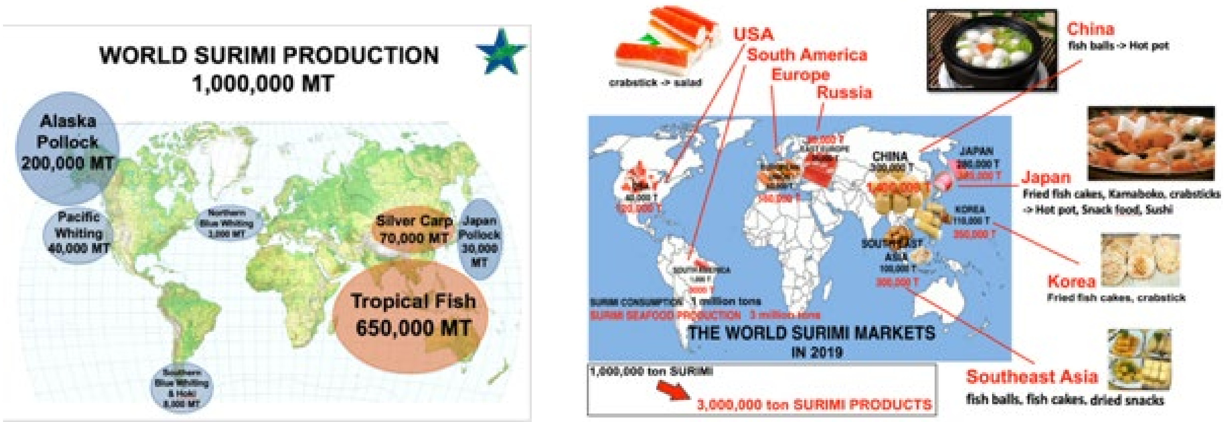



Figure 2.1 – general patterns of global surimi production and key markets

## 2.3 - Tropical fish surimi

The tropical fish surimi industry includes South East Asia countries (Thailand, Malaysia, Indonesia, Vietnam, Myanmar), as well as India, Pakistan and China. These countries are some of the largest seafood producers in the world both in terms of capture fisheries and aquaculture. Being located in the tropics the catches are particularly diverse which creates a lot of opportunities for user groups but also a lot of challenges, especially in the area of fisheries management.

### 2.3.1 – Sources of raw material for tropical surimi production

The Asia Pacific Region is the world's largest producer of fish (representing over 50% of world production), with China ranking first followed by Indonesia (6.9% of world capture fisheries tonnage). By 2010, the fisheries represented 50 million tonnes of catch. While world capture fisheries have remained stable at approximately 90–95 million tonnes per year over the past two decades, capture fisheries in the ASEAN region increased their output at nearly 3% per year in the 2000's and 2010's. In addition to notable increases from capture fisheries, the ASEAN region's share of aquaculture in total fish production has also grown from 17% in 2000 to 35.5% in 2014. Production from aquaculture is now equal to or exceeds production from capture fisheries.

The surimi industry in the Southeast Asian region is constrained by many factors, the most significant of which is the unstable and unpredictable supply of raw materials brought about by the depleted demersal fish resources in the region. Other factors that caused a slow take off of the surimi industry in some regions include the low quality of materials caused by improper handling of the fish onboard the fishing vessels, the lack of storage facilities onboard considering that the distance between the fishing grounds and the fishing ports could be quite far, and also the number of days spent by fishers in the fishing grounds which could be up to one month, in some areas, such as Vietnam.

As a result of the increasingly long distance to fishing grounds (due to overexploitation of nearshore areas by a range of fisheries, not just those for surimi), variation in the cost of fuel has a significant impact on the fishery. The fuel crisis of 2008 impacted on the development of the surimi industry in the region as this resulted in several consequences including the high cost of raw materials and ingredients, increasing transport costs and increasing labour costs, etc.

The strict product quality control imposed by the surimi importing countries such as the EU, USA, Japan, etc. has greatly influenced the production of export-quality surimi using high-grade fish species as raw materials which have become expensive as a result of the decline of the demersal resources in the region.

On the other hand the use of mixed species of fish to produce mixed-grade surimi has developed as a basic source of raw material for the production of surimi products like fish balls in China and Indonesia or fried fish cakes in Korea.

### 2.3.2 – Tropical fisheries production in general

The quantity of demersal fishes used as raw materials for surimi production increased from 165,000 tonnes in 1982 to 690,000 tonnes in 2004.  From 2005 to 2009 there was a decrease to 510,000 tonnes prior to reaching a high of 726,000 tonnes in 2014. In 2014, threadfin bream (*Nemipterus* spp.) and goatfish (*Upeneus* spp.) were the dominant species caught representing 28% and 24%, respectively, of the total capture fisheries production of Southeast Asia. These were followed by croakers (*Johnius* spp., *Pennahia* spp.), big-eye snappers (*Priacanthus* spp.) and lizardfishes (*Saurida* spp.).

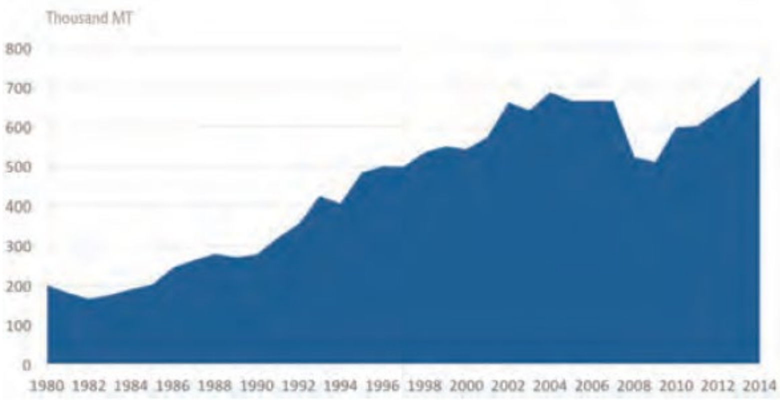



Figure 2.2 – total production of surimi species in South East Asia – 1980 to 2014

In terms of the five major producing countries the production trend of the raw materials for surimi in South East Asia indicated that the landings in Thailand dropped drastically from 350,000 tonnes in 2004 to 128,000 tonnes in 2008. In contrast Indonesian landings increased from 157,000 tonnes to 196,000 tonnes in the same period, decreased in 2009 then increased to reach 350,000 tonnes in 2014. In Malaysia, they increased from 53,000 tonnes in 1991 to 162,000 tonnes in 2014.

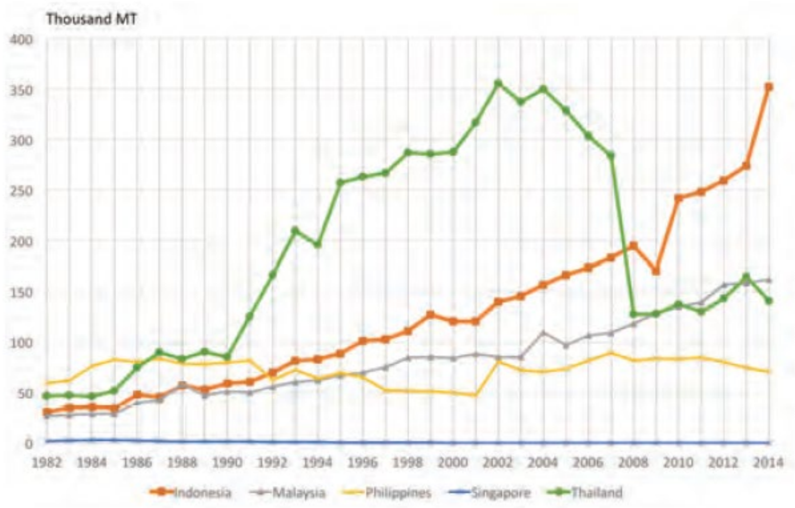



Figure 2.3 – production of surimi species for selected South East Asian countries – 1982 to 2014

The changes in the supply of raw materials for surimi production can be directly related to changes in the fisheries regulations, such as the major decrease in Thailand landings in 2008 was the result of the new policy of Indonesia that made it difficult for Thai trawlers to continue their joint ventures in Indonesia. Later, the new fisheries policy of Myanmar also impacted the limited operations of Thai trawlers in the country's waters after 2010.

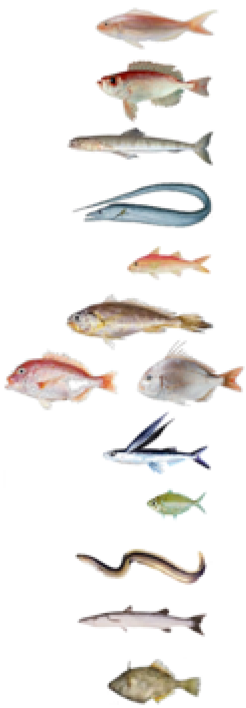
From being a by-catch of higher value and larger fish, surimi fish became a target fishery in the 2000's – 2010's, at least in some countries. With the depletion of the high value species and the development of the surimi industry which resulted in an increased value for the "trashfish", a large portion of the vessels started to target surimi fish and with the depletion of coastal fisheries a large proportion of the fleet moved offshore to find available resources.

As the offshore fishing grounds became depleted the countries that saw the largest development of surimi production moved outside their national waters and expanded their production fishing in the waters of neighbouring countries waters, legally or illegally. This was particularly true for the Thai fishery in the 2000's with a large portion of the catch used for surimi caught in Indonesia and Myanmar. The same is true for Vietnam and China in the 2000's-2010's.

### 2.3.3 - Characteristics of fish species used for tropical fish surimi

With a few exceptions (such as some tropical small pelagic species) the fish used for surimi production in the tropical countries are mainly demersal species. Demersal fishes generally live on or near the sea bed that usually consist of mud, sand or rock. Figure 2.4 provides a quick over overview of the main genera and more detail from a surimi production/quality perspective is provided below. More technical details on species and stocks can be found in Chapter 4.

Many species are used for surimi including various threadfin breams (*Nemipterus spp*, and others) Big eye (*Priacanthus spp*), snappers (*Lutjanus* pp.), groupers (*Epinephelus* spp.), croakers (*Pennahia and Johnius spp*.), lizardfish (*Saurida spp.),* fusilier (*Caesio* spp.), pony fish (*Leiognathus* spp.), goatfishes (*Upeneus spp, Parupeneus spp*.), sea bream (*Evynnis spp*.), hairtail also called ribbon fish (*Trichiurus spp.*). Other species are also used, depending on the location, availability (seasonality) and price, including flying fish (*Cypselurus poecilopterus* and possibly other species), conger eel (Congresox spp.), barracuda (Sphyraena spp.), leather jacket (*Stephanoletis cirrhifer, Navodon modestus),* various types of mackerel (*Decapterus maruadsi*) land some sardine species (*sardinella spp*). In addition, almost all by-catch that is of too small size or not suitable for commercial sale as table fish (sillago-whitings, sea catfishes, sweetlips, emperors, flounders, halibuts, soles, etc), may be used.



| | | |
|---|---|---|
| ITOYORI | THREADFIN BREAM | *Nemipterus* spp. |
| KINTOKIDAI | BIGEYE SNAPPER | *Priacanthus* spp. |
| ESO | LIZARD FISH | *Saurida* spp. |
| TACHIUO | RIBBON FISH/HAIR TAIL | *Trichiurus* spp. |
| HIMEJI | GOAT FISH/RED MULLET | *Upeneus & Parupeneus* spp. |
| SHIRO-GUCHI | WHITE CROAKER | *Pennahia & Johnius* spp. |
| RENKODAI/HIREKODAI | SEA BREAMS | *Dentex spp. / Evynnis* spp. |
| TOBIUO | FLYING FISH | *Cypselurus* spp. |
| KUROSAGI | SILVER-BIDDY | *Pentaprion & Gerres* spp. |
| HAMO | PIKE-CONGER EEL | *Congresoxs* spp. |
| KAMASU | BARRACUDA | *Sphyraena* spp. |
| KLATHI | LEATHER JACKET | *Stepphanoleptis & Navodon* spp. |

Figure 2.4 – examples of the more common genera of fish from tropical areas used for surimi production

Details on the main genera of fish from an industry perspective are as follows:

**ITOYORI** (Threadfin Bream - *Nemipterus* spp.)

The most popular fish species for tropical surimi are the threadfin breams. Catches of threadfin breams are usually not identified by species and are grouped under the generic name of itoyori. These fish are benthic, inhabiting marine waters on sandy or muddy bottoms usually in depths of 20-50 m, feeding on small benthic invertebrates and small fishes. Two prolonged spawning seasons occur from November to February and May to June for most of the species. Most of the species are 10 to 15 cm in length. The larger size individuals are usually sorted out for sale for direct consumption. The size of fish typically used for surimi processing is less than 30 g/fish.

The use of threadfin breams for surimi production increased through Southeast Asia, China, India and Pakistan in the 1980's and 1990's and while this surimi started as a resource in Southern Japan it played a major role in the surimi market of Southeast Asia where this species is preferred to Alaska pollock for its resistance to temperature abuse (easy to process). Threadfin breams give high quality surimi with good gel strength.

Fish are manually headed and gutted before being deboned and the surimi factories employ many people for fish cutting. The fish cutting cannot be mechanized because of the large size distribution of the fish and the necessity to process many different species.

**KINTOKIDAI** (Big eye Snapper - *Priacanthus spp.*)

Big eye snapper (kintokidai) belong to the family Priacanthidae and, in the South China Sea area, is represented by two species: *Priacanthus tayenus*, which is more abundant, and *P. maracanthus*. Both species have a bright crimson colour with a thick, tough skin. Unlike threadfin breams, which often have a burst-belly when kept in ice for too long, bigeye snappers have a longer shelf-life in ice. Big eye snappers can be abundant in trawl catches and often landed in substantial quantities. Due to their appearance and thick skin, they are not consumed directly and therefore considered a suitable raw material for surimi manufacture. Big Eye Snappers of large size is often combined with threadfin bream in Vietnam to improve gel strength while the smaller size is used in mix fish low grade surimi of dark colour and low gel.

**GUCHI** (Croaker - *Sciaenidae*)

According to the industry the term 'Croaker' includes two main types of species with very different characteristics:

- Jew fish (Kiguchi) gives a white high gel surimi that has long been a preferred species for the traditional kamaboko industry in Japan, especially in the Odawara area and Southern Japan due to its very high setting ability. Kamaboko made from croaker or 'kiguchi' surimi has a distinctive taste and texture, distinguishing it from the relatively blander taste of kamaboko made from Alaska pollock. Surimi production from Kiguchi in India has much declined in recent years due to high price of the fish raw material.
- Croaker (Shiroguchi) gives a low grade surimi (low gel, darker colour). It is processed as a single species in India and used in mixed fish surimi in Vietnam and China. In the sub-tropical areas of Japan, China, and Taiwan the species of croaker commonly used are the blackmouth croaker (*Atrobucca nibe*), white croaker (*Argyrosomus argenteus*), and yellow croaker (*Pseudoscianena polytis*). Surimi production from these species is limited to smaller sizes since the fish is sold at high value in the fish market. In the ASEAN region, the croaker species used for surimi are comprised mainly of *Pennahia* and *Johnius spp*. These species are abundant in the trawl fisheries especially from the coastal, muddy waters off Sarawak in the South China Sea and off Myanmar in the North Andaman Sea, near large river mouths. The usual size of croaker ranges between 5 to 10 cm and is usually sorted according to size rather than species. Croaker surimi from these species is generally darker in colour.

**ESO** (Lizard fish – *Saurida spp*.)

In south Japan, lizardfish (*Synodantidae*) has long been considered a high-grade raw material for surimi with high meat yield, white colour, good flavour, and good gel-forming ability. However, the freshness and gel-forming ability decreases very quickly over time even in ice, and only very fresh raw material is used in Japan. In the ASEAN region, lizardfish is considered a low value fish. It gives a white surimi with low gel. Lizardfish (*Saurida waniese*) is commonly used in Thailand for dried fish snacks and is used in combination with itoyori for the production of crabsticks, fish balls and other surimi products. Lizardfish surimi also became an alternative to jack mackerel surimi in Europe in the late 2000's to mix with Alaska Pollock for crabstick production and is largely used for fish cakes in Japan and Korea. The main species of lizardfish in these countries are *S. tumbil* and *S. undosquamis* (usual size is 10 to 20 cm).

**HIMEJI** (Goatfish - *Upeneus spp* and red mullet *Parupeneus spp*)

Goatfish are landed in Thailand, India, Vietnam and Indonesia. The bigger sized species (100-200g) are sold whole round or processed into skin-on fillets for Europe and other markets. The smaller sized fish are processed into surimi called himeji. The surimi is slightly pinkish in colour due to its skin colour and usually has low gel strength.

**TACHIUO** (Hairtail or Ribbon Fish - *Trichiurus lepturus* and other species)

These species have a very elongated and laterally compressed body, generally steel-blue in colour with a metallic sheen and are silvery-gray when dead. They are common in the Indo-Pacific region, up to Japan in the north and southward to Queensland, Australia. They are commonly caught in coastal waters and trawling grounds, feeding on crustaceans and fish, with a typical size of 70-90 cm and a maximum of 110 cm. The bigger size fish are in high demand in China for table fish. Ribbon Fish surimi has been a large portion of the Chinese surimi production but it has declined since 2010 due to the reduction of fish landings. The large size fish caught all over South East Asia, are exported to China while smaller sizes go to surimi production. Although ribbonfish have a low gel-forming ability and the surimi is generally dark in colour, ribbon fish surimi is used in large volume in China and also in Japan because of its good flavour and cheap price.

**HIREKODAI** (Yellowback Seabream - *Evynnis tumifrons*) and **RENKODAI** (Cardinal Porgy - *Evynnis cardinalis*)

Yellowback seabream is another species that has been caught in large volumes in the South China Sea and landed both in the northern part of Vietnam and southern part of China. Yellowback Seabream is mostly caught in China and Cardinal Porgy is landed both in north Vietnam and southern China. Seabream gives high quality surimi with high gel and white colour surimi similar to threadfin bream. One problem reported both in Vietnam and China with this species may have a chemical (chlorine/bromine) smell that sometimes develops in the fish meat due to the fish feeding on seaweed that may develop such smell at certain times of the year and some fishing grounds if the fish not properly handled and the viscera may contaminate the meat.

**TOBIUO** (Flying fish - *Cypselurus spp*)

Another fish processed into surimi during the fishing season in Vietnam is flying fish that gives a surimi with good gel ability but darker colour. This surimi has been used in Japan and Europe as a substitute for jack mackerel since the mid 2000’s.

**HAMO** (pike-conger eel - *Muraenesocidae*)

This fish has a cylindrical, eel-shaped body without scales, with 3 main species caught in the SE Asian region: *Congresox talabonoides, Congresox talabon* and *Muraenosox cinereus*. The first two species are generally larger (usually about 150-200 cm in total length) and used to be preferred species for fish balls and fish cakes. The meat is extremely white and has a high meat yield of about 68%. The pike-conger eels are found from the coast of India eastward to Celebes, the Philippines and the South China Sea. The fish live over soft bottom down to 100m, feeding mainly on bottom-living fishes, and are caught mainly by handlines and trawl. Production of surimi from conger eel is very limited due to the high price and low availability of raw material.

**KAMASU** (Barracuda - *Sphyraenidae*)

This fish is sometimes used as raw material for surimi when in season, although the gel-forming ability is generally low. The main species used include the smaller species *Sphyraena langsar* and *S. obtusata*. The larger species *S. jello* is usually used as salted-dried fish.

**KLATHI** (Leather jacket - *Stephanoleptis cirrhifer, Navodon modestus*)

This fish has a very hard and thick skin and lots of bones. It was occasionally processed into surimi in the southern region of India. It gives a low quality grayish surimi when not processed very fresh but if the fish is well preserved and processed fresh, it gives a high gel white surimi. As such the Indian surimi factories use it since 2019 to substitute the declining resource of itoyori.

The Chinese communities in SE Asia consider fish balls as a premium product and have in the past used selected species based on their strong gel-forming ability and protein stability to the relatively high temperatures in the region. The two fish species initially used for making premium quality fish balls include coral fish (*Caesio erythrogaster*) and wolf herring (*Chirocentrus dorab*). These two species form very stable gels that are ‘slow setting’ and ‘fresh’ fish balls are often formed manually in the markets in front of the customers. In Singapore there are also specialty fish ball-noodle stalls well known for their ‘coral fish’ fish balls.  Nowadays mostly itoyori imported from Thailand, Vietnam, India and Indonesia is used for this purpose.

**2.3.4 By-Products from the fisheries and the fish processing industries as sources of raw material**

Considering the conversion ratio of fish to surimi, which is probably in the range of 35%, the largest processors – Vietnam and China – also having the highest yield, this production corresponds to approximately 2 million tonnes of fish and, since the surimi industry generates around 40-50% of by products (heads, viscera, skin, bones), the fish meal resulting from the surimi production could be around 200,000 tonnes.

Fisheries and aquaculture generate a large volume of by-products leading to the production of waste that may cause environmental problems while a large volume has the potential to be utilized for animal feed or human consumption products.  The valorization of the by-products is also the means to improve the profitability of the fisheries and the fish processing industries.  However, most fish processors have limited knowledge regarding the technologies used to process the by-products and markets for these products and need support of technology, human resources and financial resources.

By-products of the fishery used for surimi production is the fish of small size and non-commercial species, usually referred to as “trash fish”.  This is one large portion of the raw material supply to the tropical fish surimi industry.  Another source is the surplus of the fisheries during high catching seasons that cannot be absorbed by the fresh market or the industry that would normally process this fish.  Left-over from the fresh fish markets is another resource that can be used to process surimi for factories located close to the area where this fish can be collected for surimi processing.   Aquaculture also generates small volumes of fish out the range of commercial size that can be used to process surimi.

By-products from the fish processing industry that can be used to process surimi includes the frames (fish bones and meat) resulting from filleting the fish that may include 50 to 70% of meat, the trimmings, the tail or body portion resulting from fish cutting in the canning industry and the skin in case of deep skinning.

Another source of by-product in the surimi industry itself is the small fragments of meat and the soluble protein lost in the process water and the meat lost in the refiner waste.  Low cost technologies adapted to the tropical surimi industry have been developed that allow to recover the fish protein in all these fractions (Surimi Tech, 2015).

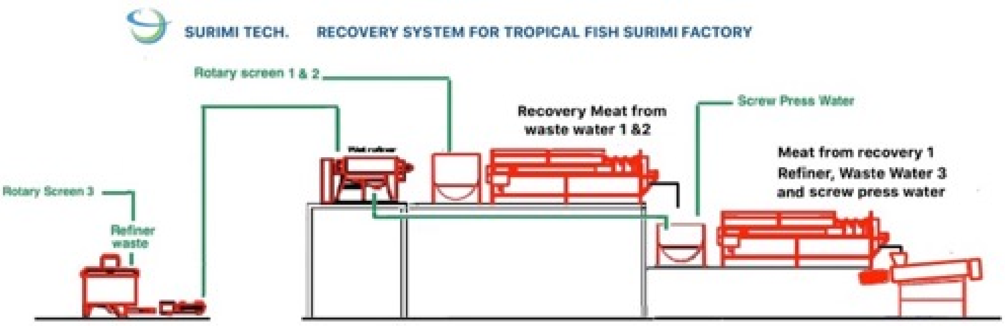



Figure 2.5 Waste recovery system for tropical fish surimi factory

The by-products from the fisheries and the fish processing industry have been used directly as fish feed or animal feed, cooked and dried to process fish meal and fermented to process silage or fertilizers.  Other possible usages include fermentation to process fish sauce and hydrolysis to process fish peptides and collagen.

### 2.3.5 - Pelagic fish used in surimi production

Pelagic fish species have been used from the early days of the surimi industry. In the years 1975 to 1990, Japan processed 10,000 to 20,000t per year of surimi manufactured from sardines and Atka Mackerel (*Pleurogrammus monopterygius*).

The surimi had a dark colour, relatively low gel strength, and a strong "fishy" taste and was used for processing traditional, low-priced, fried surimi products in Japan (fried fish cakes). There has been an active research program in Japan to develop the processing of surimi and surimi seafood from these species. The production of atka mackerel surimi stopped in Japan in the early 1990's due a reduction of the landings (Figure 2.6) resulting in a sharp increase of the price of raw material but increased again in the 2000's (Figure 2.7)

**Table 3. — Production of surimi from principal fishes in Japan: 1975–89.[1]**

| Year | Total | Production (t) | | | | |
|---|---|---|---|---|---|---|
| | | Walleye[2] pollock | Sardine, mackerel | Atka mackerel | Horse mackerel | Other |
| 1975 | 422,727 | 416,250 | | 2,908 | 5 | 3,564 |
| 1976 | 462,738 | 453,154 | | 6,361 | 10 | 3,213 |
| 1977 | 446,365 | 428,983 | | 13,044 | 1 | 4,337 |
| 1978 | 381,132 | 369,057 | | 5,669 | 1 | 6,405 |
| 1979 | 380,909 | 366,366 | | 7,459 | 21 | 7,053 |
| 1980 | 374,244 | 355,147 | | 10,353 | | 8,744 |
| 1981 | 367,518 | 349,238 | 1,674 | 9,064 | | 7,542 |
| 1982 | 383,928 | 366,915 | 2,234 | 7,629 | | 7,150 |
| 1983 | 389,805 | 374,380 | 3,914 | 3,141 | | 8,370 |
| 1984 | 425,829 | 401,571 | 8,983 | 3,875 | | 11,300 |
| 1985 | 396,174 | 364,068 | 13,451 | 3,540 | | 15,115 |
| 1986 | 352,349 | 308,957 | 13,168 | 4,451 | | 25,773 |
| 1987 | 307,751 | 283,345 | 5,260 | 2,464 | | 16,682 |
| 1988 | 291,704 | 267,513 | 4,471 | 5,286 | | 14,434 |
| 1989 | 287,070 | 264,447 | 3,215 | 5,973 | | 13,435 |
| 1990 | 241,000 | 196,000 | I[3] | I | I | 45,000 |
| 1991 | 211,000 | 166,000 | I | I | I | 45,000 |

[1] Source: Japan Fishery Products Distribution Statistics; 1990–91 values from Ministry of Agriculture, Forestry, and Fisheries, "Monthly Japanese Trade Report" - Ministry of Finance, as presented by All-Japan Kamaboko Makers Association at JETRO Surimi Forum, 1992, Tokyo.

[2] Includes fresh and frozen surimi processed at-sea or at land-based facility. J.V production excluded.

[3] I = included within "Other" category.

Note: Non-walleye pollock surimi is from land-based factories.

Figure 2.6 – Atka mackerel landings in Japan.

The Japanese importers filled the gap by initiating the production of jack mackerel (*Trachurus murphyi*) surimi in Chile (Figure 2.7) where 3 factories operated until the late 1990's, diverting to surimi a fraction of this fish which was mainly used for fish meal production.

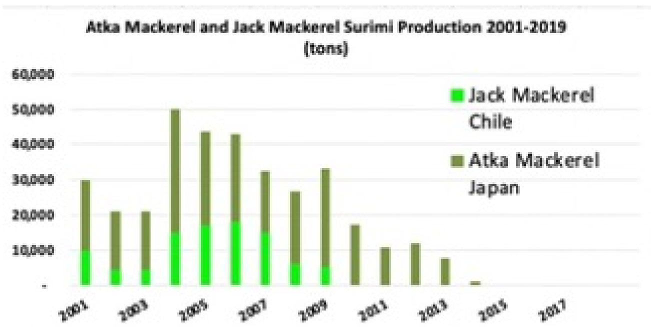



Figure 2.7 – atka mackerel and jack mackerel landings

Atka Mackerel surimi production restarted in Japan by the end of the 1990's, and the exports of jack mackerel surimi to Japan stopped. All the Chilean factories closed except one: Pesquera El Golfo, which received support from a European importer who introduced decanter technology and developed the use of jack mackerel surimi for crabstick production in Europe.

The change of technology from screw-press to decanter allowed the processing of jack mackerel surimi with low fat content, resulting in a reduced fishy taste. Through the use of titanium dioxide or vegetable oil to whiten the final product, European crabstick processors could substitute one third of the Alaska Pollock with cheaper jack mackerel surimi. Jack mackerel surimi exports to Europe reached close to 20,000 MT by 2005-2007.

The large resource of jack mackerel in Chile was depleted by 2008-2009 due to reasons that may involve natural stock variations related to the effect of changes in water temperature (El Nino) as well as overfishing both by the Chilean fishing fleet and the foreign vessels operating offshore the Chilean waters (Figure 2.8).

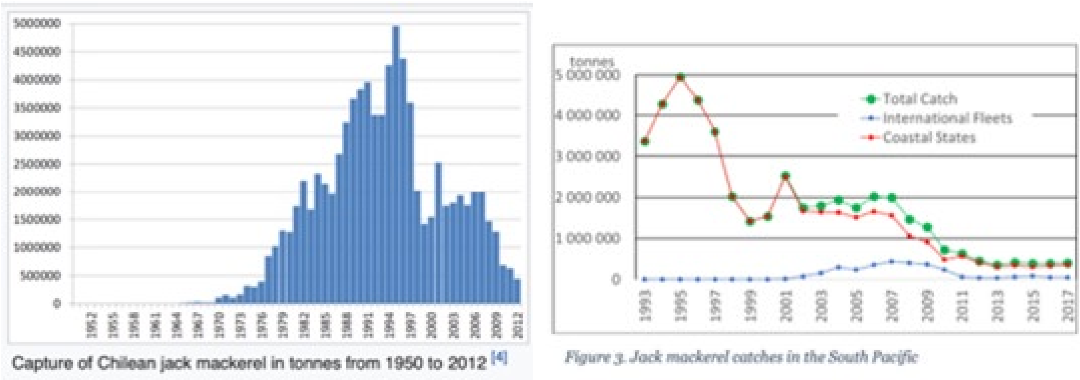



Figure 2.8 – decline in catch of Chilean jack mackerel

Jack mackerel surimi production stopped in 2009 as Chile reduced the jack mackerel quota from 1.5 million to 300,000 tonnes. Since the demand for frozen fish increased in West Africa at the same period and jack mackerel found over there a profitable market the production of surimi stopped in 2010. Atka mackerel production in Japan also dropped from around 30,000 MT in the 2000's down to 10,000 MT since 2010 as a result of reduction of the catch and increased price for this fish that made it non-competitive compared to surimi imported from Southeast Asia.

Some efforts have also been made to process surimi from anchovies (*Engraulis ringens)* in Peru. Production has been limited due to unstable landings in the location of the factory in the north of Peru (Paita). Production is estimated to have been around 1,000 MT in 2012.

Tentative attempts to process sardine surimi have also been made in Morocco. The first factory was set-up in the 1990's by a French processor of surimi products who processed a couple thousand tonnes of sardine surimi for 3 or 4 years in the mid-2000's that was used in combination with Alaska Pollock in crabstick recipes. The factory was stopped after a few years of operation because of a lack of competitiveness of this raw material compared to other sources. Some tropical sardine species have also been used as a resource to process for surimi.

The tropical surimi producers in Southeast Asia process a few thousand tonnes of sardine surimi in India (lesser sardine – *Sardinella fimbriata* - called "mamakari" in Japan) and in Thailand during periods of high landings. One factory in Center-North of Vietnam has also been processing a few thousand tonnes of sardine and mackerel surimi in the past few years. These processors use decanter technology that gives a better product and allows the dewatering of the surimi when the fat content reaches around 10% or higher, which is not possible with the traditional screw-press technology. Besides a few processors who specialized in processing sardine or mackerel surimi, the decreased supply and increased prices of the popular demersal species like threadfin bream or big-eye snapper, has led a growing number of factories in Vietnam, China and India that use sardine, mackerel, scad and various other species of tropical small pelagic mixed with demersal species to process mix fish surimi. This represents today a large portion of the production of surimi in Southeast Asia.

While most surimi seafood processors who have been used to processing surimi products with white fish surimi are reluctant to incorporate sardine of mackerel surimi in their recipes, this raw material is perfectly adapted for the production of fried fish cakes which does not require a high whiteness. However, the usage in other products, even white products like crabsticks is also possible by using technology to improve the colour, particularly through the use of high speed emulsifiers which intimately mix the fat and water to form a fine emulsion that will give some whiteness in the product. The process operates in a similar way to the results obtained when processing mayonnaise: the emulsion of oil and water, stabilized by the protein network reflects the light and gives a white colour to a product that was previously grey. This was the base of the development of the successful development of the market for jack mackerel surimi in Europe in the 2000's.

One possible use of oily fish in surimi products is for naturally bringing omega-3 fatty acids to the diet. For this purpose, the fat should be first separated during surimi production to finally be incorporated in the surimi after being processed into a fine emulsion.

## 2.4 - Surimi and social/economic benefits

### 2.4.1 Employment in the surimi industry

It is estimated that the fisheries and Aquaculture provide direct employment for over 50 million people in Asia.

**WORLD EMPLOYMENT FOR FISHERS AND FISH FARMERS, BY REGION**

| | 1995 | 2000 | 2005 | 2010 | 2015 | 2018 |
|---|---|---|---|---|---|---|
| | *(thousands)* | | | | | |
| **Fisheries** | | | | | | |
| Asia | 24 205 | 28 079 | 29 890 | 31 517 | 30 436 | 30 768 |
| Europe | 378 | 679 | 558 | 530 | 338 | 272 |
| **Total** | **29 579** | **34 439** | **36 655** | **39 305** | **38 771** | **38 976** |
| **Aquaculture** | | | | | | |
| Asia | 7 426 | 12 355 | 14 826 | 17 910 | 19 533 | 19 617 |
| Europe | 98 | 104 | 100 | 118 | 115 | 129 |
| **Total** | **7 878** | **12 825** | **15 364** | **18 625** | **20 390** | **20 533** |

NOTE: The regional and global totals have been adjusted in some cases as a result of extended work on the dataset to revise historical data and improve the methodologies applied for estimations. SOURCE: FAO.

2.9 World employment for fishers and fish farmers

Besides the creation of employment in the fishing industry and the services around it, the surimi industry also creates large employment. A medium size surimi factory processing 500-600 tonnes of surimi monthly (30-40 tonnes surimi capacity = 100-120 tonnes fish/day) with annual production of 5,000 tonnes employs around 200 workers for fish cutting (mostly women), another 150-200 for handling the fish and processing, 10 managers and 20 administrative staff … in total around 400 people. Since the tropical fish surimi production reached around 600,000 tonnes, this industry represents nearly 150,000 employment in the region, half of it being women employment.

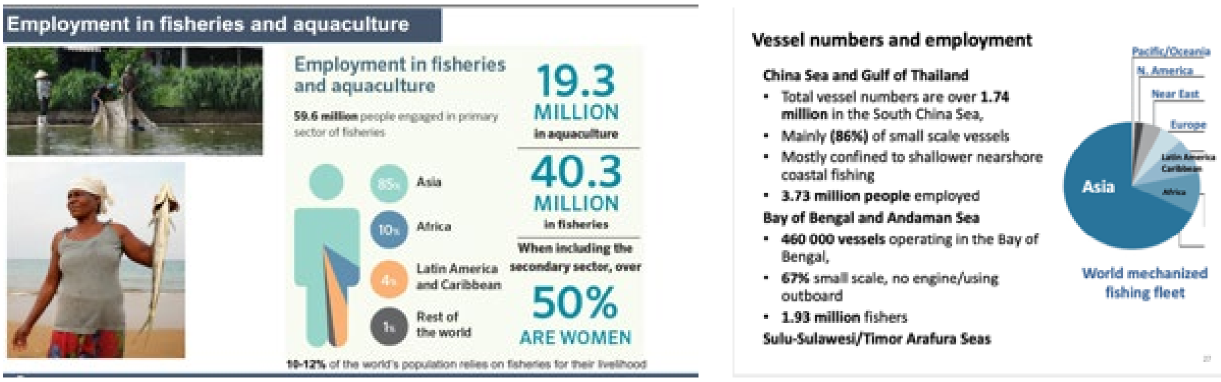



Figure 2.10 Employment in fisheries and aquaculture, including gender.

The surimi industry certainly contributed to the rapid increase of the fishery in Southeast Asia by increasing the revenues of the fishing vessels. While the coastal resources were depleted of the large fish of higher value and replaced by smaller fish with a short live span, the increased value of surimi fish allowed the vessels to go further offshore. As revenues increased, the construction of fishing vessels accelerated, the catch increased and the depletion of inshore fishing grounds forced vessels further offshore. The average fishing trip for Vietnamese vessels today is around 3 to 4 weeks.

Through the development of its offshore fishing fleet, ASEAN has emerged as a global fish producer. At the same time, aquaculture has overpassed the volume of the capture fisheries.

### 2.4.2 Regional development

As with other types of fish processing plants a surimi factory is likely contribute to livelihoods and well-being of the surrounding population as well as the economy and balance of payment in the national economy. Unfortunately, specific information does not appear to be available. While fish is a primary source of protein in the Southeast Asia, it has also largely contributed to the regional development and the trade balance of the region (see Figure 2.11).

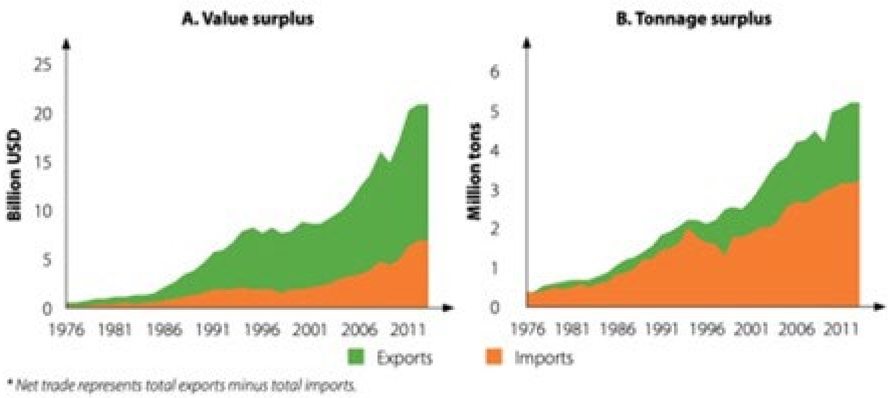



Figure 2.11 – ASEAN nett surplus of fish Value (A) and tonnage (B) 1976-2013

The 180,000 tonnes of surimi production and exported by the Vietnamese industry, as an example, generated a positive trade balance of 240 million USD in 2019.

## 2.5 - The tropical fish surimi production industry

In 2019 tropical fish surimi production reached an estimated 630,000 tonnes, excluding the production of 70,000 tonnes of fresh water surimi from silver carp in China.

The main countries producing surimi in Southeast in 2019 are:

- China : 230,000 tonnes from sea catch + 70,000 tonnes aquaculture fish
- Vietnam : 180,000 tonnes
- India : 90,000 tonnes
- Thailand : 60,000 tonnes
- Indonesia : 40,000 tonnes
- Malaysia : 20,000 tonnes
- Pakistan : 10,000 tonnes
- Myanmar : 2,000 tonnes
- Total: 630,000 tonnes from capture fisheries + 70,000 tonnes from aquaculture

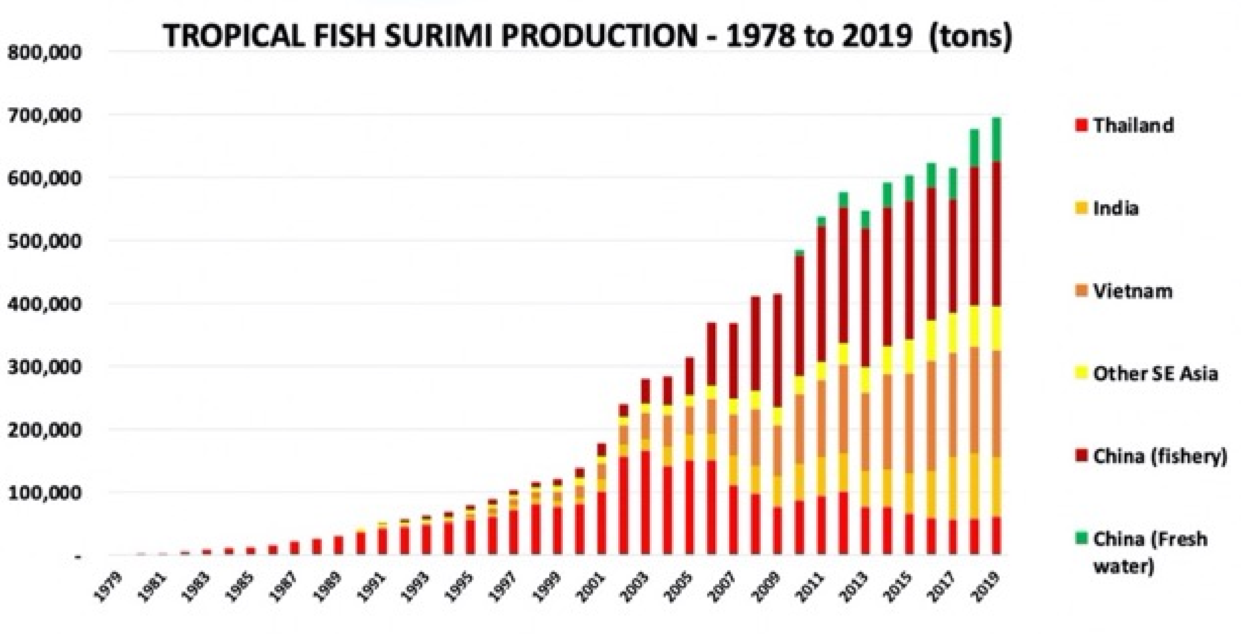



Figure 2.12 – growth in the production of tropical surimi by Asian countries

The tropical fish surimi industry in Southeast Asia started in the late 70's and grew in the 80's in Thailand, followed by Malaysia in early 90's, Vietnam and Myanmar in the late 90's.

The development of the surimi industry from tropical fish accelerated in the 2000's and this can be put in parallel with the growth of the Southeast Asia fishery.

## 2.5.1 – Thailand

2.5.1.1 Development

Surimi production in South East Asia started in Thailand in cooperation with Japanese importers in the late 1970's in small factories of capacity one to two thousand tonnes annually. Demersal species such as Threadfin bream (Nemipterus spp) and Big eye snappers (Priacanthus spp), suitable for processing good quality surimi, were abundant and the Thai surimi industry grew rapidly to follow the growing demand of the surimi seafood industry globally. Financial support and market access was supplied by the Japanese buyers in need of finding new resources to diversify the supply at a time when Japan's access to the Alaska pollock fishery in US waters was threatened by the US EEZ Agreement. By 1990, 11 factories already processed 25,000 tonnes and the number doubled in the next few years responding to the demand of the industry for alternative raw materials to Alaska pollock. Production grew rapidly until the mid 2000's (Figure 2.13)

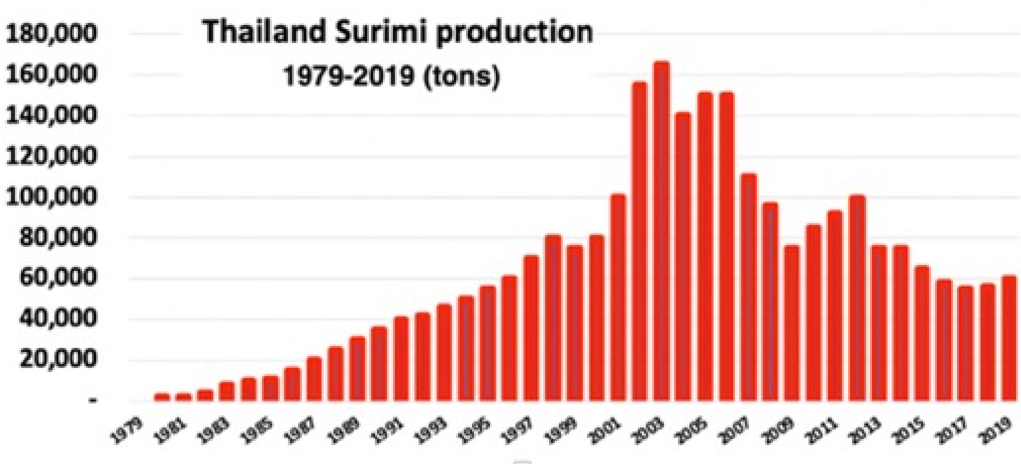



Figure 2.13 – changes in production of surimi in Thailand

The question about sustainability had already appeared by the 1990's, since according to the Thai Government, the Catch Per Unit Effort in research trawls in the Gulf of Thailand had declined from about 300 kg/hour in 1960 to 80 kg/hour by 1998 and 20kg/hour by the year 2000. Much of the depletion took place by the early 1970's and the development of the surimi industry forced a noticeable decline in the 1980's.

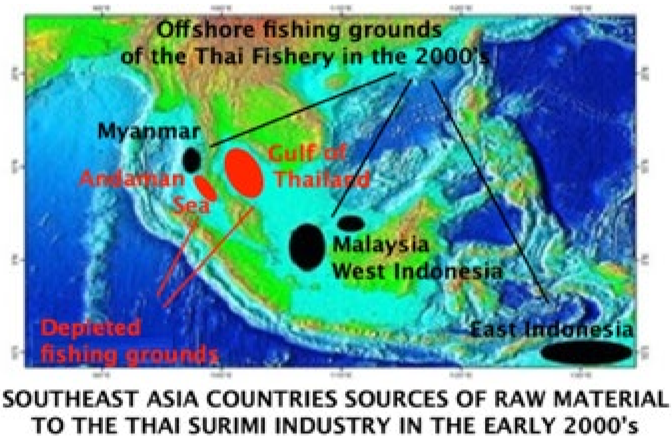



Figure 2.14 – sources of raw material for Thai surimi processors in the early 2000's

While the stocks of fish were already largely depleted in the Gulf of Thailand as a result of overfishing, landings remained steady as the vessels ventured into the waters of neighbouring countries (Figure 2.14). Domestic production in Thailand had already demonstrated a decline by the 1990s and the country should have taken action to recover the resources of their own waters but instead it focused the extra fishing effort on other countries rather than recover their own depleted stocks along the coasts of the Gulf of Thailand and the Malay Peninsula.

Indonesia, in particular, represented up to one third of the fish brought to Thailand for surimi production. Most of this fish was frozen on-board by large freezer vessels operating in the eastern seas of Indonesia. The fish was transferred by carrier vessels to Thailand where it was mixed with fresh fish to process surimi to get commercial characteristics. This is probably the only experience of successful surimi processing from frozen fish and was possible because of the better resistance to denaturation of the protein from tropical fish and because of the ability to mix frozen fish with fresh supply and because of the cost of this resource. The other fishing ground where the Thai vessels operated on a large scale is the Andaman Sea in Myanmar waters.

Thailand's surimi production reached the peak of its annual production of around 160,000-170,000 tonnes in 2003 – 2007. At the time, 21 surimi processing plants in Thailand were processing surimi regularly or occasionally throughout the year.

The main raw material species used in the processing plants were threadfin bream (Nemipterus spp), Big eye (Priacanthus spp), lizardfish (Saurida spp), Croaker, Goatfish (Upeneus spp), snapper (Lutjanus spp). The raw material also included some small pelagic species such as Sardine (Sardinella spp) and Rainbow runner (*Elagatis bipinnulata*).

In 2006-2007, the Indonesian Government did not renew the fishing licenses for foreign vessels and changed regulations with the requirement for the foreign vessels to offload the catch in Indonesian ports prior to export to their country and pay taxes for this fish. This regulation made the operation unprofitable for the Thai fishing vessels and they withdrew from Indonesia. Later, the new fisheries policy of Myanmar also limited the operations of Thai trawlers in the country's waters after 2010. As a result, the total (not just surimi fish) landings of the Thai vessels decreased from 2.8 million tonnes in 2000 down to 1.5 million tonnes in 2010 and surimi production dropped by half from 160,000-180,000 tonnes to 80,000 - 90,000 tonnes.

Finally two more events pressed the production further down: the market crash of 2013 and the yellow card from the European Union.

The production of tropical fish was fueled by strong demand and high market prices in 2008-2010 when the Alaska pollock quota was reduced by half and continued to grow in the early 2010's when the Alaska pollock fishery was recovering. That led to an oversupply despite the growth of the surimi seafood market and the market crashed in the beginning of 2013. Alaska pollock producers dropped prices by 30 to 40% in this year putting the tropical fish surimi industry in stand-by until the market absorbed the excess inventory. During this period, a number of factories closed down in Thailand.

In 2015, the EU issued a yellow card Thailand to drive action to tackle the widespread illegal fishing. The EU yellow card is a determination by the EU that IUU fishing in a country that supplies fish to the EU is at a level of concern to EU member states and action needs to be taken. Some illegal catches would often land in Thailand on refrigerated cargo ships. Some of these huge vessels were getting their daily catch from smaller, illegal fishing boats on the high seas — a practice called "fish laundering".

Following the yellow card being issued a new Thai fisheries law was enacted in November 2015 which prohibited foreign vessels from entering Thai ports unless their cargo was properly certified. Thailand fishing law also requires all the fishing vessels to be registered and equipped with tracking devices (GPS and VMS). A large number of fishing trawlers were removed from the fishery resulting in lower catch and less surimi production in 2016 to 2018. However, the aim is to rebuild fish stocks which remain in a poor state after 50 years of overfishing.

Nevertheless the domestic consumption of surimi products in Thailand remained stable and the market for surimi seafood producers continued to expand in the northern regions and into the neighbouring countries (Laos, Cambodia, Vietnam and Myanmar). Tto satisfy demand for surimi seafood products and to compensate for the reduced local surimi supply, there was a 60% increase in imports of imports into Thailand, mainly from Vietnam (25,700 tonnes) and U.S.A. (3,700 tonnes).

The EU lifted the IUU yellow card on January 11th, 2019 in recognition of the constructive cooperation of the Thai authorities with the Commission resulting in a comprehensive and structural reform of the fisheries legal and policy systems to curb illegal fishing.

The measures taken include:

- Comprehensive review of the fisheries legal framework in line with the International Law of the Sea, including a deterrent sanctions scheme;
- Full reform of the management of the fleet, sound systems of registration, control of the fishing vessels;
- Strengthening of the Monitoring, Control and Surveillance tools, including full coverage with Vessels Monitoring System (VMS) of the industrial fleet and a robust system of inspections in the ports;
- Full implementation of the United Nations Food and Agriculture Organisation (FAO) Port States Measures agreement on foreign-flagged vessels that land their catches in Thai ports to supply the processing industry;
- Development of a comprehensive traceability system covering the whole supply chain and all modes of transportation, in line with international standards;
- Improved administrative procedures, training and political support, for proper enforcement of the legislation;
- Significant reinforcement of the financial and human resources for the fight against IUU fishing.

After 3 years, the Thai fishery and the surimi industry started to recover. Surimi production increased in 2019 to 60,000 tonnes from a low of 50,000 tonnes in 2016.

It may be noted that while the EU impose strict control on the fisheries of foreign countries, the same standards are not necessary applied in the European Union itself. It is only in September 2020 the European Commission voted for a number of measures for transparency of the fisheries of the European Union such as systematic vessel tracking and reporting of the catch.

### 2.5.1.2 Thailand surimi industry

From 21 surimi producers in the high production years of 2002-2005, only 7 remain today, most of them located in Mahachai, near the largest fish market of Thailand, south of Bangkok (Figure X). The largest manufacturers who once produced around 20,000 tonnes/year have reduced their production by 50 to 70% as the volumes of fish landed in Thailand were decreasing. To avoid direct competition with the leading processors (Sea Royal, Starfish, Pacific Marine or Apitoon), the last ones to enter the market found a niche in processing species that were not the main target of the larger processors (e.g. goatfish for Andaman, sardine for Anusorn).

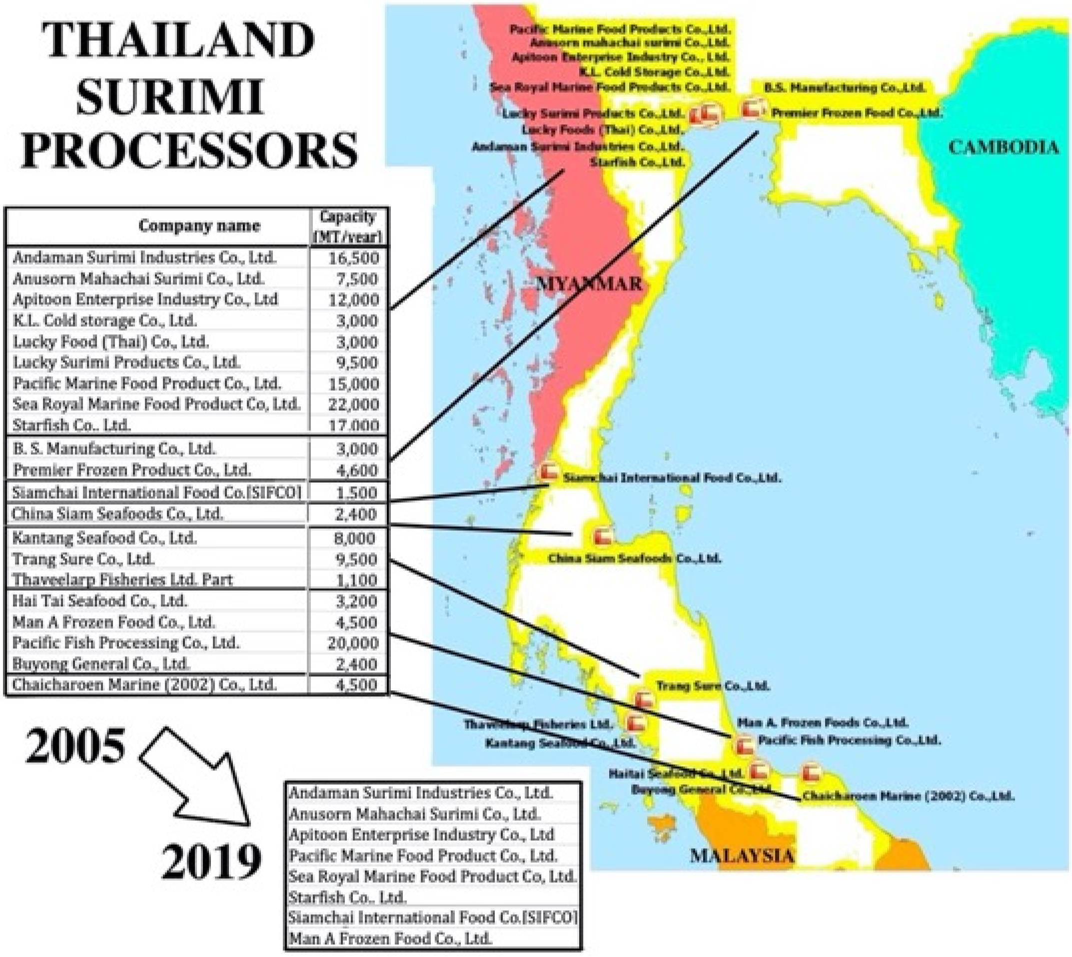



Figure 2.15 – number and location of surimi processors in Thailand

Since the Thai surimi industry developed in partnership with Japanese importers and later expanded their business to Europe and the US, the factory technology, quality management and sanitary condition are high level and the product reputation for high quality.  For this reason, Thai surimi is preferred in Japan and sells at the highest price levels in Southeast Asia and until today Thailand still remains the reference for tropical fish surimi despite the decreased share of Thailand production in the tropical fish surimi market.


#### 2.5.1.3 Domestic usage and exports of Thai Surimi

While Thai surimi production started primarily for export to Japan, domestic consumption has increased over time such that by 2012, half of the production was consumed in the domestic market. As domestic production decreased, Thailand started importing increasing volumes of surimi while exports decreased. Imports reached the same level as domestic production around 50,000 tonnes by 2018 (Figure 2.16a).

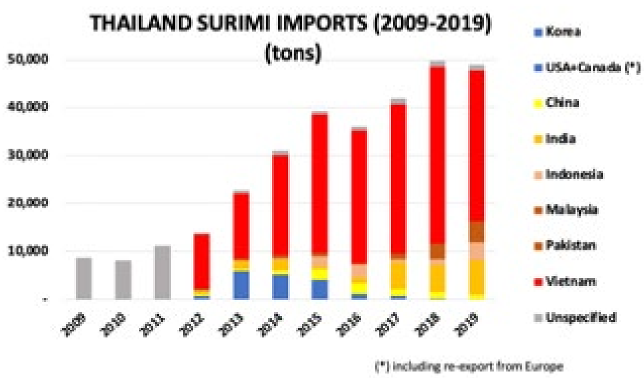



Figure 2.16a – sources of surimi imported into Thailand.

The main export market for Thai surimi remains Japan but the volume decreased by half from 40,000 to 20,000 tonnes over the period 2009-2012 to 2016-2019 while the Thai production decreased and domestic consumption increased (Figure 2.16b). The other export countries in Asia include Taiwan, Korea, Singapore and Malaysia.

Exports to USA jumped up to 10,000 tonnes in 2008-2009 when the Alaska pollock quota was reduced by half but quickly decreased as the pollock resource recovered and itoyori became uncompetitive compared to Alaska pollock.

Similarly, Thai surimi exports to Russia jumped when the USA put a ban on sales of US fishery products to Russia after the war in Ukraine.

Exports to the EU have decreased since 2013 when pollock price decreased after the oversupply crisis of 2012 and stayed at low levels as a result of buyers restrictions for product from non-certified fisheries.

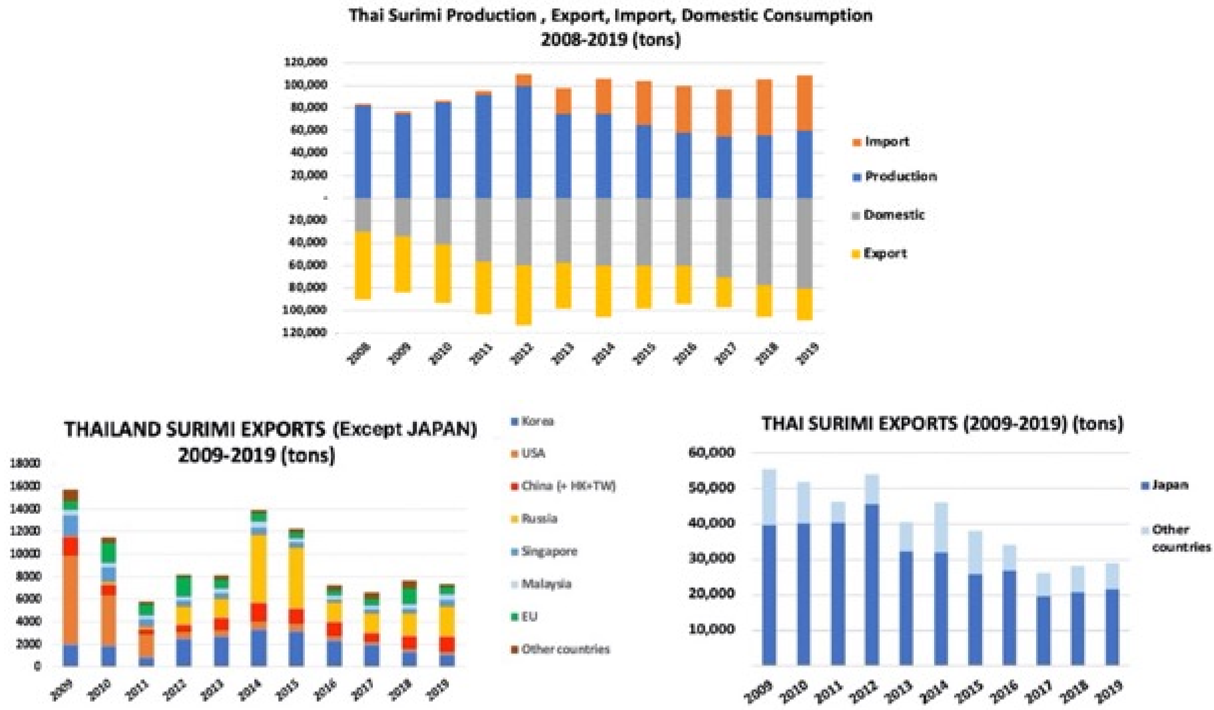



Figure 2.16b – changes in domestic production, consumption, imports and exports – Thailand surimi

As production decreased after 2012, the domestic market absorbed over half of the Thai surimi production and the surimi seafood producers started to import raw material, primarily from Vietnam to respond to the demand for cheaper raw material and from the US for export to EU buyers requesting surimi from certified fisheries.   US surimi exports to Thailand do not appear in the last years since this surimi is imported free of duties for re-export.

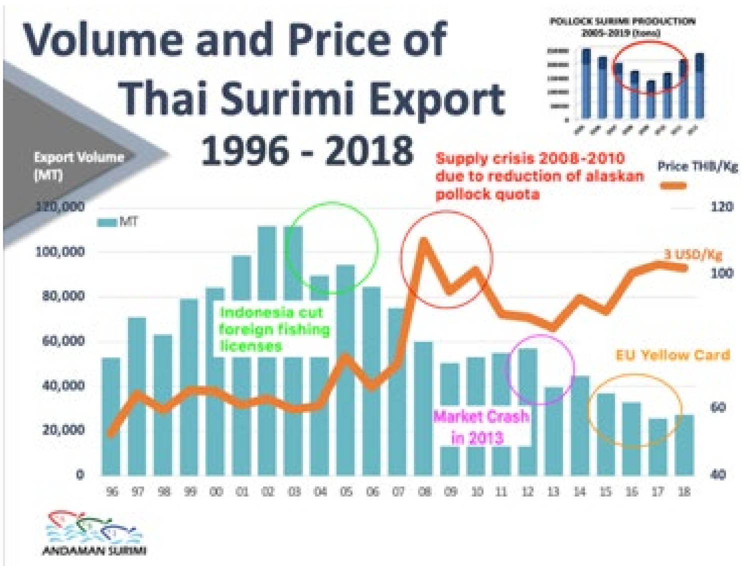


Figure 2.17 Factors affecting Thai surimi production over past 20 years

Figure 2.17 shows the different events that affected Thai surimi production in the past 20 years and how the surimi market reacts globally to changes in supply and demand. The drastic cut in the Alaska pollock quota in 2008-2009 resulted in a sharp increase of Thai surimi prices in anticipation of the shortage to come. At the opposite the inventory accumulated in 2012 resulted in a large drop of Thai surimi prices.


Figure 2.18 fluctuations in raw material prices in Thailand

In fact, the price of eso and itoyori raw material already started to increase in the (northern) fall of 2007 in anticipation for a shortage to come since the cut in the Alaska pollock quota was known several months in advance before the opening of the 2008 'A Season'. In the same manner the price of fish started to decrease before the pollock 'A Season' in 2013 in anticipation of the market crash (Figure 2.18).

### 2.5.1.5 Thailand surimi seafood industry

While a number of surimi factories started in the early 80's, the group Apitoon was one of the first to start production of surimi seafood when they established A & N FOODS CO., LTD. in a Joint-Venture with Nissui in July 1988. While initially they tried to follow the variety of products proposed by their Japanese partner, they rapidly realized that their market was not (yet) ready for this multitude of exotic surimi products and after some time they focused on the production of crabstick for export to the European market.

After a rapid growth in the export markets to USA, Europe, Russia, Australia, Japan and the South East Asian markets, the Thai producers have developed a healthy domestic market growing at around 10% annually.

In 2019, the surimi products from Thailand include 3 categories of products for a total production of around 140,000 tonnes sold for 60% in the domestic market and 40% to export markets:

- Market 1 - 100,000 tonnes of crabsticks and analogues (shrimp, lobster tail …) and Japanese style products (chikuwa…) in various formats for the retail and foodservice markets. A large portion is still sold in the frozen form but the domestic market of high quality chilled products is growing. Some products have also found a particular market like the molded shrimps sold on skewers in barbecue street food.
- Market 2 - 25,000 tonnes traditional products for the domestic market: fish balls and Thai fish cakes
- Market 3 - 12,000 tonnes of dried snacks found through all Thailand in convenience stores, gas stations, retail market, etc

Surimi is also used in smaller volume in the manufacturing of a number of fish products or food preparations like dumplings, etc.

The Thai surimi seafood industry counts over 20 processors of surimi products (Figure 2.19). The main processors are for the three categories described above are as follows:

Market 1 – Lucky Union Foods, Taeveevon, Pacific Fish Processing, Kibun Foods (Thailand), Smile Heart Food, A&N Foods, AP Frozen Food, BS Manufacturing.

Market 2 – Mahachai Food Processing, SIFCO, Man A

Market 3 – PM Foods, Siam Daily Foods, Thai Union Foods, Big Kitchen


Figure 2.19 – location of surimi seafood processors in Thailand

The surimi seafood industry in Thailand grew in the 1980's and 1990's to supply crabsticks and molded analogue products (lobster tail, shrimp, scallop) to the developed countries (USA, Europe, Australia, New Zealand and Japan. However, as is evident from Figure 2.20 below the trade is primarily within the Asia region.

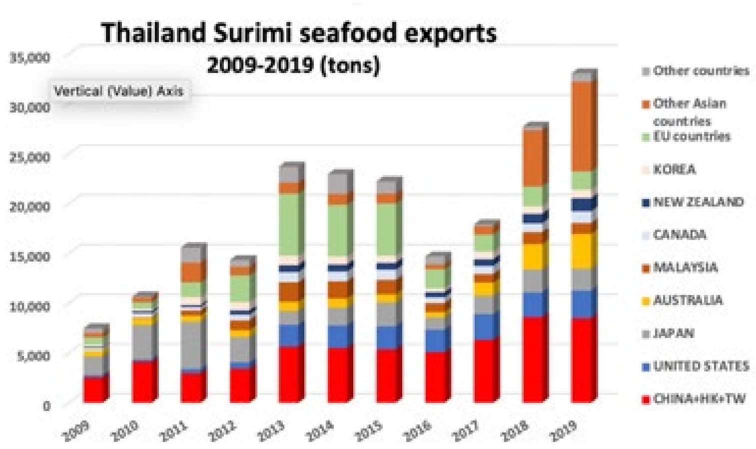



Figure 2.20 – country destinations for surimi seafood exports - Thailand

Since the export markets declined with the development of the surimi seafood industries in the main export destinations, the growth in the 2010's was fueled by the expansion of domestic sales through the retail distribution and convenience stores like 7/11, food service for traditional surimi products (fish balls, fish cakes) and specialty restaurants (hot pot, sushi), street food (fish balls and molded shrimps used for barbecue food and cooked on skewers).

In recent years, the sales of Thai surimi products have expanded, particularly in remote regions away from coastal areas (north of Thailand) and to the neighbouring countries (Laos, Cambodia, Myanmar, Vietnam) and to China for high quality products. One example is the burgeoning sales of Thai fish balls to Myanmar and Laos and a fast growing market for crabsticks in Cambodia (Figure 2.21).

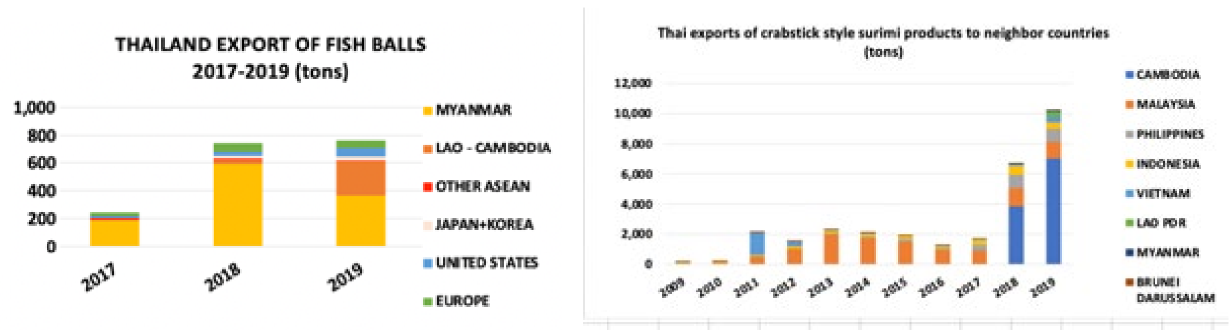



Figure 2.21 – main regional destinations for Thai fish balls and crab sticks

## 2.5.2 – Vietnam

Vietnam has a long coastline with a marine environment dominated by tropical and subtropical characteristics and high species diversity with more than 2000 fish species being reported (Chung et al. 2001).

Vietnam has traditionally been a very active fishing nation with over 130,000 fishing vessels registered in 2010, mostly artisanal, employing over one million fishermen and generating work for several million workers in the fish processing and fishing related industries. The 5 main fishing ports located in the south (Vung Tau, Rach Gia, Ca Mau), central (Da Nang) and north (Than Hoa). The main fish landings and surimi production happen in the southern part of Vietnam.

While a survey conducted in 2004-2005 showed a relatively large biomass of the usual demersal species used to process surimi, many resources have been overfished and most coastal areas are largely depleted, forcing the Vietnamese fleet to go further offshore to catch fish.

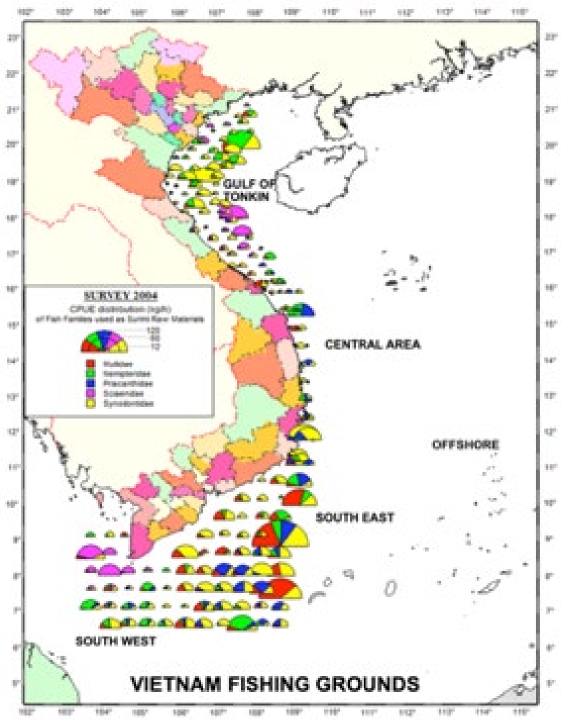



Figure 2.22 Main fishing grounds in Vietnam

Based on overall environmental conditions, the sea of Vietnam is divided into five main areas: the Gulf of Tonkin, the Central area, the Southeast area, the Southwest area and the Offshore waters.

The demersal fish stocks on the continental shelf of Vietnam in 2004 and 2005 were assessed by trawl surveys which recorded the main fish species used for surimi (Ha et al (2005) and Sơn (2005):

- Lizard fishes were widely distributed with high concentration in the Gulf of Tonkin and the southeast area. The biomass was estimated at 100,000 tonnes in 2004 but this dropped to 50,000 tonnes in 2005
- Threadfin Breams were distributed mostly in the middle of the Tonkin gulf and edges of the southern waters and the biomass was estimated at 40,000 tonnes in 2004 and 30,000 tonnes in 2005
- Croakers were mainly distributed in the mouth of the Tonkin gulf and shallow waters of the southwest area with a biomass of 10,000 to 20,000 tonnes
- Goatfishes were estimated at 36 thousand tonnes in 2004 and dropped in 2005 to 17.6 thousand tonnes
- Red big eye biomass was estimated at 28 thousand tonnes in 2004 and increased to 37 thousand tonnes in 2005 with highest concentration in the South and lowest in the Gulf of Tonkin

### 2.5.2.1 Vietnam surimi Industry

Surimi production started in the 1990’s mostly supported by Korean importers. Seventeen surimi factories were registered in Vietnam in 2005.


Figure 2.23 Location of surimi factories in Vietnam

The lack of enforcement of fishing regulations and poor management of the resource and overfishing led to erratic and unpredictable fish landings and poor quality of raw material for processing surimi for most of the production. Nevertheless the surimi production kept growing to reach over 100,000 tonnes by 2010, rising to 180,000 tonnes in 2018 (Figure 2.24).

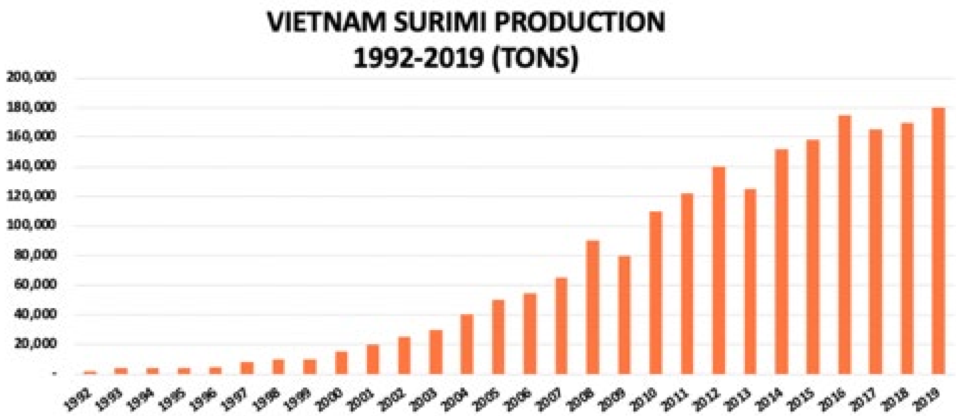



Figure 2.24 – growth in surimi production in Vietnam

While the fishery kept growing with increased numbers of fishing vessels, Vietnam's fisheries in general have been poorly managed with no controls over catches and regulations rarely enforced. Over the years, the overexploitation of coastal fishing grounds resulted Vietnamese vessels fishing near the borders with Malaysia, Thailand, Indonesia and China, if not further. This has created a growing number of international incidents and arrests of vessels fishing illegally.

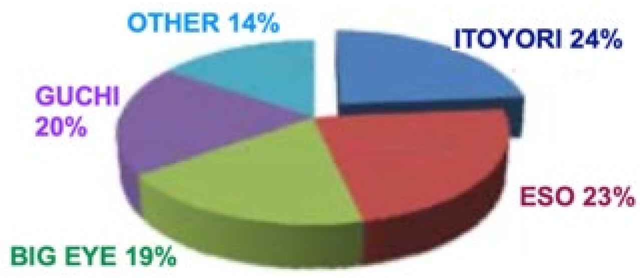



Figure 2.25 Main species groups used for surimi in 2005

The resource used for processing surimi also changed over time. While demersal species of threadfin bream, lizard fish, croaker, big eye and goat fish represented 90% of the fish supply used for surimi in 2005 (Figure 2.25), today over 50% of the catch processed into surimi is pelagic fish : scad, mackerel, sardine and other dark meat fish.

Vietnam surimi factory (Ngoc Tuan Surimi – 2019)

Vietnam is the second largest surimi producer in Asia. Except for the economic crisis of 2008, the market crash of 2013 and the issuance of the yellow card by the European Union in 2017, surimi exports continuously grew for the past 30 years to reach a record level of 180,000 tonnes in 2019 (Figure 2.26).


Figure 2.26 – growth in surimi exports from Vietnam

Nearly 100% of the production is exported to South Korea, Thailand, China, Japan, Malaysia, Singapore, Eastern Europe and the European Union. South Korea is the main export destination for Vietnamese surimi and the main volume is comprised of mixed fish surimi sold at very low prices and used for the production of fried fish cakes (ahmok).

Considering that Vietnam was not taking sufficient measures to tackle illegal fishing, the EU issued a yellow card to Vietnam in October 2017. Since then many measures have been taken to improve the fisheries governance, including the issuance of the 2017 Fisheries Law and other related guiding documents for the prevention of illegal fishing.

The effects of the Yellow Card started to be visible particularly in the ports of Tac Cau (Rach Gia province), Ca Mau province and Vung Tau province in 2017. As a result of the IUU Regulations, many fishing boats have not been fishing since the northern summer of 2020 and stay tied up in ports. The result was a decrease in fish landings that also reflects on the surimi production and exports.

However, the improvement in tackling IUU fishing has remained modest, proven by rampant violations by vessels fishing illegally in the territories of other countries. Reports from the Directorate of Fisheries in 2018 showed that 137 vessels were caught illegally fishing in Thailand, Malaysia, the Philippines, Cambodia, Indonesia and Brunei, an increase of 46 vessels compared to the previous year. This reflects in the surimi exports increasing again by 2019.

As its surimi production was initially mostly directed to South Korean processors of fried fish cakes, the main product was low grade mixed fish surimi, a situation that remains today: Since the mid 2000's, some companies developed better quality product from threadfin breams, lizard fishes, flying fishes etc and were successful in entering the Japanese and European markets and later South East Asia (Thailand, Singapore) and China when demand from these countries surpassed the local supply capabilities (Figure 2.27).

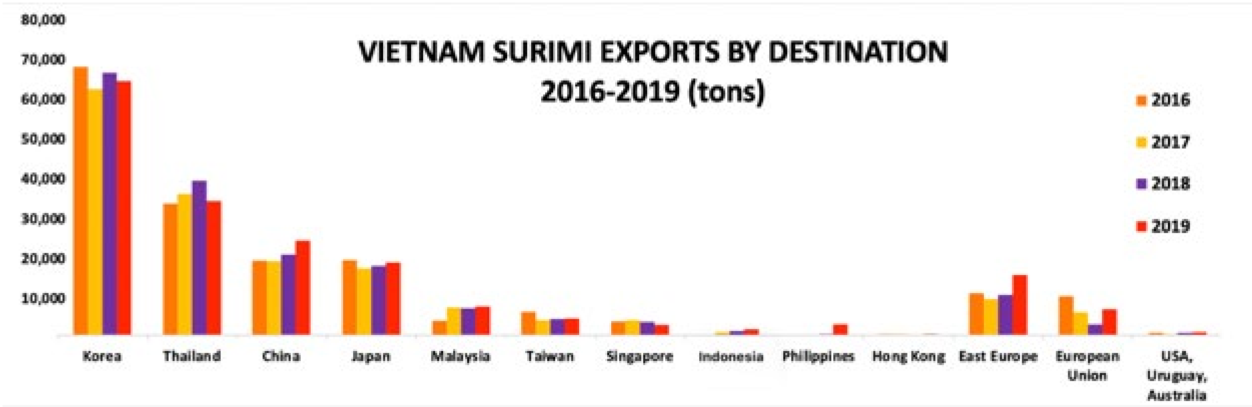



Figure 2.27 – destinations for surimi exports from Vietnam

The industry is largely located in southern Vietnam where the largest catches of fish are made (Fig 2.28)

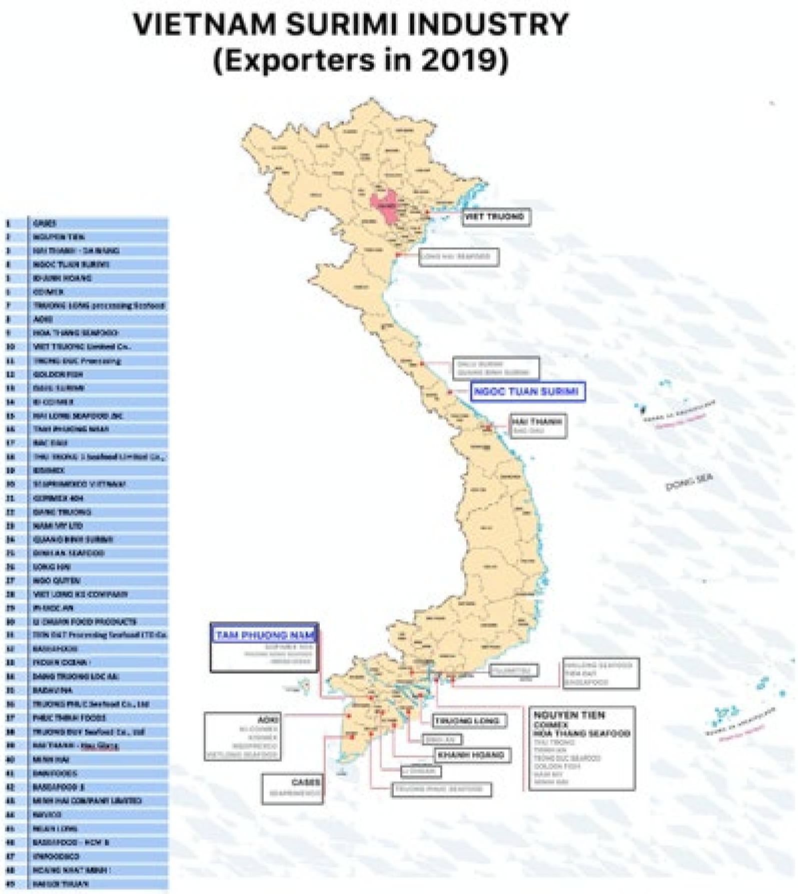



Figure 2.28 – location of surimi exporters in Vietnam

The large number of competitors (over 50 companies), instability in the supply of raw materials, the lack of capital of the companies involved in this industry and the fact that most of the companies rely on traders who can easily change suppliers for price consideration results in a difficult market environment for surimi processors. One notable attribute of the Vietnamese surimi industry is the degree of turn-over in the production factories: from 2016 to 2020, ten processors disappeared while about the same number of new exporters appeared in the market (Figure 2.29).

| | 2016 | 2,019 |
|---|---|---|
| CASES | 22,131 | 22,121 |
| NGUYEN TIEN | 17,874 | 17,119 |
| COIMEX | 11,877 | 7,661 |
| KHANH HOANG | 12,585 | 10,005 |
| KI-COIMEX | 515 | 5,436 |
| DALU SURIMI | 234 | 5,542 |
| HAI THANH | 7,525 | 9,648 |
| HOA THANG | 4,038 | 6,069 |
| AOKI | 4,623 | 6,583 |
| TAM PHUONG NAM | | 4,973 |
| INDIAN OCEAN | | 1,438 |
| TRONG DUC | 5,349 | 5,591 |
| NGOC TUAN SURIMI | 1,699 | 9,048 |
| TRUONG LONG | 6,932 | 7,085 |
| TUONG PHUC | | 1,106 |
| HAI LONG | 7,693 | 4,689 |
| GOLDEN FISH | 3,417 | 4,932 |
| BAC DAU | 4,077 | 3,934 |
| KISIMEX | 3,242 | 4,010 |
| DANG TRUONG LOC AN | | 1,840 |

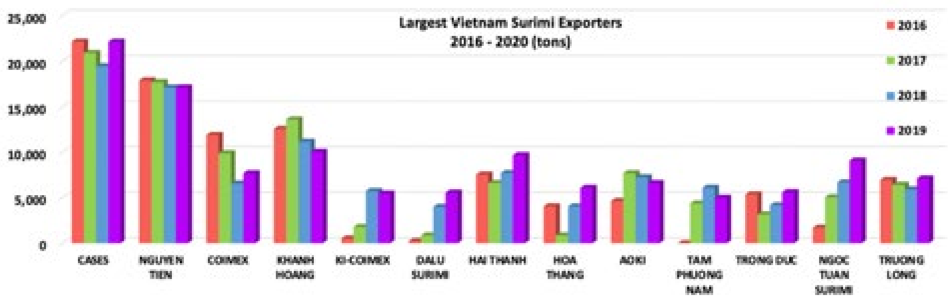



Figure 2.29 Production variability in the larger producers of surimi

### 2.5.2.2 Vietnam Surimi Seafood Production and Market

While some companies started production of surimi seafood products in the 2010's, production was still limited to a few thousand tonnes in 2020. The surimi seafood processors are associated with foreign companies and oriented to the export markets: Danifood in Danang (Japan), Li Chuan in My Tho (Singapore), Coimex in Vung Tau (France), Kanetetsu near Ho Chi Minh City (Japan) but in recent years Vietnamese companies have started to grow this business, processing fish balls and primarily using the pangas resource. A domestic market has appeared and is fast growing both with imported and domestic products. In addition to fish balls, fish cakes and molded products sold as snack foods or used in hot pots, the crabstick market is growing with sushi restaurants. The market for these products also grows in retail distribution while many restaurants and small workshops are processing local specialties from fresh fish mince ("Cha Ca") used in hot pot.

A fast expansion can be expected in the coming years for two reasons:

- While having cheap labour and a large supply of raw material at competitive prices, Vietnam signed a trade agreement with EU that exempts surimi products from import taxes and foreign companies (particularly from Thailand) look at delocalizing some production to Vietnam to take advantage from this situation.

- the fast growing domestic market is offering an opportunity for surimi processors facing a slow-down in their domestic market.

## 2.5.3 - Indonesia

The Indonesia surimi industry was initiated by Japanese, South Korean and Taiwanese companies. In 2005 there were eight processing plants for surimi production (Pangsorn *et al*., 2007) but by 2015 the number had increased to 20 (SEAFDEC 2017). While it has the largest fish resource in South East Asia the uncertainty regarding government policy on fishing regulations has frozen investment in the surimi industry.

A number of factories were old and based on outdated technology and had to close down in the face of reduced fish landings as the government banned trawling and Danish seining in 2015. Nevertheless about 22 or 23 factories were still in operation in 2020, located primarily in Java (Figure 2.30).

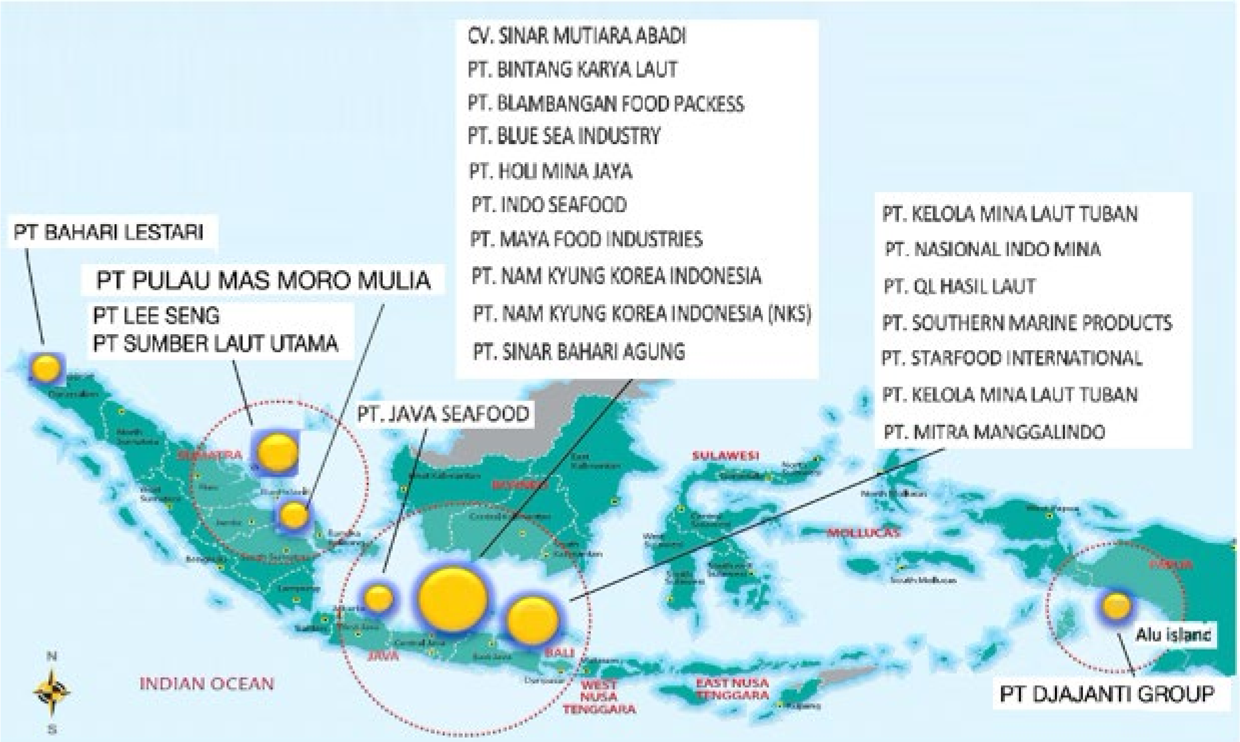



Figure 2.30 Location of surimi factories in Indonesia

According to local industry leaders, the production in 2019 was estimated at around 30,000 tonnes, a decrease when compared to 2018.

While surimi seafood was processed locally from fresh fish mince, most of the production was exported until recent years to Japan, Korea, China, Singapore, Malaysia and Thailand.

Local producers (Figure 2.31) started processing surimi seafood in joint ventures with Taiwan and Japan and the products found a fast growing domestic market.


Figure 2.31 Surimi seafood producers in Indonesia

Surimi seafood is increasingly popular as an affordable, healthy, nutritious product and with a population of 250 million it is probably the country which has the highest potential to grow its surimi seafood market in Southeast Asia.

The main surimi seafood producers include Citra Dimensi Arthali, Indomina Seafood, ISC Seafood, CP Prima Proteina, Sekar Bumi TBK, PT Indo Mina, with factories located in Sumatra and Java.  In addition to the large processors a number of small shops and restaurants are processing fish balls and local surimi products.  Anecdotally, the production of surimi products by the small scale players could rival the production of the industrial sector. Indonesia surimi products include various kinds of fish balls and Taiwanese style of products sold in retail market, street food stalls and specialty restaurant chains like sushi bars and hot pot.


## 2.5.4 Malaysia & Singapore

### 2.5.4.1 Surimi production - Malaysia

Malaysia has 7 factories processing around 20,000 MT of surimi, located on both peninsular Malaysia and on the island of Borneo (Figure 2.32)


Figure 2.32 – location of surimi producers in Malaysia

The Malaysian market for surimi products is growing while surimi production is stable or slowly decreasing and as a result, surimi exports from Malaysia are decreasing while imports increase year after year. The main export market for Malaysia is Japan which takes around 4,500 to 5,000 tonnes per year and the volume is relatively stable while exports to other countries have decreased to around 1,000 tonnes per year.

Between 2015 and 2017, the import volume of surimi to Malaysia remained stable at around 14,000 tonnes while exports decreased nearly by half from 11,000 to 6,500 tonnes. The main exporters to Malaysia in 2017 are Vietnam (7,000 tonnes), India (2,500 tonnes), Indonesia (1,000 tonnes) and Thailand (1,000 tonnes). In the past two years, the imports from Vietnam have increased while exports from other processing countries decreased.

**2.5.4.2 Surimi seafood – Malaysia**

The surimi seafood market in Malaysia is fast growing and mostly a HALAL market. The products include a large variety of fish balls, fried products, molded products and crackers. While the street food and wet markets are still present the modern distribution and restaurant sales represent the major volume of the market.


Malaysia's main processors are the QL Group and Kami Food Service but Singapore processors are delocalizing their production and investing in Malaysian factories to expand their market. While the surimi seafood market in Malaysia is growing, local producers and subsidiaries of Singapore processors are also developing the export markets to ASEAN countries, USA and China (Figure 2.33).

| COUNTRIES OF SURIMI BASED PRODUCTS EXPORT ( MT ) | | | |
|---|---|---|---|
| COUNTRIES | 2015 | 2016 | 2017 |
| ASEAN | 2,115 | 4,323 | 7,268 |
| CHINA | 1,551 | 2,801 | 4,491 |
| NORTH AMERICA | 1,848 | 2,217 | 3,043 |
| AUSTRALIA | 475 | 879 | 1,647 |
| EU | 183 | 270 | 382 |
| OTHERS | 574 | 714 | 1,862 |
| | | | |
| TOTAL | 6,746 | 11,204 | 18,693 |

Figure 2.33 Destinations for Malaysia surimi exports

**2.5.4.3 Singapore surimi seafood**

Singapore has been well known for its high quality fish balls. The main processors are Ha Li Fa and Thong Siek. Production of fish balls and surimi products in Singapore is estimated to be around 30,000 to 40,000 tonnes and besides a large local market the products are exported through ASEAN.

SINGAPORE SURIMI SEAFOOD FACTORIES

Singapore is importing its raw material and the main source countries for the surimi in 2019 were Vietnam (3,000 tonnes), India (2,500 tonnes), Indonesia (2,500 tonnes).

SINGAPORE & MALAYSIA SURIMI SEAFOOD

### 2.5.5 Pakistan

While the local resource is overfished, Pakistan still has access to fresh and good size raw material and can process one of the best quality of itoyori surimi.  The main season is February to May, until the fishing ban that lasts 2 months and August – September after the fishing ban.

Three surimi factories located in Karachi originally were started by South Korean investors.   Kaneshiro once dominated the Pakistan surimi industry but went bankrupt in 2018. Surimi production reached around 10,000 MT in 2018 with additional investment by Thailand, Vietnam and China processors in existing factories.  In 2020, local companies took over the existing factories while PK International has moved to a new location in Karachi (Figure 2.34)

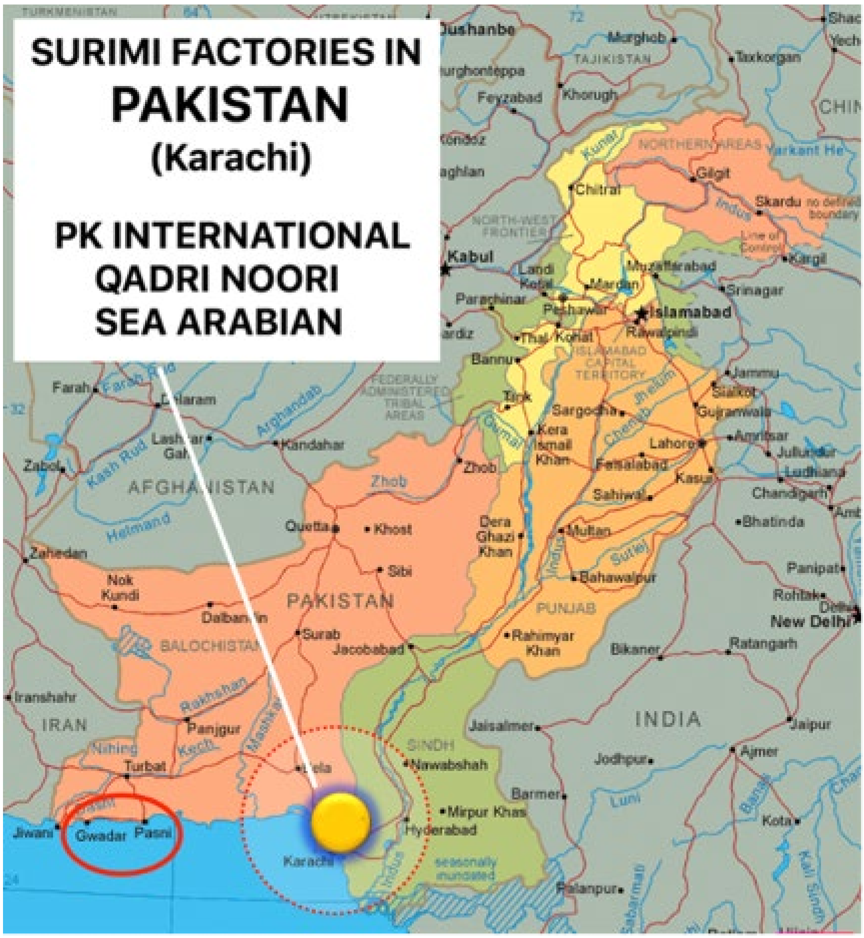



Figure 2.34 Location of surimi factories in Pakistan

With several projects involving new factories and raw material available in large volume on the west coast (Gwadar, Pasni) the surimi production in Pakistan has the potential to grow in the coming years.

The surimi production from Pakistan is exported primarily to South Korea, Thailand and China.

### 2.5.6 Myanmar

Myanmar has been processing surimi in 3 factories (Figure 2.35) for a number of years but the production remains limited to 2,000 to 3,000 MT.  One reason may be the trade of fish with neighboring country Thailand which pays higher prices than local the market.  Myanmar fish supply to Thailand may  represent 25 to 30% of the supply to the Mahachai fish market.

The surimi production is exported mainly to Japan and South Korea.


Figure 2.35 – location of surimi factories in Myanmar

Despite the fact that the local industry has not yet started processing surimi seafood, surimi products are popular and the market is quickly growing with products imported from Thailand and Singapore sold through sushi and hot pot restaurants and in supermarkets.


## 2.5.7 Taiwan

While Taiwan was one of the early Asian surimi processors, all the surimi factories closed down in the 1990's due to lack of resources.

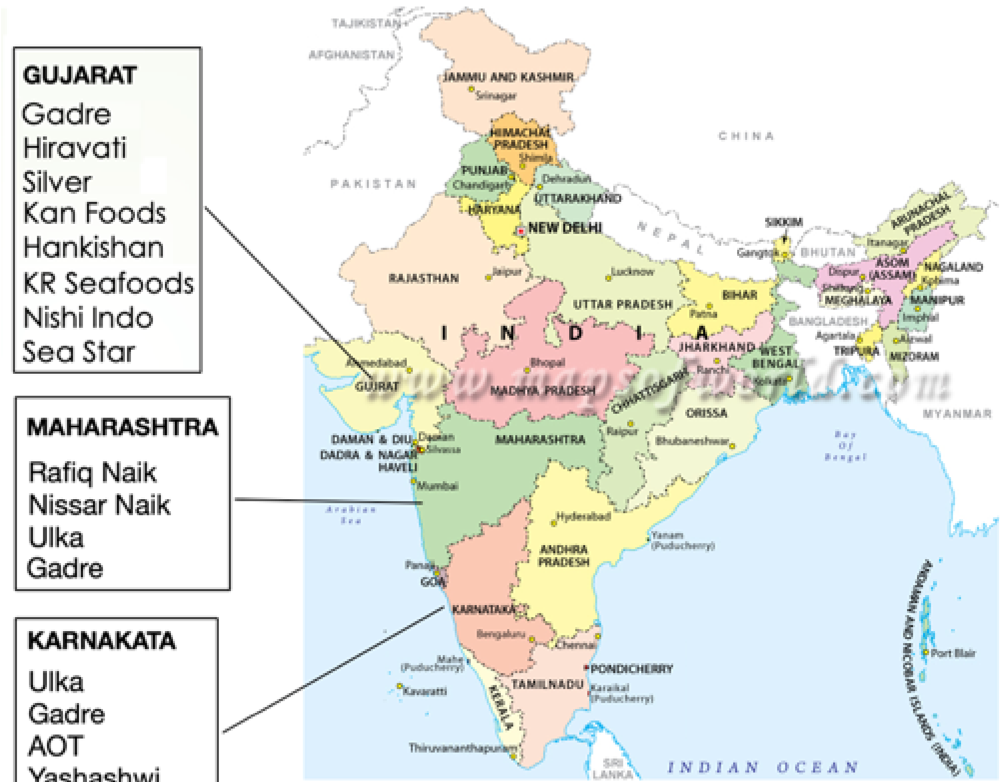
Nevertheless surimi seafood products remain popular and Taiwan imports around 15,000 tonnes of surimi annually, Alaska pollock from the USA and Itoyori and Eso from India, Indonesia and Vietnam.


## 2.5.8 India

India's coastal area is very large, extending about 8,000 kilometres, with one fishing village every 2 km. The nine coastal states of Gujarat, Maharashtra, Goa, Karnataka and Kerala on the West coast, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal on the East Coast have 30 large fishing harbors, 4,000 fishing villages and 2,000 traditional landing centres. The fishermen represent around 10 million people. The total catch of India's fisheries is estimated at over 5 million tonnes (FAO) and has increased by 1 million tonnes in the last decade. The fishing fleet includes 144,000 motorized boats and 50,000 non-motorized.

In addition to the capture sea fisheries, India also has many freshwater fisheries and also considerable potential for growing its aquaculture sector, including fresh water fish.

Since the west coast has a large continental shelf favorable for the growth of demersal fish, this is where the surimi industry is located. India had 17 surimi factories in 2019 (Figure 2.36). The largest processors are Gadre Marine, Hiravati and Ulka.




INDIA SURIMI INDUSTRY (2019)

Figure 2.36 – location of India surimi factories

### 2.5.8.1 Surimi production

The fish commonly used for surimi are from the same fish families found across tropical Asia: threadfin bream, bigeye, lizard fish, ribbon fish, goat fish and croaker. In addition surimi is also made from the lesser sardine (*Sardinella fimbriata*) and with the capture of large numbers of triggerfishes in recent years these have also been used for surimi production.

The surimi industry was introduced by Shinto Corporation in partnership with Hindustan Unilever in the 1990's and became the main alternative to Thai surimi for Japanese importers. After a slight drop below 60,000 tonnes in 2013, a result of the market crisis, the production and export of surimi from India increased quickly in 2016 to 2018 to reach a record production of 100,000 tonnes (Figure 2.37). But production dropped again in 2019 due to a labour strike at the fish meal plants and poor fish landings during late months of the year.

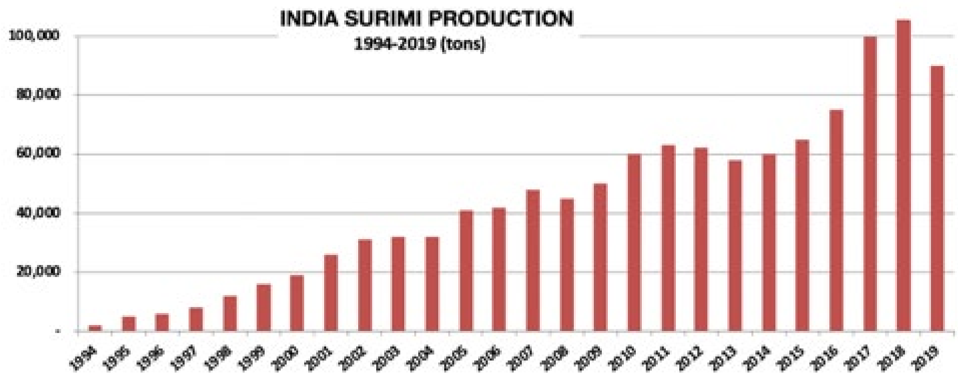



Figure 2.37 – surimi production volumes in India

Most of the production is exported to Japan, Taiwan, China, Korea, Thailand, Malaysia, Singapore, Europe and Russia (Figure X).

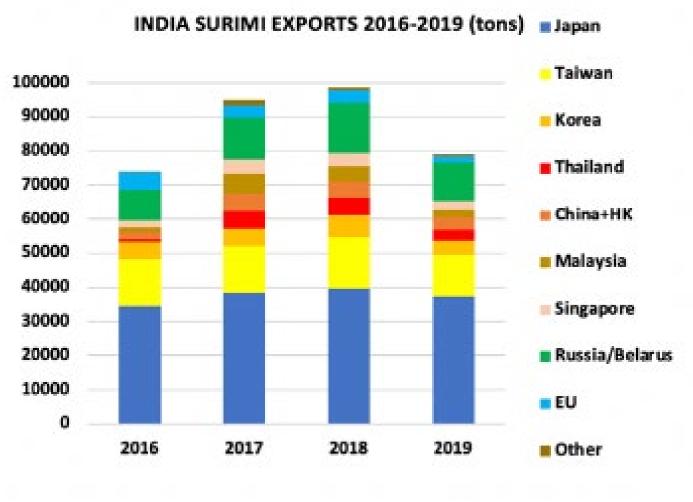



Figure 2.38 – volume and destination for India surimi exports

Over the years, the landings of threadfin bream have substantially decreased. While itoyori represented 90% of the surimi production in India in the 90's, it decreased down to 65% in the early 2010's as production reached 60,000 tonnes/year and is probably down to 30% by 2020 while the fish size decreased from 100g to 25-50g.

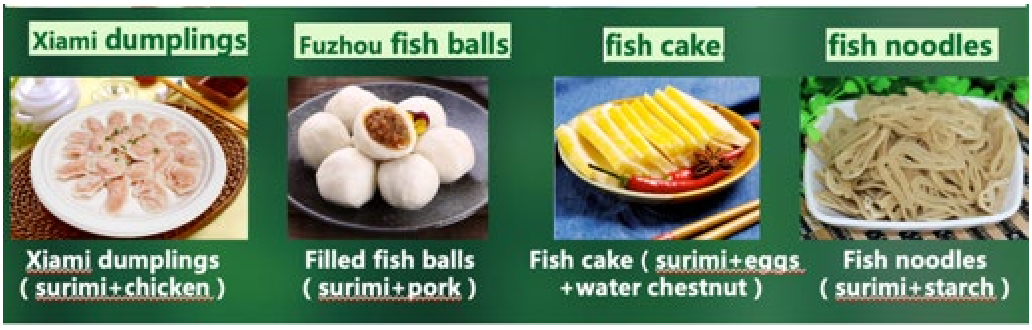
As a result of the depletion of the resource of threadfin bream due to overfishing and the increased processing capacity, the Indian surimi industry had to diversify the raw materials used to feed the production lines.  In recent years, India started processing surimi from a large variety of fish including pelagic fish and is gradually moving from processing single species surimi to multiple species mixed fish surimi.

### 2.5.8.2 Surimi seafood production

Gadre Marine, who took over the factory of Unilever when the group decided to quit the fish business, is the only processor of surimi products.  The production volume is around 12,000 tonnes of crabsticks and molded products and for the main volume exported to EU, USA, Southeast Asia and Japan.  The domestic market is very small in volume but growing slowly.

## 2.5.9 - China

The manufacture of surimi products in China can be traced back to ancient times when traditional foods were produced in some areas in southern China.  Some examples are the fish ball from Fujian Province, the "fish wrap dumplings" from Jiangxi Province, the fish cakes from Hubei Province and even fish noodles.  All of these types of foods used to be hand-made from fresh surimi




One special characteristic of China surimi products is the fact that the products combine fish with meat and vegetable proteins.

In the modern times, China started to study surimi in the mid-80's with some research programs on surimi and surimi products from fresh water fish in the Central Province of Hubei.  China imported its first production lines for surimi and surimi products from Japan in 1985.  Trials of production using  fresh water fish were conducted in Hunan and Hubei Provinces as early as 1986 and in the early 1990's the Fisheries Department of the Agriculture Ministry initiated comprehensive studies of the use of fresh water fish to process surimi.

In 1992, the first production line using marine fish was established in Zhejiang Province and Dalian Marine Fishery Group launched a factory trawler in 1993.  In the same year Longsheng Aquatic Products opened the first shore based plant processing marine fish and more than 60 surimi factories were built in the 1990's in response to the demand from Japan and Korean markets.  The surimi industry grew in parallel with the surimi products industry to feed this demand.  By 2010, around 100 factories were processing surimi from marine fish for a total production of about 200,000 tonnes.

 China's fisheries production grew in the late 1980's and 1990's from 200,000 to 1 million tonnes in part to supply the growing surimi industry but the growth slowed down in the 1990's and  fishery production has since stagnated.

### 2.5.9.1 China fisheries

According to Chinese statistics, China expanded its domestic fishing capability in the past 30 years through a 4 fold increase of the engine power of its fishing fleet and the size of the vessels without increasing the number of fishing vessels which has been stable around 25,000 to 30,000.  By going further away to the fishing grounds, China has been able to increase its catch from 4 million tonnes in 1986 to 12 million tonnes in 2098.  In the following years the production slightly decreased until 2005 and slowly increased again to reach 13 million tonnes through an increase of 40% of the fishing power.

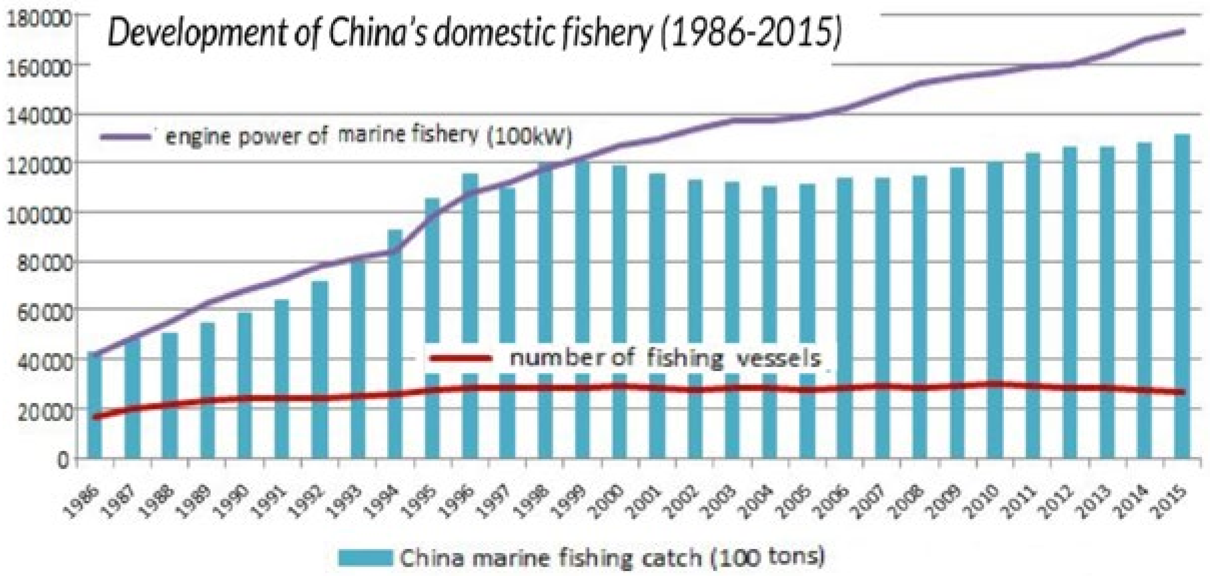



Figure 2.39 China's marine fish catch

#### 2.5.9.2 Marine fish surimi

The surimi industry is based on domestic catch and onshore surimi factories located in the coastal provinces of Zeijiang, Fujian, Guangdong, Guangxi and the Island of Hainan.

For the production of high grade surimi, in addition to the usual tropical species of threadfin bream, the fish species used to process surimi in China include some species of sea bream and gurnard.  The volume produced of high gel white surimi has much decreased over the years and total production is now below 15,000 tonnes.

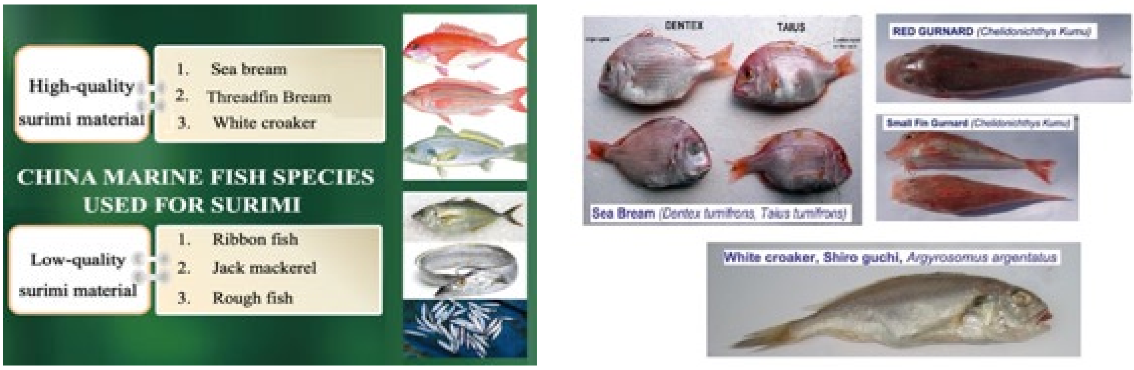



Figure 2.40 – some of the species used for surimi in China

For low grade surimi ribbon fish is the main resource in large volume, while jack mackerel, scad and other rough fish are used to process mix fish surimi (Figure X).


Ribbon fish (hairtail) surimi has always provided the largest portion of all marine fish surimi produced in China and it represents over 50% of the total volume. It is mostly produced at Ningbo and Zhoushan city in Zhejiang Province. Lower quality ribbon fish surimi is exported to Korea while better quality is processed for export to Japan and the domestic market. For export to Korea, the production yield can reach as high as 60% through sacrifice of quality by putting whole round fish into the meat separator without removing heads. The production volume was 120,000 tonnes in 2019 and the quantity was slightly increased during first season of 2020.

The main provinces for surimi production from marine fish were Zheijiang, Fujian, Guangdong and Guangxi Provinces (Figure 2.41). The production was estimated around 170,000 MT in 2010 and grew until 2015 to reach 220,000 tonnes. Since then production stopped increasing due to lower fish landings, decreased in 2017 but recovered in 2018-2019 to reach 230,000 tonnes.

| | Ribbon Fish | Mix Fish | Silver Carp |
|---|---|---|---|
| **Ningbo** | **59,000** | | |
| Jinhai | 13,000 | | |
| Guolong | 26,000 | | |
| Lanyang | 12,000 | | |
| Lianyang | 3,000 | | |
| Feiri | 5,000 | | |
| **Zhoushan** | **54,000** | **14,000** | |
| Huida | 10,000 | | |
| Mingcheng | 13,000 | | |
| Xingye | | 5,000 | |
| Jiazhu | 8,000 | | |
| Hongming | 7,000 | | |
| Hong'An | 5,500 | | |
| Shichuang | 4,500 | | |
| Huifeng | 4,000 | | |
| Tengxin | 2,000 | 9,000 | |
| **Taizhou** | **6,000** | **30,000** | |
| Longsheng (WL) | | | |
| LongSheng (YH) | | | |
| Dahua | | | |
| Haizhiwei | | | |
| Haiyi | | | |
| Yuantai | | | |
| **Guangxi Beihai** | | **39,000** | |
| Beihai | | | |
| Riran | | 15,000 | |
| Fenghua | | 11,000 | |
| Tongbao | | 8,000 | |
| Others | | 5,000 | |
| **Fujian** | **10,000** | **10,000** | |
| **Guangdong** | | **5,000** | |
| **Hubei, Jiangsu** | | | **70,000** |
| **Total Nationwide 300,000** | **Ribbon fish 130,000** | **Mix Fish 100,000** | **Silver Carp 70,000** |


Figure 2.41 – location of the main surimi production centres.

| China Surimi Producers Top 10 | | | |
|---|---|---|---|
| **Company Name** | **Location** | **Production (mt/year)** | **Main Product** |
| Hubei New Hongye Co., Ltd | Honghu City, Hubei Province | 20000 | Fresh Water Fish Surimi |
| Honghu Jingli Aquatic Food Co., Ltd | Honghu City, Hubei Province | 17000 | Fresh Water Fish Surimi |
| Qinjiang Liuwu Aquatic Food Co., Ltd | Qinjiang City, Hubei Province | 15000 | Fresh Water Fish Surimi |
| Shipu Gulong Aquatic Co., Ltd | Shipu, Ningbo City, Zhejiang Province | 25000 | Ribbon Fish Surimi |
| Zhejiang Yuantai Aquatic Food Co., Ltd | Songmen, Wenling City, Zhejiang Province | 12000 | Mix Fish Surimi |
| Zhoushan Mingcheng Aquatic Co., Ltd | Zhoushan City, Zhejiang Province | 13000 | Ribbon Fish Surimi |
| Zhejiang Jinhai Aquatic Food Co., Ltd | Shipu, Ningbo City, Zhejiang Province | 13000 | Ribbon Fish Surimi |
| Ningbo Lanyang Aquatic Food Co., Ltd | Shipu, Ningbo City, Zhejiang Province | 12000 | Ribbon Fish Surimi |
| Zhejiang Huida Aquatic Food Co., Ltd | Zhoushan City, Zhejiang Province | 10000 | Ribbon Fish Surimi |
| Beihai Riran Aquatic Food Co., Ltd | Beihai City, Guangxi Province | 15000 | Mix Fish Surimi |
| Beihai Fenghua Food Co., Ltd | Beihai City, Guangxi Province | 11000 | Mix Fish Surimi |

Figure 2.42 – location of the larger producers

In total, China surimi production in 2019 was over 300,000 tonnes comprised of 120,000 to 130,000 tonnes of ribbon fish surimi, 10,000 to 15,000 of high quality white fish surimi (threadfin bream and sea bream), 80,000 to 90,000 tonnes of mixed fish low grade surimi and 70,000 tonnes of silver carp surimi. The price of marine fish of good quality for surimi like sea bream has reached such a level that producers of itoyori and sea bream also commonly mix these with silver carp surimi to reduce their costs.

### 2.5.9.3 Freshwater fish

By the 2000's the production of the Chinese surimi industry started to decline because of reduced landings resulting from overfishing and increasing labour costs. In the late 90's China started to process surimi from freshwater fish to compensate for the decreased supply of marine water fish surimi. The production of surimi from freshwater species is estimated to be around 70,000 tonnes and is mainly produced in Hubei and Jiangsu provinces.

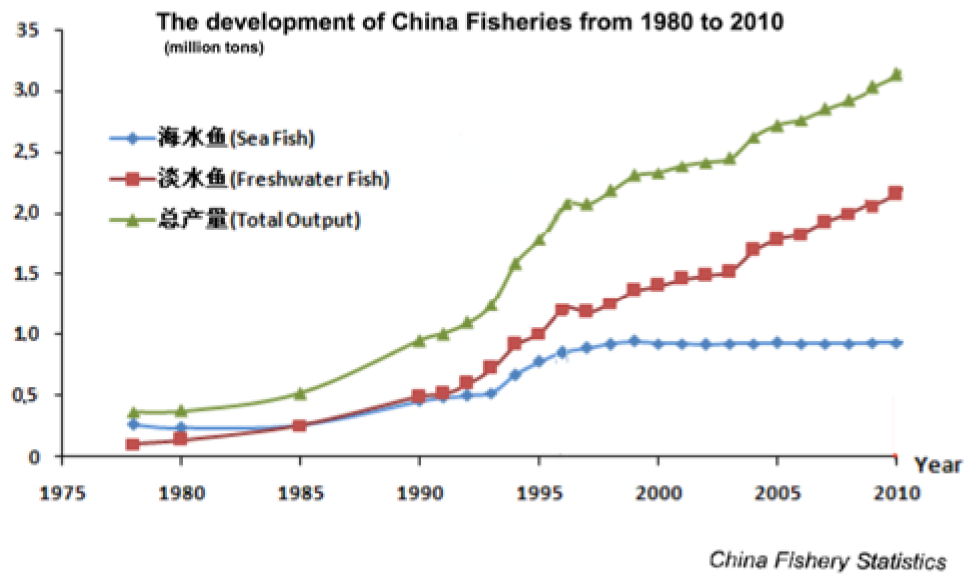



Figure 2.43 – growth in production of freshwater and marine fish in China

Overall, freshwater fish production has equalled the volume from marine fisheries in China in the early 1990's, growing from 500,000 tonnes in the early 90's to over 2 million tonnes by 2010 (Figure 2.43).

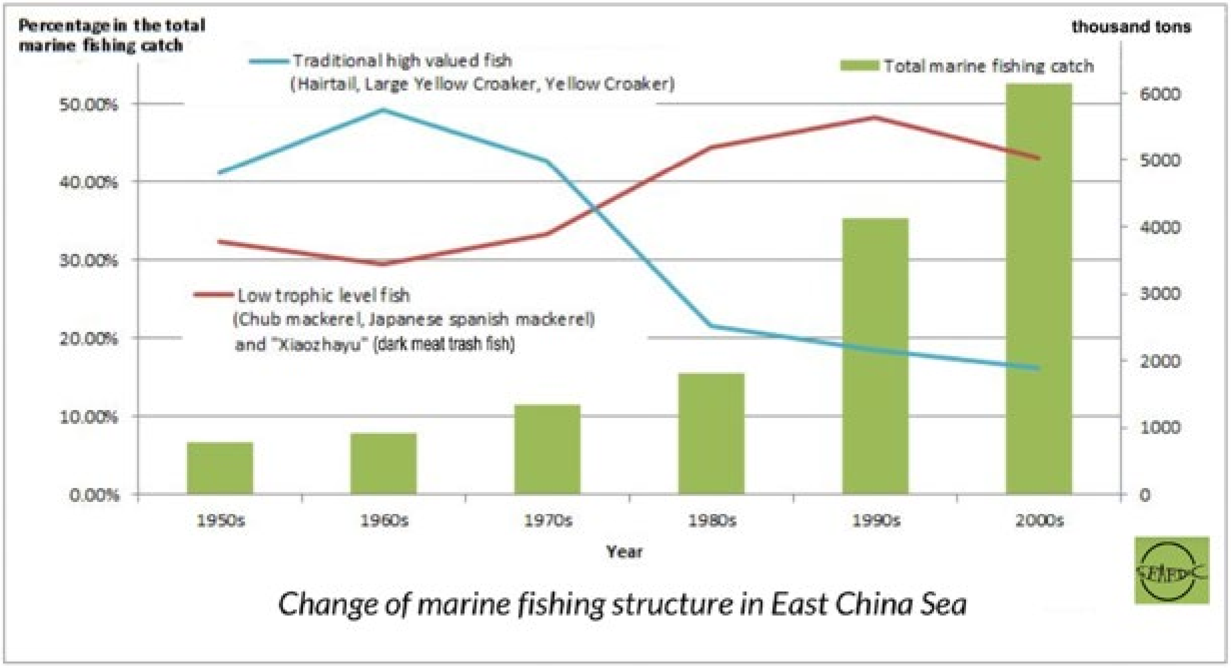



Figure 2.44 – change in composition of marine fish catches 1950's to 2000's

One of the results of overfishing was a partial replacement of demersal species by small pelagics which have been more actively processed into surimi in the recent years in China (Figure 2.44). Freshwater fish have started to become more utilised as a resource for surimi production (Figure 2.45)

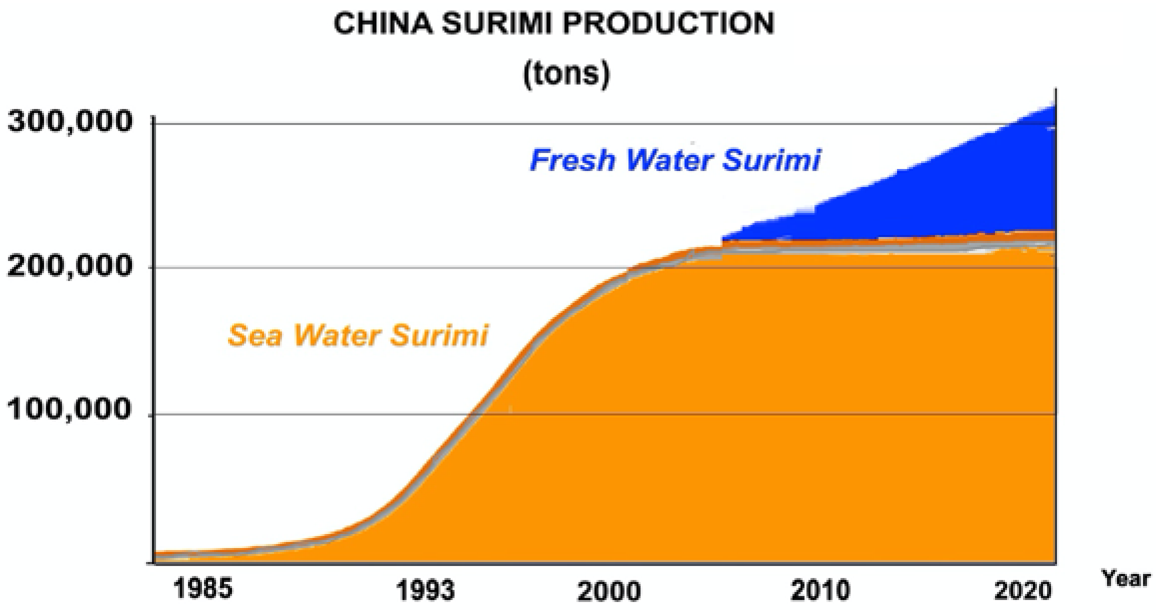



Figure 2.45 – growth in use of freshwater fish for surimi production

The main species of freshwater fish used to process surimi is silver carp. The production was 70,000 tonnes in 2019. By 2012 there were 7 factories processing silver carp surimi in Hubei Province. Silver Carp became a major resource of raw material for surimi production in China. Recently the Province of Jiangxu also started to process silver carp surimi (Figure 2.46).

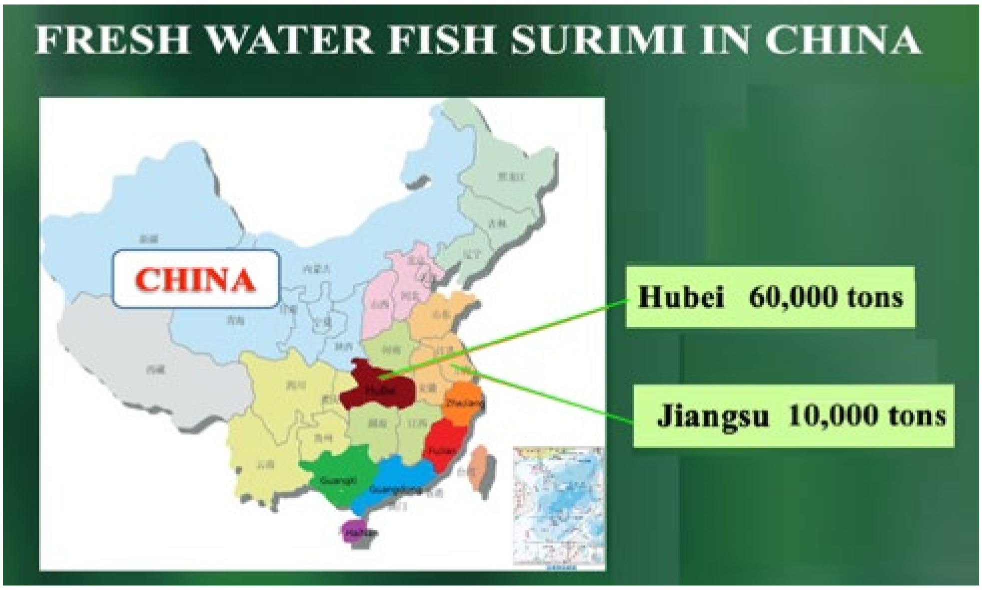



Figure 2.46 - location of main surimi factories using silver carp

The raw material is silver carp of size over 1kg, grown in natural ponds or artificial reservoirs, and usually delivered alive to the surimi factory. The fish is harvested during 2 seasons: November until Chinese New Year and August to October.

If properly processed silver carp may create a surimi of medium to high quality with good deformation and high whiteness and, as such it is used in China as a substitute for itoyori. The cutting yield is around 65% and the surimi yield from fillets is around 50 to 55% giving a final yield of surimi of 30 to 35%. Average yield may reach around 38% to 40% through increasing the surimi moisture to 78%.

### 2.5.9.4 Import and Export of Surimi

China has a had a long history of exporting its surimi to Japan (20,000 tonnes) and Korea (30,000 to 35,000 tonnes) since the beginning of its surimi production. Most of the surimi exported is low grade ribbon fish surimi used for the production of fried fish cakes in Japan and Korea. The surimi is lower value and quality than the product used for China domestic production. Exports of Chinese surimi have decreased from about 70,000 MT in the 2000's and early 2010's to 50,000 tonnes since the mid 2010's (Fig 2.47)

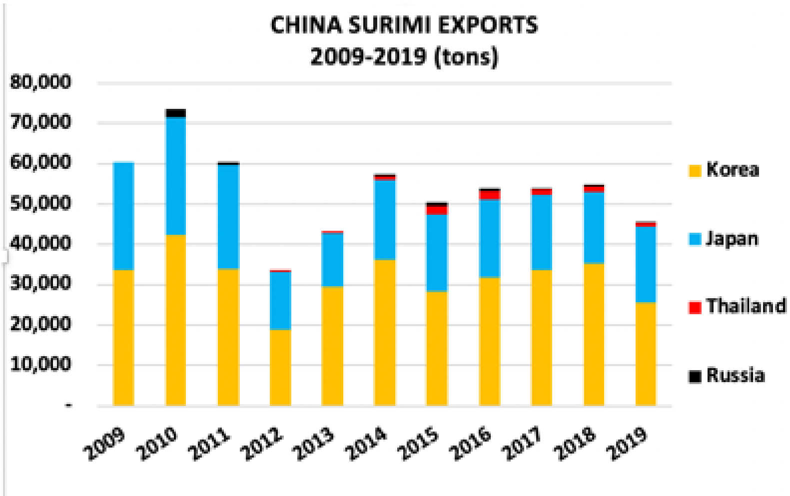



Figure 2.47 – exports of surimi from China

China imports around 25,000-30,000 tonnes of mainly high grade surimi for the production of crabstick and products of high quality, Alaska pollock from the USA (4,000 to 5,000 tonnes), high grade itoyori from India

(2,000-3,000 tonnes) and Indonesia (1,000-2,000 tonnes), and medium grade surimi from Vietnam (15,000 tonnes)(Figure 2.48).


Figure 2.48 Imports of surimi to China

### 2.5.9.5 China Surimi Seafood

The development of the surimi product industry in China started in parallel to the surimi industry in the early 1990's in the southern provinces through the introduction of technology by Taiwanese companies (Longfeng, Haibawang) for the production of fish balls and fish cakes for the domestic market.

The northern provinces started production of crabsticks using Japanese technology either independently or through joint ventures with Japanese (Maruha, etc) and Korean companies (Dongwon, Samho, Daerim) looking for cheap labour. These companies were mostly processing crabsticks and molded products for export markets in the USA, EU and Russia. The location of the larger producers is shown below (Figure 2.49).

| China Surimi Seafood Producers Top 10 | |
|---|---|
| **Company** | **Location** |
| Fujian Anjoy Foods Co., Ltd | Xiamen City, Fujian Province |
| Fujian Haixin Foods Co., Ltd | Fuzhou City, Fujian Province |
| Shandong Huifa Food Co., Ltd | Zhucheng City, Shandong Province |
| Hai Pa Wang Food Co., Ltd | Guangzhou City, Guangdong Province |
| Fujian Shenglong Food Co., Ltd | Zhangzhou City, Fujian Province |
| Fujian Fuhua Food Co., Ltd | Fuqing City, Fujian Province |
| Zhangzhou Xingwei Food Co., Ltd | Zhangzhou City, Fujian Province |
| Fuzhou Baiyang Food Co., Ltd | Fuzhou City, Fujiang Province |
| Guangdong Jinjin Food Co., Ltd | Foshan City, Guangdong Province |
| Dalian Youlian Seafood Co., Ltd | Dalian City, Liaoning Province |
| Guangdong Hoayang Food Co., Ltd | Yangjiang City, Guangdong Province |

Figure 2.49 – location of main surimi seafood producers in China

Surimi products quickly became popular in China and the domestic market soon surpassed the export market which declined as a result of the development of the surimi seafood industry in the main export countries. Around 600 manufacturers were registered by 2005 and the number reached 2,000 by 2010, selling surimi products throughout China. The Chinese market for surimi products had a rapid growth through the 2000's and, by 2010 had reached 1 million tonnes, consuming between 200,000 to 250,000 tonnes of surimi raw material. It is now in the vicinity of 1.5million tonnes (Figure 2.50).

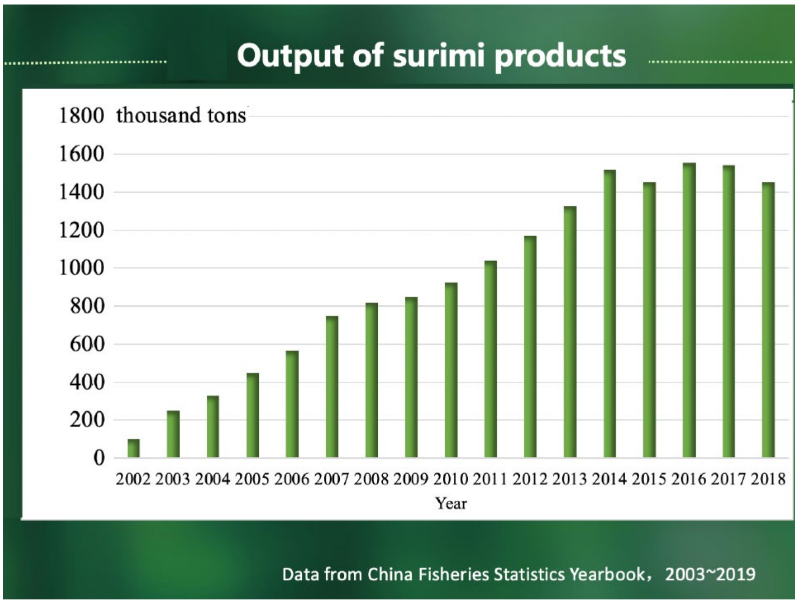



Figure 2.50 – production of surimi seafood products

The market stopped growing in the mid 2010's after facing shortages of raw material, increased labour costs, stricter food safety controls and stricter environmental controls. In addition the industry went through a phase of consolidation. After growing a mass market, the surimi seafood producers look for diversification on the high end of the market. Big companies promote their brand and smaller producers gradually get eliminated.

One difference in the concept of surimi products in China is the fact that surimi is used as an ingredient in a food composition that may include meat and vegetables instead of being a fish product *per se* like in most other markets. As a result the average percentage of surimi in Chinese products is only around 20% while it is over 50% in Japan, 40% in Korea, and 35-40% in Southeast Asia, USA and Europe.

Surimi products are consumed warm in hot pots or as barbecue fast food and the traditional high consumption season is during cold season from October to February. However, this seasonality is decreasing as surimi seafood gradually develops into a daily food item. Moreover, consumption of surimi products is also changing from being a hot pot item to become a product of leisure and multipurpose.


While fish was the backbone of the growth of the surimi seafood market in China in the 2000's and is still the main product in volume, the processors diversified their offer with a large number of new products in the 2010's. The annual report of Anjoy Foods (the largest processor of surimi products in China)(Figure

2.51), for example, shows the trend of the market to higher quality products: increased surimi price (10% in 2 years) and increased percentage of surimi in the final products.

reports, http://www.anjoyfood.com/)

| Year | 2017 | 2018 | 2019 |
|---|---|---|---|
| Price of surimi raw material (CNY/mt) | 11 100 | 11800 | 12300 |
| Raw Surimi (mt) | 38 368 | 53 598 | 78 913 |
| Total production of surimi-based products | 121,300 | 148,303 | 183,592 |
| Ratio of surimi-based products to raw surimi | 3.16 | 2.76 | 2.32 |

CHINA SURIMI SEAFOOD - MARKET TREND

Figure 2.51 – China market trend based on one major company's report

**CHINA SURIMI PRODUCTS**

## 2.6 Import Trends in the Surimi Markets Outside Southeast Asia and China

The import volumes of surimi, Cold Water (Alaska Pollock-Pacific Whiting (CW) and tropical fish (TF) of the main importing countries outside Southeast Asia and China are:

- 230,000 tonnes to Japan including 100,000 tonnes of CW (AP) & 110,000 tonnes TF

- 120,000 tonnes to Korea including 20,000 tonnes of CW (AP) & 100,000 tonnes of TF
- 50,000 tonnes to EU including 45,000 tonnes of CW (AP-PW) & 5,000 tonnes of TF
- 25,000 tonnes to Russia and Belarus including 3,000 tonnes of CW and 22,000 tonnes of TF

These markets appear to be relatively stable with no strong trends exhibited (see Figure 2.52).

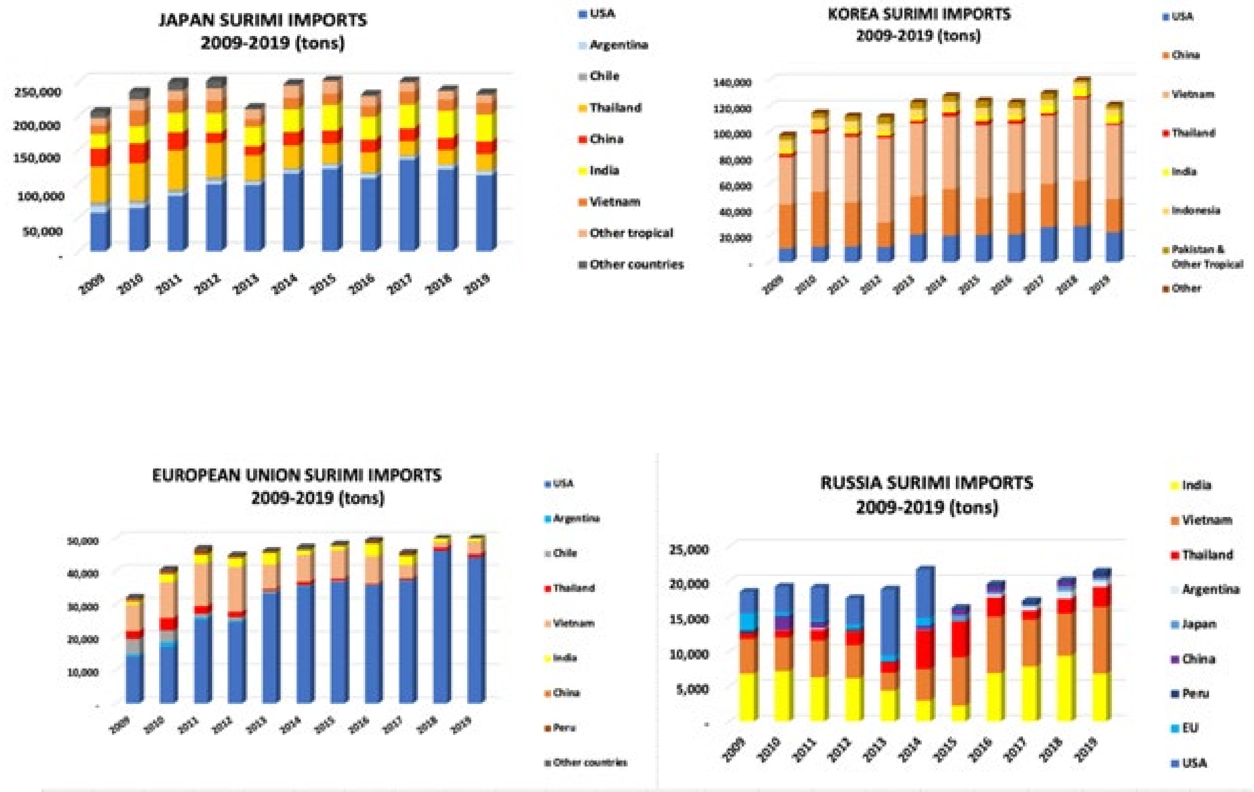



Figure 2.52 – imports for the decade 2009/2019 for the main markets

### 2.6.1 Japan

The Japanese market consumes around 250,000 tonnes of surimi including 200,000 tonnes of high and medium grade surimi and 50,000 tonnes of low grade surimi used for a lower quality of fried fish cakes. Over the past decade, Alaska pollock imports have increased in volume to reach 100,000 tonnes while imports of high grade itoyori imported from Thailand and India decreased as the product was less competitive and not sufficiently attractive compared to pollock.

On the lower end, the 50,000 tonnes of low grade surimi imported by Japan mostly comes from China, India and Vietnam.

### 2.6.2 South Korea

By comparison, South Korea is importing a large volume (around 80 000 tonnes) of low grade surimi primarily from Vietnam and China while India has a smaller share of this market. The high and medium grade surimi used for the production of high quality crabsticks is Alaska pollock (about 20,000 tonnes) with the same amount of itoyori being used for high and medium grade surimi.

### 2.6.3 The European Union

The EU used to share equally its supply of 50,000 tonnes of surimi between American surimi (Alaska pollock and Pacific Whiting) and lower grade surimi, mainly jack mackerel surimi imported from Chile and tropical fish surimi imported from Vietnam, Thailand and India. As a result of decreased Alaska pollock prices following the oversupply crisis of 2012, and the market trend that followed promoting sustainability and restricting the access to non-certified fisheries, Pacific Whiting and low grade pollock surimi replaced the tropical fish surimi while jack mackerel disappeared from the market as Chile stopped production.

### 2.6.4 Russia and East Europe

Russia and Belarus consume around 25,000 tonnes of surimi and used to share the supply between tropical fish and pollock surimi until 2014 when Russia put a ban on imports of American origin. Since then the main supply comes from Vietnam (50%), India (25%) and Thailand (15%) while around 10% of high grade, cold water surimi is imported from Argentina, France and Japan.

## 2.7 – Maintaining production of the surimi industry via adding alternative sources of raw material

It seems logical that the current resources used to process surimi like Alaska pollock, which faces increasing demand for fillets and industrial blocks, and the tropical demersal species such as threadfin breams, decreasing as a result of overfishing, will be reduced over time and reserved to the high end of the surimi market. The consequences of inadequate fisheries management are a concern given trends over time (Figure 2.53)

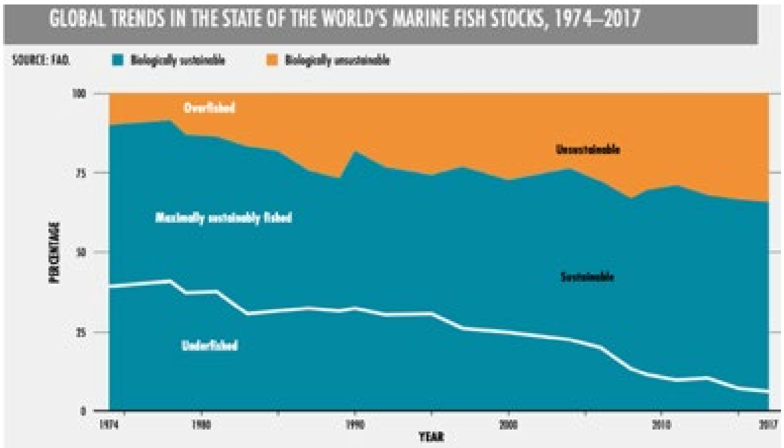



Fig 2.53 – trends in status of global fish resources

However, the surimi and surimi seafood industries may not face a problem of supply thanks to changes in the fish resources used to process surimi.

There are four alternative resources identified that could replace the decrease of the current resource of fish used in surimi production:

- by-catch from fisheries
- by-products from the filleting industry
- forage fish, mostly pelagics, currently used for fish meal
- fresh water fish from aquaculture

### 2.7.1 By-Catch from Fisheries

This was the base material used by the tropical fish surimi industry in the beginning of this industry in Southeast Asia but over time the demersal species became a target fishery. In other regions of the world, the by-catch which is currently discarded may be used as it was the case in Asia. Changes to the laws in the European fisheries that prohibits the discarding of the non-commercial and over quota catches may have resulted in the landing of sufficient volumes of fish that can be converted into fresh fish mince or into surimi. Since the mechanization of the cutting step will be difficult if not impossible, the raw material has to be cheap and available in sufficient quantity. The implementation of the new regulation and the difference in profitability between the production of fish meal and the production of surimi will determine the economic viability of the surimi production from this raw material.

### 2.7.2 By-Products of the white fish filleting industry

The by-products of the white fish industry is another potential resource for white fish surimi. This resource already represents 30 or 40% of the production of pollock surimi and it is likely that this percentage will increase as the global demand for white fish fillets keeps increasing.

The use of the by-products from the aquaculture filleting industry (like pangas in Vietnam) is another potential resource. While around 35% of the fish is used for fillets, the by-product from filleting may result in production of 15% surimi and 35% of fish meal and fish oil to be used by the feed industry.

### 2.7.3 Small pelagic fish

Small pelagic fish like scads, mackerels and sardines used in fish meal production is another potential resource for producing surimi. This surimi is suitable for fried products and it can be combined with white surimi from farmed or marine white fish to process products acceptable both in terms of quality and cost to meet the demand of most surimi seafood markets for affordable products. The technology has been developed to use these resources and obtain good quality surimi (Surimi Tech, 2020).

While these changes in the raw material supply are not a problem for consumers in the growing markets of Southeast Asia or in China, the prejudice of the surimi seafood industry against pelagic species and the resistance from the markets in developed countries like Japan, the EU or the US to these changes in the formulations, are also obstacles for this evolution of the industry.

Over time pelagic species have tended to replace the demersal fish traditionally used for surimi processing in some overfished fisheries of Southeast Asia. Some resources of small pelagics are known to be in good shape but there is considerable uncertainty, largely due to a lack of any information, in Asia in particular. The catches include various kinds of mackerels, scads, anchovies and sardines.

One issue for the Southeast Asia surimi industry may be that the catch of these pelagic species is largely the result of a mixed fishery and/or a seasonal catch. However, this is no different from the demersal species and almost all fish have some seasonal variability. The stocks of most small pelagic species fluctuate quite widely which will affect production planning and the lack of good fisheries management in Asia will always be a source of uncertainty. This is changing in Thailand but remains a major issue almost everywhere else.

As a consequence, while the surimi derived from these mixed species is suitable for the Asian markets, it does not respond to the demand of the western surimi seafood industry for a stable supply of single species surimi that can respond to the question of traceability.

### 2.7.4 Fresh Water Aquaculture

One response to the decreasing availability of white fish to process surimi is the use of farmed fresh water species as is already occurring, especially in China. The main freshwater fish species include many species of carp, but also tilapia and catfish. In total the 50 million tonnes of freshwater fish are harvested every year (see Figure 2.54) and thus there is potential for use in surimi production.

| Main Fish Species fresh water aquaculture | 2010 | 2012 | 2014 | 2016 | 2018 | 2018 share |
|---|---|---|---|---|---|---|
| | | | (thousand tonnes) | | | (percentage) |
| Grass carp, *Ctenopharyngodon idellus* | 4 213.1 | 4 590.9 | 5 039.8 | 5 444.5 | 5 704.0 | 10.5 |
| Silver carp, *Hypophthalmichthys molitrix* | 3 972.0 | 3 863.8 | 4 575.4 | 4 717.0 | 4 788.5 | 8.8 |
| Nile tilapia, *Oreochromis niloticus* | 2 657.7 | 3 342.2 | 3 758.4 | 4 165.0 | 4 525.4 | 8.3 |
| Common carp, *Cyprinus carpio* | 3 331.0 | 3 493.9 | 3 866.3 | 4 054.7 | 4 189.5 | 7.7 |
| Bighead carp, *Hypophthalmichthys nobilis* | 2 496.9 | 2 646.4 | 2 957.6 | 3 161.5 | 3 143.7 | 5.8 |
| Catla, *Catla catla* | 2 526.4 | 2 260.6 | 2 269.4 | 2 509.4 | 3 041.3 | 5.6 |
| Crucian Carp *Carassius spp.* | 2 137.8 | 2 232.6 | 2 511.9 | 2 726.7 | 2 772.3 | 5.1 |
| Freshwater fishes nei Osteichthyes | 1 355.9 | 1 857.4 | 1 983.5 | 2 582.0 | 2 545.1 | 4.7 |
| Striped catfish, *Pangasianodon hypophthalmus* | 1 749.4 | 1 985.4 | 2 036.8 | 2 191.7 | 2 359.5 | 4.3 |
| Roho labeo, *Labeo rohita* | 1 133.2 | 1 566.0 | 1 670.2 | 1 842.7 | 2 016.8 | 3.7 |
| Milkfish, *Chanos chanos* | 808.6 | 943.3 | 1 041.4 | 1 194.8 | 1 327.2 | 2.4 |
| Torpedo-shaped catfishes nei, *Clarias spp.* | 343.3 | 540.8 | 867.0 | 961.7 | 1 245.3 | 2.3 |
| Tilapias nei, *Oreochromis (=Tilapia) spp.* | 472.5 | 693.4 | 960.8 | 972.6 | 1 030.0 | 1.9 |
| Wuchang bream, *Megalobrama amblycephala* | 629.2 | 642.8 | 710.3 | 858.4 | 783.5 | 1.4 |
| Black carp, *Mylopharyngodon piceus* | 409.5 | 450.9 | 505.7 | 680.0 | 691.5 | 1.3 |
| Cyprinids nei, Cyprinidae | 639.8 | 601.1 | 628.0 | 596.1 | 654.1 | 1.2 |
| Yellow catfish, *Pelteobagrus fulvidraco* | 177.8 | 233.7 | 302.7 | 434.4 | 509.6 | 0.9 |
| **total** | **37 745.1** | **42 338.2** | **47 219.1** | **51 078.0** | **54 279.0** | **100** |

Figure 2.54 – growth in global production from freshwater aquaculture by major species

While there has been tentative moves in the past decade to process surimi from pangas filleting by-products and a number of marine fish surimi factories in the Mekong Delta have been using pangas in mixed fish surimi production, it is only in 2020 that this industry really picked-up with 3 new factories specializing in this production.  The production and sales were quite successful since the export volume reached over 1,000 tonnes/month in the first half of 2020.

Nevertheless, one issue seems to remain which is the acceptance by the market for aquaculture fish in surimi products. Only around 10% of the production is labeled as pangas surimi and even though the production is exported quasi-exclusively to China, it is often labeled as “mixed fish” or “itoyori mix” surimi. There is likely an image issue which needs to be addressed such that potentially sustainable farmed sources of raw material can find wider market acceptance.

This transition could be one way for the Southeast Asia countries to adopt more effective conservation policies for the fishery resources without having much impact on the employment and the social and economic consequences of reducing the fishing effort in the catch fisheries. The Asian countries, including all the major surimi producers, which harbor over 90% of the fresh water aquaculture fisheries, are particularly well prepared for this transition.

It may well be that the ultimate sustainable source of raw material is the non-fed freshwater aquaculture which represents the major portion of world aquaculture production but these production systems are usually dispersed geographically.  The development of smaller size surimi factories may be the appropriate response to this problem and since these fisheries are often located in underdeveloped areas, if properly designed, it would have a positive social and economic impact while preserving the environment and as such become the ultimate sustainable resource for the surimi industry.

**AQUACULTURE FISH PRODUCTION IN CHINA & SOUTHEAST ASIA**
**(in thousand tons and % of global production)**

| countries | 1995 | 2000 | 2005 | 2010 | 2015 | 2018 |
|---|---|---|---|---|---|---|
| Asia | 21 677.1 | 28 420.6 | 39 185.9 | 51 228.8 | 64 591.8 | 72 812.2 |
| | (88.90%) | (87.67%) | (88.46%) | (88.72%) | (88.76%) | (88.69%) |
| China | 15 855.7 | 21 522.1 | 28 120.7 | 35 513.4 | 43 748.2 | 47 559.1 |
| | (65.03%) | (66.39%) | (63.48%) | (61.50%) | (60.12%) | (57.93%) |
| India | 1 658.8 | 1 942.5 | 2 967.4 | 3 785.8 | 5 260.0 | 7 066.0 |
| | (6.80%) | (5.99%) | (6.70%) | (6.56%) | (7.23%) | (8.61%) |
| Indonesia | 641.1 | 788.5 | 1 197.1 | 2 304.8 | 4 342.5 | 5 426.9 |
| | (2.63%) | (2.43%) | (2.70%) | (3.99%) | (5.97%) | (6.61%) |
| Viet Nam | 381.1 | 498.5 | 1 437.3 | 2 683.1 | 3 462.4 | 4 134.0 |
| | (1.56%) | (1.54%) | (3.24%) | (4.65%) | (4.76%) | (5.04%) |
| Bangladesh | 317.1 | 657.1 | 882.1 | 1 308.5 | 2 060.4 | 2 405.4 |
| | (1.30%) | (2.03%) | (1.99%) | (2.27%) | (2.83%) | (2.93%) |
| Rest of Asia | 2 823.4 | 3 011.8 | 4 581.4 | 5 633.1 | 5 718.4 | 6 220.7 |
| | (11.58%) | (9.29%) | (10.34%) | (9.76%) | (7.86%) | (7.58%) |

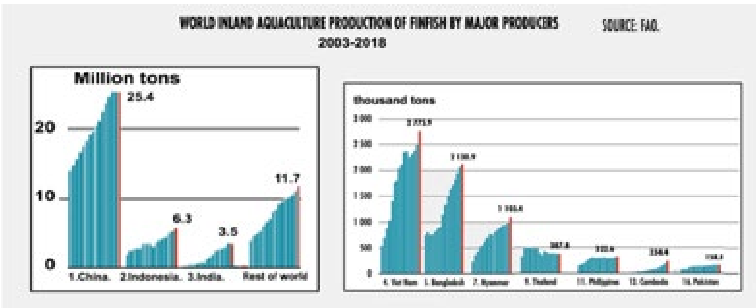


Figure 2.55 Main country sources of freshwater aquaculture

Nevertheless, communication will be necessary to address the resistance of the importing countries to this change as well as regulatory systems that tends to restrict the access to the market for surimi from aquaculture and mixed fish species.

**2.8 Links between the surimi industry and other fishery products**

Rarely is the full catch from any fishery directed to one market and one product. This is increasingly the case with the development of new products and an increasing drive for extracting value from scarce resources and reducing wastage. Investments in biotech for example, are increasingly finding usages for fish processing byproducts. One example is chitosan from crab shells which is showing promising value in the fight against certain cancers.

Fish directed to the production of surimi is generally a very variable proportion of the overall catch which varies from species to species and fishery to fishery. Price is a big determinant of the disposition of the catch but so too is the type of species involved (some make better quality surimi than others), the availability of processing facilities (and any government controls on imports and exports of fish) and availability of supplies, amongst others. Due to the relatively higher price, the catches of high volume groundfish such as Alaska pollock, hoki, whiting and hake is generally directed to the frozen fish market where there is either simple processing (e.g. filleting) or value added (e.g. coatings) and fish for surimi is a secondary market. Wastes from the processing are commonly sent to fish meal plants (including onboard processing aboard factory trawlers). The fish meal sector also takes wastes from the surimi processing plants as well. With a few exceptions, such as northern blue whiting, there is little whole fish sent for fishmeal.

For the tropical fisheries the situation is more complex. Figure 2.56 below shows a generic map of catch disposition for many of the trawl fisheries. The volumes going to each sector will vary. Moreover, there may be short term variations. For example, fish normally destined for surimi may go to fishmeal if either surplus to requirements or the quality is poor. By and large, fish for fishmeal is the market of last resort due to the low price.

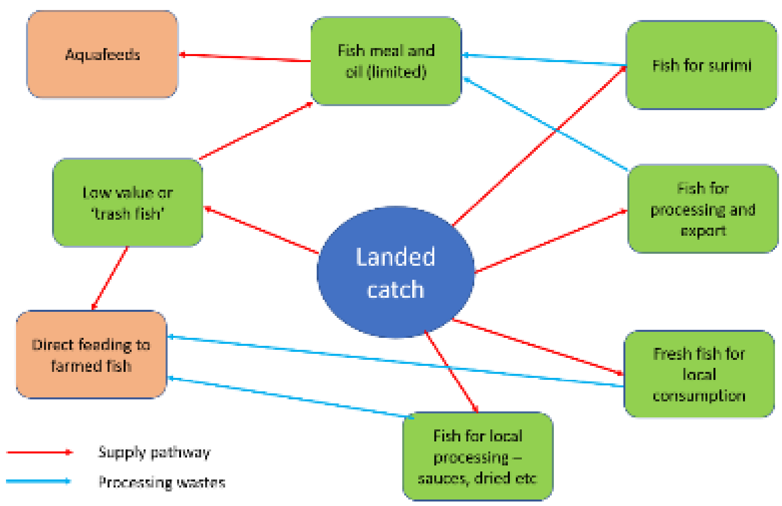



Figure 2.56 Relationship between surimi sector and other seafood sectors

There appears to be little discarding in the tropical fisheries (although there is a dearth of onboard observer studies to verify this view) and part of the reason is the view amongst developing countries that discarding wastes valuable protein. Moreover, the low cost structure means that even small volumes of processing wastes can be put to beneficial use. Photographs 1 and 2 below were taken at a landing site in north Java, Indonesia where small volumes of fish were being manually processed prior to the wastes being sent to fish farms and the bodies for either surimi or fish cracker production. Fish for human consumption are diverse and may include processed or fresh fish (Photos 3 and 4).

Photo 1 -Threadfin bream wastes ready for sale to farms

Photo 2 Lizardfish wastes for sale to fish farms – fish fillets for fish crackers, rest for fish feed

Photo 3 Dried ponyfish for local consumption – Vietnam

Photo 4 Snappers/groupers for local consumption, Vietnam

The tropical trawl fisheries, in particular, have some attributes which increase the diversity of supplies and potential markets, as follows:

- Although trawls are commonly used for cold/temperate water groundfish, their configuration can be optimized for a single species with mesh sizes designed to let juvenile fish through, based on the size and shape of the fish. In tropical fisheries with a huge variety of species of different shapes and of different sizes when they reach sexual maturity, there is no net configuration that protects all species although there are optimum mesh sizes (which are generally larger than currently used).
- There is a much wider variety of usages of the catch that is not necessarily related to species diversity. Fish for drying, salting and for smoking, as well as for making fish sauces and fermented products are in local demand based on cultural traditions. This not only provides options for fishermen selling their catches but may be competition for fish that could be used for surimi. This is especially the case as fish get smaller.

- There is much more demand for restaurant quality fish from the tropical fisheries than there is for many of the groundfish fisheries where species such as Alaska pollock and whitings are not regarded as high quality table fish. For the tropical fisheries species such as groupers, snappers and pomfrets are highly valued and this is increasingly the case for some threadfin breams as scarcity becomes more of an issue.
- The creation of the tropical surimi industry added value to a component of the catch that once went to fishmeal. For example, in the early days of the development of the trawl fishery in Thailand a relatively large proportion of the catch (>40%) went to the fishmeal plants as there was no interest from other markets. This resulted in the fish being poorly handled by the fishermen, which meant that even the quality of the fishmeal was poor (as the fish were largely rotten). Processing wastes from the surimi sector provides better quality material for fishmeal as the fish have been kept on ice prior to processing. Thus, the surimi industry resulted in quality improvements but overfishing and the declining size of fish is putting these gains at risk.
- Fish that are for fishmeal continue to be poorly treated (in general), in part because poor fisheries management and declining profits in the fishing sector means that investments in refrigeration onboard vessels are not possible for what remains a low value product. The reform process needed to improve fish stocks would also benefit all the user sectors in terms of availability, size and quality of fish.

**2.8.1. Nature of supply chains also influences market use**

In some countries, the catch from the trawlers is auctioned in the ports with informal commitments agreed from time to time by the brokers with the fishing fleets and the factories. The brokers regulate and control the market but ultimately adjustment comes the market and the cost of fishing. In the case of Vietnam, the development of the fisheries in the 2000’s, and multiplication of surimi factories resulted in overcapacity. In this situation, the competition between factories determines a price for the fish compatible with the surimi market while the cost of fishing will result in adjustment in the amount of landings. In Thailand, by contrast the fishmeal industry developed (1970’s) after the trawl sector was developed for the purpose of catching shrimp and fish (1960’s) and then the surimi industry was developed in the 1980’s (Figure X).

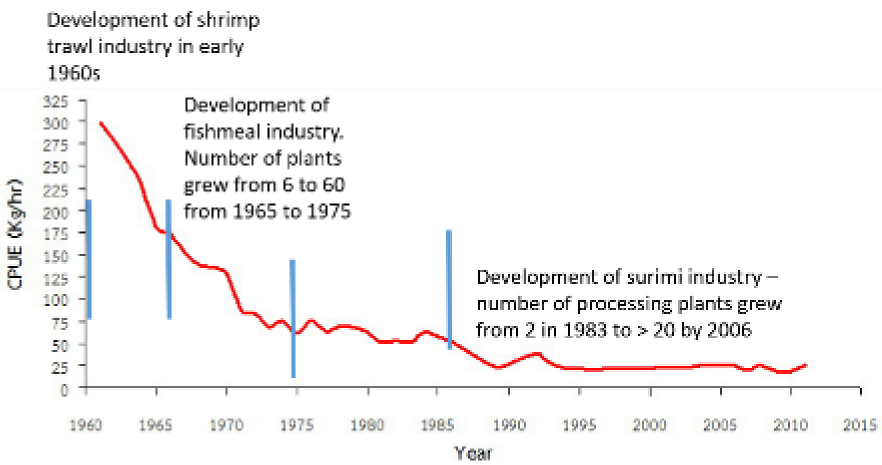


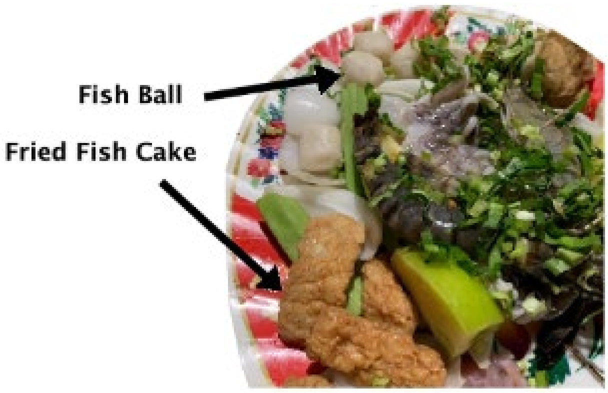

Figure 2.57 – sequential development of the food fish fishmeal and surimi sectors in Thailand compared to Catch Per Unit Effort

In terms of prices the surimi industry sits between the fresh fish market and the fish meal market. In Vietnam for example, the surimi industry competes on the high end with the fresh fish market, the artisanal processors of fresh fish mince (otoshimi used for fish ball and local fish food) and the dried fish producers and on the low end with the fish meal industry.

The demand from the different markets usually results in a clear segmentation of the resource between the different markets but the frontiers move over time as a result of changes in the demand of the different markets, the volume of landings and the cost of fishing.  Some changes in the segmentation of the disposition of the catch are progressive and respond to long term trends but there may be sudden changes in response to the markets.

The increasing demand for fish by the domestic fresh fish markets is one long term trend in the Southeast Asian markets.  As the population grows in most of the countries involved in the tropical fisheries, the volume of fish used by the fresh fish market keeps increasing over time but the size of fish tends to decrease if the bigger sizes are not sufficient to supply the market.

While the demand for frozen fish was mostly driven by the developed countries in the 1990's and 2000's, the demand from Asia for frozen fish, particularly from China, increased in late 2010's and this also had some impact on the disposition of the catch in Vietnam and India, fish of size 100g+ (mackerel, scad) and 50g+ for white fish like threadfin bream.




VIETNAMESE HOT POT IN SADEC
(Dong Thap Province, Vietnam)

The restaurants in Southeast Asia increasingly use fish to process fresh fish mince (otoshimi) used for local specialties (ex Vietnam).  As such what was once considered as "trash fish" has a valuable resource of the tropical fisheries.

In most of the countries that started surimi production, the product was exported overseas but it has also led to the development of a surimi products industry in a number of countries first for export but later or simultaneously for consumption in the domestic market: this has been the case of Thailand, Malaysia and China.

While Vietnam, Indonesia and Malaysia have not developed a large surimi seafood industry oriented to the export markets, surimi has been used for local specialties.  Malaysia and Indonesia have developed a large industry for fish balls and fish cakes.  Thailand processors also developed dried surimi-based product analogues of cuttlefish using surimi.

Although the surimi industry usually first targets to produce high grade surimi for export, most of the countries have benefited from using surimi as raw material in the production of fish products for the domestic market.

### 2.8.2 The relationship with the fish meal industry

The surimi sector is associated with the fishmeal sector in two ways. Both sectors are generally supplied by the same types of fisheries and, as mentioned above there will be price competition for the species of interest to the surimi sector. In addition, the processing of fish for surimi results in the generation of by-products which are a valuable feedstock for the fish meal sector, particularly given the fact that, in comparison to 'trash fish' the fish used for surimi are handled to the same quality as fresh fish and thus the wastes make better quality fishmeal. This better quality may offset the lower protein content due to the fact that the muscle tissue has been removed for surimi.

The growth of aquaculture has resulted in increased demand for fishmeal although prior to this, bycatch and small fish found a ready market for animal feed.  Indeed, trawl bycatch is still commonly called 'duckfish' in some areas. In some countries the development of the surimi industry and been a large contributor to the development of the fishery and as such, directly and indirectly a contributor to the development of the fish meal industry even though it is using 50% of the "trash Fish". Depending on country, there is also a considerable demand for processing wastes and 'trash' (low value) fish for direct use in aqua feeds. In Indonesia, for example, a large contributor to the production of farmed fish is the small scale sector which farms carp and catfish species. Home made feeds (pakan mandiri) are common and the fish component, which can be relatively high, is derived from the not only the same fisheries that supply surimi fish (i.e. Danish Seine – known locally as cantrang or dogol) but also a myriad other fishing gears.

In this sense, the surimi industry, fish meal and aquaculture has been a winning combination for the growth of countries like Thailand, Vietnam, India and Indonesia, although this period is coming to an end due to overfishing which is reducing the availability of fish, decreasing fish sizes and fueling illegal activity. The combination of a canning industry with surimi and fish meal is another option that maximizes the revenues from pelagic catch.

### 2.8.3 By-products from the fisheries and the fish processing industry as sources of raw material for surimi

Globally, the amount of fishmeal derived from processing wastes is estimated to be about 30% (https://www.iffo.com/byproduct). Vietnam, China and Thailand are amongst the world's ten largest producers of fish meal (Figure X, extracted from IFFO 2017 – Statistical Yearbook). This Yearbook does not distinguish between meal made from wholefish or processing wastes. Moreover, as it focuses on fishmeal it does not cover the widespread use of whole fish for direct feeding or the local manufacturing of farm based feeds (known as pakan mandiri in Indonesia, for example).

For Thailand the breakdown is:

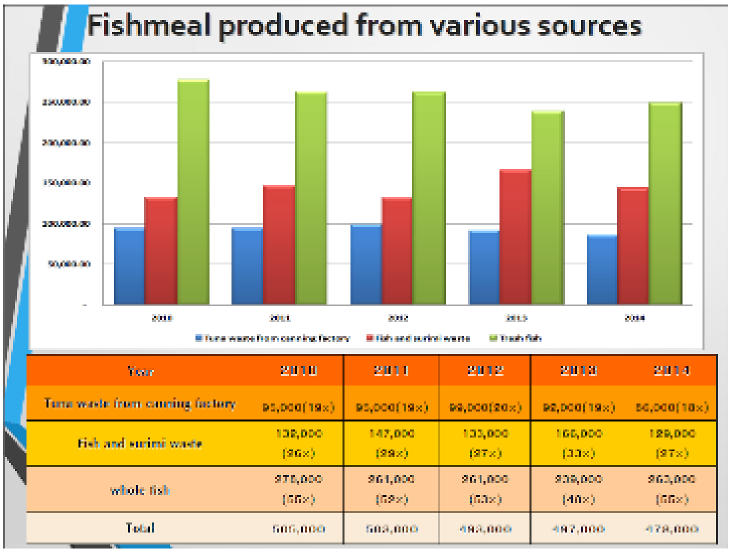



Figure 2.58. Source of fishmeal in Thailand 2010-2014. Source: Thai Fishmeal Producers Association

Thus, fish (non tuna) processing wastes account for over a quarter of the fishmeal produced in Thailand. Non-tuna sources include canning of small pelagics (e.g. sardines), processing of frozen fish and surimi. Over the period 2000 to 2014 the percentage (and amount) of low value fish sent directly to fishmeal in Thailand has declined from about 45% to 15% which strongly suggests that fish are being better handled and going to higher value uses (Leadbitter, 2019).

Considering the conversion ratio of fish to surimi, which is probably in the range of 35% (but up to 50%), the largest processors – Vietnam and China – also having the highest yield, this production corresponds to approximately 2 million tons of fish and, since the surimi industry generates around 40-50% of by products (heads, viscera, skin, bones …), the fish meal resulting from the surimi production is around 200,000 tons.

Fisheries and aquaculture generate a large volume of by-products leading to the production of waste that may cause environmental problems while a large volume has the potential to be utilized for animal feed or human consumption products. The valorization of the by-products is also the means to improve the profitability of the fisheries and the fish processing industries. However, most fish processors have limited knowledge regarding the technologies used to process the by-products and markets for these products, and need support of technology, human resources and financial resources

Another source of raw material is the surplus of the fisheries during high catching seasons that cannot be absorbed by the fresh market or the industry that would normally process this fish. Left-overs from the fresh fish markets is another resource that can be used to process surimi for factories located close the area who can collect this fish for surimi processing. Aquaculture also generates small volumes of fish out the range of commercial size that can be used to process surimi.

By-products from the fish processing industry that can be used to process surimi includes the frames (fish bones and meat) resulting from filleting the fish that may include 50 to 70% of meat, the trimmings, the tail or body portion resulting from fish cutting in the canning industry and the skin in case of deep skinning. Another source of by-product in the surimi industry itself is the small fragments of meat and the soluble protein lost in the process water. Technologies have been developed that allow to recover the fish protein in all these fractions and Surimi Tech has been a precurser in developing these technologies.

The by-products from the fisheries and the fish processing industry have been used directly as fish feed or animal feed, cooked and dried to process fish meal and fermented to process silage or fertilizers. Other possible usages includes fermentation to process fish sauce and hydrolysis to process fish peptides and collagen.

# Chapter 3 Tropical surimi – fish and fisheries

As stated by Park (2005) any fish (and some shellfish such as cuttlefishes) can be used to make surimi and this makes for a great deal of flexibility which is a benefit when dealing with tropical species as many are available in relatively small volumes (as compared to species like Alaska pollock).

As will be demonstrated below we have found over 120 species having been used in tropical surimi. Many of these have been documented in peer reviewed research papers using DNA. We are aware of some of the limitations of using DNA but it remains a significant source of information as the level of species identification at the factory level is low.

In terms of the fisheries we have not gone back to specific fisheries (as defined by gear type and jurisdiction) as there are likely to be too many. We have simply focused on the main gear types (generally trawls) and, where there is easily accessible information, the main fishing grounds. To document the sources of raw material for any given surimi plants would require a much more thorough examination than we have been able to do.

## 3.1 What do we mean by tropical

With the exception of China all the countries we focus on in this report are solely located between the tropics of Cancer and Capricorn and are thus considered to be tropical. China straddles the Tropic of Cancer and the southern half of the country is bathed by warm waters sourced from the South China Sea thus many fish species have tropical affinities.

There are some families of fish that are characteristic of tropical surimi, notably the lizardfishes (Synodontidae), threadfin breams (Nemipteridae), bigeye snappers (Priacanthidae), croakers/drums (Sciaenidae) and the goatfishes (Mullidae). These families of fish are not confined to the tropics but they may be more species rich or abundant in tropical waters.

With the increasing use of aquaculture sourced fish for surimi there may be fish that are grown in areas outside of their natural range and thus the distinction between tropical and other species is becoming increasingly blurred.

Whilst some invertebrates such as squids are used for the production of surimi the species we have found records for are largely confined to colder waters. There may be some localized production, for example for the production of cuttlefish balls which are a popular food item in some Asian countries.

## 3.2 Location of fisheries

Almost all of the world's tropical surimi is produced in Asia, from Pakistan east to China. There two small production facilities in Central America (Mexico and Suriname), both of which use croakers as raw material)(Park pers comm, Guenneugues pers comm, August 2020). The Clupeid *Dorosoma pretense* (threadfin shad), which is found in the Gulf of Mexico and Central America, has been detected in a surimi product (Giusti et al 2017).

Despite some attempts to establish production plants in Africa, non have been successful to date, although African species, notably several species of tilapias and the North African catfish (see below) have been detected in surimi products (Sultana et al 2018, Galal-Khalaff et al 2016). However, given that some of these species (especially *Oreochromis niloticus*) are widely cultured throughout the world their presence in surimi does not necessarily confirm an African origin.

## 3.3 Production systems – farmed and wild

Out of the approximately 630 000t of tropical surimi produced in 2019 an estimated 70 000 tonnes is comprised of silver carp (*Hypophthalmichthys molitrix*) farmed in China. This is the largest known source of farmed fish used. At least one China based company (http://longshengsurimi.com/En/About.Asp) advertises the use of big headed carp (H*ypophthalmichthys nobilis*) as a raw material but volumes are likely small as this species is more typically used in food service due to its relatively high price (Joe@ Future Foods pers. Comm.).

There is a growing interest in the use of farmed catfish such as tra (Family Pangasiidae *Pangasianodon hypophthalmus* - Striped catfish) from countries such as Vietnam. Interestingly, in Hong Kong, one sustainable seafood restaurant is promoting the use of Pangasius for the production of fish balls as previously abundant species such as lizardfish (*Saurida tumbil*) and the golden threadfin bream (*Nemipterus virgatus*), have declined in availability (https://www.chooserighttoday.org/5695/).

Other cultured species that have been found in surimi include:

- Family Cichlidae *Oreochromis niloticus* Nile tilapia (Sultana et al 2018)
- Family Cichlidae *Oreochromis aureus* Blue tilapia (Sultana et al 2018)
- Family Cichlidae *Oreochromis mossambicus* Mozambique tilapia Galal-Khalaff et al 2016

Note that there is such a wide variety of freshwater species cultured, especially in Asia, that it may be difficult to allocate a species to being wild caught or farmed but, given the relatively small yields from freshwater wild fisheries, its likely that many are farmed.

Milkfish (Family Chanidae - *Chanos chanos*) is an abundant species in Asia which is extensively cultivated but may also support wild capture fisheries. It can be grown in freshwater and brackish water. Whilst it does not seem to be widely used in industrial surimi it is used in locally made fish balls in the Philippines (ref)

## 3.4 Broad scale habitats – marine/freshwater

The production of surimi is largely dependent on wild caught marine fish. Our literature search has documented 123 species of fish used for surimi of which 105 are marine.

The families and species of fish which are found in freshwater include:

- Family Bagridae *Mystus gulio* Long whiskered catfish Sultana et al 2018
- Family Bagridae *Hemibagrus nemurus* Asian red tailed carp Sultana et al 2018. Note that this species may be either wild caught or farmed (Irin et al 2019).
- Family Cichlidae *Etroplus maculatus* Orange Chromide Giusti et al 2017
- Family Cichlidae *Paretroplus maculatus* Giusti et al 2017 (note that this species is listed as IUCN Critically Endangered)
- Family Clariidae *Clarius gariepinus* North African catfish Sultana et al 2018
- Family Cyprinidae *Cyprinus pellegrini* Barbless carp Sultana et al 2018
- Family Notopteridae *Chitara ornate* Clown featherback Park 2013
- Family Notopteridae *Notopterus notopterus* Bronze featherback Park 2013, may be farmed.
- Family Osphoronemidae Trichopodus leeri Pearl gourami Giusti et al 2017
- Family Mastacembelidae *Mastacembelus unicolour*, and probably *M. erythrotaenia*, - two species of freshwater spiny eels (Sultana et al 2018)

For the marine species a more detailed analysis about the species taken is found below;

## 3.5 Broad scale habitats - pelagic/demersal

For the marine species, these can be found in a wide variety of habitats, which has implications for the types of fishing gear used and the potential impacts. In a broad sense both pelagic (mid and surface water dwelling) and demersal (seabed dwelling) species are used.

## 3.6 Known marine species used for tropical surimi

3.6.1 Pelagic species

- Carangidae (jacks, scads etc) – 5 species
- Clupeidae (sardines etc) – 4 species
- Coryphaenidae – 1 species (mahi mahi)
- Engraulidae (anchovies) – 1 species
- Exocoetidae (flying fishes) – 1 species
- Prisitigasteridae (herrings) – 2 species
- Sphyraenidae (barracudas) – 2 species (and likely 4)
- Trichiuridae (hairtails) 3 species
- Chirocentridae (wolf herrings) – 1 species

3.6.2 Demersal species

- Balistidae (triggerfishes) – 1 species
- Caesionidae  (fusiliers) – 3 species
- Cynoglossidae (tongue soles) – 1 species
- Gerreidae (biddies) – 1 species
- Haemulidae (grunts) – 1 species
- Leiognathidae (ponyfishes) - 2 species
- Lutjanidae (snappers) – 3 species
- Monacanthidae (leatherjackets) – 2 species
- Mullidae (goatfishes) – 4 species
- Nemipteridae (threadfin breams) – 16 species (including one species of Scolopsis)
- Muraenesocidae (conger eels) – 2 species
- Pomacentridae (damsel fishes) – 1 species
- Priacanthidae (bigeyes) – 3 species
- Rhinobatidae (shovelnose rays) – 1 species
- Sciaenidae  (croakers/drums) – 9 species
- Scombridae (mackerels) – 2 species
- Serranidae (groupers) – 1 species
- Sillaginidae (sillagos) – 1 species
- Sparidae (porgies, sea breams) – 3
- Synodontidae (lizardfishes) – 5 species
- Triglidae (sea robins) – 3 species

In addition the following families are mentioned with no specific species

- Carcharinidae – sharks (but see link below which references blue sharks – *Prionace glauca*)
- Polynemidae – threadfins
- Siganidae - rabbitfishes

With regards to sharks there are some particular dishes in Japan that utilise surimi made from shark (https://www.nikkama.jp/wp-content/uploads/kamaboko-E.pdf)

## 3.7 Species – finfish, invertebrates

Understanding exactly what species are being used is complicated by a number of factors, not the least of which is that the factory owners commonly do not keep records of what they buy beyond trade names. We have used Fishbase.org as the source of the names listed in the database as it reconciles old scientific names and also has a repository of local names in many cases. Some species found in the literature have been reclassified and their 'disappearance' may simply be due to a change of taxonomic status.

### 3.7.1 Trade names

The trade names in use are largely linked to the market names used in Japan

- Itoyori – threadfin breams
- Eso - lizardfishes
- Hamo – pike conger eels
- Klathi – leatherjackets
- Hamasu – barracudas
- Tachio – hairtails
- Himeji – goatfishes
- Guchi – croakers (Yellow croaker - Kiguchi / White croaker - shiroguchi)
- Kinmedai/kintokidai – bigeye snappers
- Renkodai/Hirekodai – porgies
- Houbou – red gurnard
- Kurosagi – silver biddies
- Mamakiri – sardinellas

Source: Ji C-L (2012)

### 3.7.2 Fish names and catch reporting

As is the case with fish supplied for direct human food the reporting of species is subject to a variety of distortions for quite practical reasons, for example:

1. The reporting of landings can be subject to aggregation at the port of landing – for example, enumerators may be instructed to lump certain groups of species together for reporting purposes;
2. Fisher logbooks may not require species level detail. Fisher log books commonly have variable levels of accuracy even in the absence of high species diversity. This is not a situation restricted to developing countries.
3. Landings data, even if collected at relatively fine levels of resolution, may be aggregated for reporting purposes. India, for example, collects detailed data but publicly available reports are highly aggregated (and even more so for reports to FAO). The detailed information is available, at a cost.

The rationale for the aggregation is understandable given the huge range of species taken in many tropical fisheries, especially trawl fisheries. However, the rationale for some of the groupings may not be clear and they can range in scope from a few species within a genus up to several hundred within a category (e.g. the term 'trashfish' may apply to hundreds of species). Whilst its true that many species may only be taken in very small numbers, it is not uncommon for the overall species count to top 400. Similar fisheries in developed countries such as Australia do not regularly report all species taken and this is especially the case where discarding is common (more so in western fisheries than in Asian fisheries).

3.7.3 Local names

We do not propose to list the local names here as the project covers seven different countries with a number of major language groups. However, it is important to know that:

1. The same name can be used for a number of different, but generally related species. For example, the Indonesian name Alu-alu applies to all species of barracudas, the name kuro applies mainly to threadfins (Family Polynemidae) but also to the porgy *Evynnis cardinalis* (Family Sparidae) and gulamah applies to a variety of croakers (see White et al 2013 for an excellent compendium of Indonesian fish names). Note that the threadfins (Polynemidae) are a different family of fish to the threadfin breams (Nemipteridae).
2. The local name of the fish may change from place to place within a country. This is not uncommon, and not just in Asia.

## 3.8 DNA testing

Many of the fish names (Genus and species) we have documented have been sourced from DNA studies. By and large these corroborate names sourced from other sources but there are a few (for example mahi mahi and the Jimbaran shovelnose ray) which have only appeared in published DNA studies. We are not DNA specialists and cannot comment authoritatively on the accuracy of the results but we have only made use of determinations in the peer reviewed literature and have not had access to any analyses carried out by commercial market actors. We are aware that DNA testing can be carried out with varying degrees of accuracy (and price) and that the reference library of fish species continues to grow.

An unknown amount of surimi is made from ‘mixed species’ and we have not been able to find any reports or studies on what may be in such mixes. Its possible that researchers have simply bought surimi products for testing and the product has been quite clearly marked as being of ‘mixed species’ origin. As discussed in Chapter 5, there is a wide range of implications of the degree of disclosure of ingredients including allergic reactions (e.g. not disclosing molluscs in products sold as fish based), religious violations (e.g. inclusion of pork products), use of species of conservation importance, use of illegally sourced fish and general traceability challenges.

## 3.9 Documented species

Our species list is, at best, indicative and more than likely an underestimate for the following reasons:

1. Lack of directed studies that could document exactly what species are being used;
2. The region from Australia north to Vietnam is particularly rich in species, many of which are very similar and so identification may well be compromised. For example, a number of ponyfishes (Leiognathidae) and silver biddies (Gerreidae) are similar, as are some Gerreids and Sparids (sea breams). However, not all species in a given group (e.g. genus) may be taken in exactly the same type of habitat. For example, some species of bigeye (Priacanthidae) may venture into open ground and thus be vulnerable to trawling in sufficient quantities whilst other species may confine themselves to reefs.
3. Catch and landings reporting systems that range from absent through irregular but in some cases sufficient to support management regimes.
4. Insufficient detail on what species are used by surimi producers, especially what is used to produce ‘mixed species’ surimi. Similarly, there is a commonly a reliance on describing species used at the genus (e.g. Nemipterus spp) or family level (e.g. lizardfishes).

5. Lack of information on small scale production of 'otoshimi' for local surimi seafood products. Whilst production may be small on an individual producer basis the aggregate may be large (as may anecdotally be the case in Indonesia).
6. Substitution – substitution is a significant issue in seafood worldwide. Its possible that lower value surimi species are substituted for higher value species.
7. The requirements of various government reporting systems (such as export/import requirements). Governments may only approve the export of particular species but this may not reflect how the industry works and thus multiple species get identified as the approved species.
8. Short term changes in species used that may be missed by catch monitoring systems or other reporting systems. These may be seasonal, interannual or in some cases episodic. For example, in the past couple of years the numbers of red-tooth triggerfish on the west coast of India have increased enormously and provided a feedstock for industries such as the fishmeal and surimi sectors, if not local food fish. Such an increase may compensate for decreases in other species but the usage in surimi may not be well documented.

We do not propose to describe every species here but here is a description of the main families of fish that appear in our list. Note that the attributes of individual species within any given family may vary – some may have life history attributes that make them either robust or vulnerable to fishing activity which has important implications for yields and management arrangements. This is critical when considering, for example, the MSC's multispecies approach which focuses on the most vulnerable species in a chosen cluster. Managing around the most vulnerable species could significantly restrict yields of other, less vulnerable species, an issue discussed below.

### 3.9.1 Nemipteridae

The Nemipteridae are the most numerous species in our list (17) and are represented by three genera (Nemipterus, Scolopsis and Pentapodus), of which Nemipterus (threadfin breams) are the most numerous.

A brief overview of this family of fishes can be found at - https://www.fishbase.se/summary/FamilySummary.php?ID=324. A much more detailed treatment can be found at - http://www.fao.org/3/t0416e/t0416e00.htm (based on Russel 1990) including a list of which of the main FAO fishing grounds the species have been recorded in (http://www.fao.org/3/t0416e/T0416E17.pdf) and also, for each species, detail on distribution, common names, biological and ecological information. They are used a variety of ways including fresh, steamed, dried, salted, dried, smoked, fermented or made into fish balls and fish meal. They are most commonly caught using otter or pair trawls but other commercial and artisanal gear includes seine net, gill net, longline, handline, fish stakes and traps, lift nets, surrounding nets, drive-in nets.

*N. japonicus*, one of the most commonly used species for surimi, is also one of the most widely distributed. Its range stretches from the east coast of Africa to the most southern island of Japan. It is a demersal fish that occurs in small schools in depths from 5m to 80m and feeds on small fishes, crustaceans, molluscs, (mainly cephalopods), polychaetes and echinoderms.

*N. randalli,* commonly reported from India, has a more restricted range, being found from the east coast of Africa to the west coast of India. *N. virgatus*, in contrast is largely found in the waters of the tropical western Pacific (http://www.fao.org/fishery/species/3140/en) *N. mesoprion* has an even more restricted range, being recorded from the Guld of Thailand and the Indonesian waters of Sumatra and Java.

The genus Scolopsis is also found in tropical and subtropical waters of the Indo-Pacific, with some species being widely distributed such as *S. taeniopterus*. Species in this genus were investigated for their potential as raw material for surimi by Seafdec (REF). Members of this genus are found in similar habitats and feed on similar groups of small animals as the Nemipterus species. Russell (1990) records the use of *S. taeniopterus* for the making of fish balls.

In 2018 landings of threadfin breams reported to the FAO totalled 701 133 tonnes (dominated by China, India and Indonesia) and for Scolopsis species, 9621 tonnes (all from Thailand and Malaysia).

Note that Russell's work is some 30 years old and information on distribution and even naming needs to be checked on a fishery by fishery basis. Its also worth noting that non of the individual species were recorded as supporting a major fishery but mixtures of species can make a significant contribution to landings in some areas.

**3.9.2 Sciaenidae**

The Sciaenidae (croakers and drums) comprised 7 species from five genera in our list. Given the diversity of this group of species and the fact that species are commonly not separated at the landing sites nor in the supply chains it is more than likely that far more species find their way into surimi supply chains.

This is a highly speciose family of fishes with 286 species from 66 genera (https://www.fishbase.de/Summary/FamilySummary.php?ID=331). They are so named because of their ability to make grunting/croaking noises from the swim bladder which is highly sought after and sold for food as highly prized fish maw in some countries and used as a source of isinglass for fining wine, in others. They are generally coastal and estuarine fish found in the Atlantic, Indian and Pacific oceans and are not confined to the tropics but are more diverse in the tropical waters of Asia. Croakers are carnivores, eating a wide variety of fish and invertebrates, depending on species. Many species are relatively small (<40cm) but some grow to well over one metre in length.

Given their wide distribution they are caught by a range of fishing gears including trawls, gillnets, demersal longlines and handlines (Fischer and Whitehead 1974). They are marketed fresh, dried, salted and made into fish balls (Fischer and Bianci 1984). There is also a growing industry for the farming of some species, especially in China where the critically endangered large yellow croaker (*Larimichthys croceus)* is extensively cultured.

Some species are widely distributed such as the Japanese meagre (*Argyrosomus japonicus*) which occurs from southern Africa across the southern Indian Ocean and north to Japan whilst others such as the small yellow croaker (http://www.fao.org/fishery/species/2362/en) are less so, being found in the waters of China, the Koreas and Japan.

In 2018 landings of croakers reported to the FAO totalled 756 349 tonnes (dominated overwhelmingly by China, followed by India).

**3.9.3 Synodontidae**

The Synodontidae  are represented in our list by 6 species, 5 from the genus Saurida and one from the genus Harpadon.

A brief overview of this family of fishes can be found at - https://www.fishbase.de/Summary/FamilySummary.php?ID=160. It includes four genera and 75 species. Almost all species are marine and, as a family, members are distributed across the Atlantic, Pacific and Indian oceans. Some more detailed information can be found at - http://www.fao.org/3/e9163e/e9163e00.htm (for the eastern Indian Ocean and the western Pacific ocean and here - http://www.fao.org/3/ad468e/ad468e00.htm for the western Indian ocean.  Information on the widely distributed *S. tumbil*, including FAO landings data can be found at - http://www.fao.org/fishery/species/2984/en.

For each species Fischer and Whitehead (1974) and Fischer and Bianchi (1984) provide detail on distribution, common names, biological and ecological information. As a family they are distributed on muddy, sandy seabeds down to depths of about 200m. They predate on a wide variety of small fishes and invertebrates. They are most commonly caught bottom trawls but also artisanal gear. Sometimes marketed fresh, they are also made into fish cakes and fish balls, as well as fishmeal.

In 2018 landings of lizardfishes reported to the FAO totalled 170 579 tonnes (dominated by India, followed by Malaysia). In addition there were 145 500 tonnes of Bombay duck (*Harpadon nehereus*) reported as landed (32500 in Malaysia and 113 000 in India) some of which is also used for surimi.

The Bombay duck is a widely distributed species across the tropical waters of the Indian and western Pacific oceans http://www.fao.org/fishery/species/2949/en, including China, from where we have a record of it being used in the production of surimi. It is described as a 'voracious' predator that lives at depth but migrates to the mouths of rivers at certain times of the year to predate on small fish.

Note that the work of Fischer and Whitehead (1974) and Fischer and Bianchi (1984) is some 45 and 35 years old respectively and information on distribution and even naming needs to be checked on a fishery by fishery basis, noting that non of the species were recorded as supporting a major fishery.

#### 3.9.4 Mullidae

Our species list records four species from two genera in the family Mullidae (goatfishes, red mullets) out of a total 6 genera and 88 species recorded worldwide (https://www.fishbase.se/Summary/FamilySummary.php?ID=332). They are found in sand associated, shallow habitats in the Atlantic, Indian and Pacific oceans and are not confined to the tropics. They are commonly valued as a food fish. For example, 'red mullet' is a popular fish in a number of Mediterranean countries, some of whom import goatfishes from Asia due to overfishing of their own waters. According to Fischer and Bianci (1984) they are carnivorous, feeding on a wide variety of small animals, particularly small crustaceans and worms and are taken by trawls, demersal/beach seines, lines and trap nets,

For the 7 countries which are part of our study the total landings reported to FAO in 2018 were 119 655t (dominated by Indonesia, Malaysia and India and Indonesia) noting that some countries, which are known to catch goatfishes, such as Thailand, do not report their catches separately (may be included in NEI – not elsewhere included).

Some species like *Parapeneus indicus* and *P. heptacanthus* are widely distributed in the eastern Indian Ocean and western Pacific ocean whereas *Upeneus bensasi* (current name *U. japonicus*) occurs along the coast from northern Vietnam, parts of south Korea and across to Japan.

#### 3.9.5 Priacanthidae

Our species list includes three species of bigeye snappers (also called bigeyes, bullseyes) from one genus out of a potential four genera and 19 species (https://www.fishbase.se/Summary/FamilySummary.php?ID=303). Generally small in size (<50cm) they occur in water depths from 5 to 400m and most are reef associated although some species (such as *P. tayenus*, *P. macracanthus* and *P. hamrur*) are found in more open areas which makes them vulnerable to trawls. Feed on small crustaceans, polychaetes, small squids and fishes.

India is the largest producer accounting for about 58 000t out of the 118056t reported to the FAO in 2018.

Taken by trawls and hook and line, traps, gillnets, they are described as 'excellent food fishes' by Fischer and Bianci (1984) and they are marketed fresh - whole, dry salted, or made into fishballs (Fischer and Whitehead 1974)

#### 3.9.6 Sparidae

The Sparidae, also known as sea breams or porgies, are a large family of fishes comprising 159 species from 38 genera (https://www.fishbase.se/Summary/FamilySummary.php?ID=330). They are widely distributed in the tropical and temperate waters of the Indian, Pacific and Atlantic oceans where they can be found in a wide variety of habitats ranging from the estuaries out to the continental shelf slope. Some species grow to 1.2m in length. Most are important food and sport fishes and some species are extensively farmed (e.g. *Sparus aurata* in the Mediterranean and *Pagrus major* in Japan). They are generally demersal carnivores feeding on echinoderms, worms, crustaceans and molluscs.

*Evynnis cardinalis* is found on soft seabeds close to reefs from central Vietnam north along the coast of China which is a similar distribution to *Dentex tumifrons*, which is an important food fish in the region.

These species can be taken by a wide variety of gears including trawls, lines and seines, and depending on species, may be marketed fresh, whole and/or dried-salted.

#### 3.9.7 Sphyraenidae

Members of the Sphyraenidae (barracudas) are amongst the few pelagic species that are used in tropical surimi (but see below). There is only one genus, with 28 species. Our species list records two to species level. Most species are small but the great barracuda grows to 1.8m in length. They are a schooling fish and voracious feeders on other fish (https://www.fishbase.se/Summary/FamilySummary.php?ID=360).

Both species in our database are widely distributed, occurring in marine waters in the Indian and western Pacific oceans. They are found in both the tropics and in temperate waters (including the southern waters of Australia).

The FAO landings database recorded 108815t in 2018 with landings dominated by India and Indonesia.

Barracudas are caught with a wide range of fishing gears including bottom trawls, set nets, trolls and longlines. They are marketed fresh; also dried-salted, fermented, smoked or prepared as fish sauce.

#### 3.9.8 Leiognathidae

Ponyfishes (Leiognathidae) are small, generally abundant demersal fishes that have a wide variety of uses in tropical Asia. It is not uncommon to see them at wet markets, dried or as the raw material for a fishmeal plant but they are also used for surimi. Two species are documented as being used for surimi but its likely that, given the variety of species this is an underestimate. Both are widely distributed in tropical waters from the northern Indian Ocean to the western Pacific Ocean.

This is a diverse family of small fishes comprising 51 species from 10 genera (https://www.fishbase.se/Summary/FamilySummary.php?ID=318) that generally live in shallow coastal waters and tidal creeks.

They are commonly caught with bottom trawls, as well as with beach seines, gillnets, traps and other artisanal gear. Ponyfishes are marketed fresh, dried and also used for fish meal and duck food, and Chinese medicine (fishbase.org)

## 3.10 Species characteristics – management implications – vulnerability

The ability to harvest fish resources sustainably depends on a wide variety of factors, not the least of which is the ability of the species/stock to handle the fishing pressure that is, hopefully, controlled by adequate rules and regulations, respected by fishers. The biological attributes of species are critical to gaining an understanding of their vulnerability to fishing pressure. Species which grow slowly, are relatively old before reproducing and which produce few offspring, such as orange roughy and many species of sharks, have low productivity and cannot support major removals via fishing. Conversely, species which grow and reproduce quickly and produce large numbers of offspring have greater productivity and can support larger harvests. Examples include tropical shrimps, anchovies and ponyfishes.

In between is a wide range of species with varying attributes that influence their vulnerability to fishing pressure. In species rich parts of the world, especially when an area is accessed by gear that takes a variety of species the relative vulnerabilities of species in the mix have a major influence over how each one responds to the overall fishing pressure but also how these responses may play out in terms of the ecological interactions between species. This is explored in more detail below.

The relative vulnerabilities of species in a fished system has been a known challenge for many decades. For simple, single species fisheries, the vulnerability of the species of interest has been at the centre of determining sustainable harvest rates. As concerns about bycatch grew then the same considerations were directed at other species, although the outcomes sought were focused on species protection rather than productivity. The mitigation solutions pursued were largely focused on making harvesting more selective based on the assumption that minimizing the collateral impacts of harvesting on vulnerable species will protect them. In some circumstances this approach works well.

With the shift to the Ecosystem Approach to Fisheries Management (EAFM) there is now a focus on how changes in the population status of species may cause other changes in the wider ecosystem. An interesting, but influential consequence of this approach, is a growing view that selective fishing may not be as protective as previously thought (REF). Central to these views is the need to consider predator/prey relationships in ecosystems as the selective harvesting of one in the absence of harvesting the other, may have unintended consequences. This issue is explored in detail below as it is pivotal to how the fisheries are managed as the ecosystems can be fished in different ways, which influences overall yields plus which groups in society may benefit.

Another important consideration is the fact that the fisheries that supply fish for surimi production rarely operate in isolation from other fisheries, especially in tropical developing countries. The vast majority of species are exploited by a range of gear types by different fisher groups. In the discussion about fish families above the list of gear types include trawls (the most common gear for producing the volumes used by the surimi sector as well as food fish for processing and export) and gillnets/seines/traps/handlines and longlines, which are generally used by smaller scale fishers for either subsistence purposes or local, commercial supply. Thus, species vulnerability needs to be considered in an overall way as much as possible as the pressures may be coming from various quarters.

## 3.11 Fish preferences for the industry – quality of surimi, sizes of fish, availability, market demand

The surimi sector uses fish that are smaller than those used for direct human consumption but larger than those used for fish meal. In comparison to the fish meal sector, the range of species used is smaller.

The characteristics of the species of interest to the surimi sector are described in Chapter 2.

## 3.12 Gear types – demersal trawls, Danish seine, purse seines

This section seeks to document the nature of the main fisheries in the target countries so as to gain an understanding of their characteristics, development and role in the seafood economy.

### 3.12.1 Types of trawl gear in use in Asia

Trawling is one of the most widely used fishing methods used in Asia, the other being purse seining. Depending on the country of consideration, trawling accounts for between 25% and 52% percent of the catch (Funge-Smith et al 2012) and, as of 2012, there are an estimated 83 000 vessels in the region covered by the Asia Pacific Fisheries Commission (APFIC – http://www.fao.org/asiapacific/apfic/en/) region and this is likely an underestimate (see Le and Nguyen 2011 for Vietnam). Not only has the number of vessels increased over the decades but so too has the area subject to trawling (Watson et al 2006). The exception appears to be Thailand which has experienced a marked decline in the number of trawl vessels in response to management actions and overfishing. Indonesia has also seen declines due to trawl bans in the early 1980's then again in 2016 (now reversed).

Defining fishing gear can be problematic as there are many variants that straddle not only the criteria that separate trawl from other gear but also the criteria that separate one type of trawl gear from another. Examples of the first challenge include towed gillnets and Danish seining (known as cantrang or dogol in Indonesia). Gillnets are most commonly deployed as static gear which rely on fish swimming into the net which is either set on the seabed or floating in the water column (http://www.fao.org/fishery/geartype/219/en). However, in some areas gillnets can be towed (very slowly) by a vessel and this active movement embodies one of the key characteristics of trawling (Dudley and Tampubolon 1985). Danish seining is another example whereby a net is used to encircle fish on the seabed in a similar manner to a purse seine but the ends of the net are towed together to ensure that the fish are trapped, rather than bringing together the bottom of the net by pursing. Generalised descriptions of the diversity of fishing gears in Thailand and Vietnam, as examples, can be found in Munprasit et al (2004) and Ruansivakul et al (2002) respectively.

In terms of the second category (i.e. excluding towed gillnets), there is overlap between the different types of trawling, especially demersal, otter trawls and pelagic trawls, which are described in more detail below. The type of net is one factor determining the range of species taken and the degree of environmental impact and so being able to categorise the type of net being used is important for generating an understanding of potential impacts.

Generating a clear understanding of the nature of the trawl fisheries is further complicated by a range of other factors such as:

- definitional issues and lack of clarity around gear type – e.g. not separating gears or landings by demersal from pelagic trawls which has implications for interpreting impacts.
- Illegal, Unregulated and Unreported fleets – some, especially inshore, small-scale fleets can be large and may not require licencing. Indonesia and the Philippines host a large number of so called mini trawls (known as arad in Indonesia). Lack of registration requirements for certain classes of vessels, especially small scale vessels creates an incentive to under-report vessel size. Double counting where vessels are required to be registered under more than one jurisdiction
- Under reporting is also an issue due to the large number of small, private landing sites where records are either not kept or submitted to authorities. This is particularly a problem where one part of the catch is landed at the government run port and another part is landed directly to a factory wharf. At some ports, fish destined for the fresh/frozen and surimi markets are landed at the government run port but fish destined for fish meal production are taken directly to fish meal plants in the nearby river (personal observations).
- dated information - policy or other (e.g. economically driven) changes that may not be reported or are not being implemented or effective. Thailand collects very detailed information and makes this publicly available on an annual basis. This is not the case for Vietnam.

A trawl is a triangular shaped net that is towed through the water column by a moving boat (or boats). The net can be run along the seabed and is known as a demersal or benthic trawl or it can be positioned in the water column itself where it is known as a midwater or pelagic trawl. There are a number of variants but the three most common are described below.

#### 3.12.1.1 Beam trawls

According to the FAO (http://www.fao.org/fishery/geartype/305/en).

*A beam trawl consists of a cone-shaped body ending in a bag or codend, which retains the catch. In these trawls the horizontal opening of the net is provided by a beam, made of wood or metal, which is up to 12 m long. The vertically opening is provided by two hoop-like heads/shoes. The trawl mostly made from steel. No hydrodynamic forces are needed to keep a beam trawl open.*

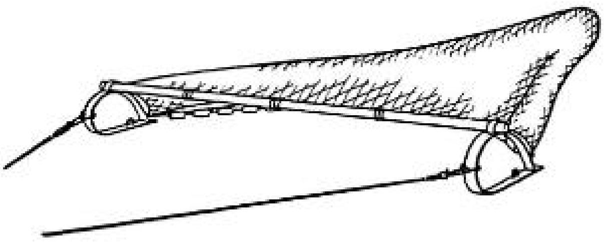


Figure 3.1 Beam Trawl. Source http://www.fao.org/fishery/geartype/305/en).

Beam trawling is generally undertaken by small (approx. 10m) vessels fishing close inshore for shrimps. In comparison to other forms of trawling, the numbers of vessels is generally quite small (see below). Vessels may tow a single net or multiple nets. Due to the main species of interest being shrimps the mesh sizes are small (10mm or so) and this results in relatively large numbers of small and juvenile fish.

3.12.1.2 Otter board trawling

The net can also be kept open by the pressure of moving water operating on flat plates (made of wood or metal) attached to the front of each side of the net. These trawl doors are often called otter boards and demersal trawling is commonly called otter board trawling (http://www.fao.org/fishery/geartype/306/en)

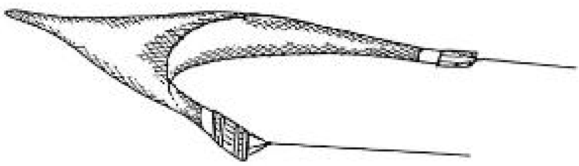


Figure 3.2 Otter board trawl. Source http://www.fao.org/fishery/geartype/306/en

There are several variants employed as a result of environmental differences (seabed or other environmental conditions) or local innovations/capacity. Trawlers may tow two (twin trawls http://www.fao.org/fishery/geartype/208/en) or even more nets. A variant known as boom trawling simply describes the common practice of using booms projecting out from either side of the vessel to increase the spread of the net.

3.12.1.3 Pair trawling

According to the FAO (http://www.fao.org/fishery/geartype/307/en) pair trawling involves:

*Two vessels, each towing a trawl warp attached to the bridles in front of the two trawl wings. One of the vessels is handling the trawl and takes the catch. The other is only a towing vessel, the so-called "slave".*

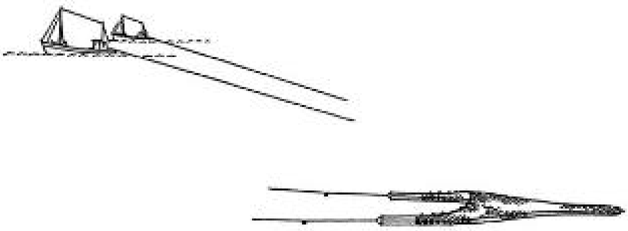


Figure 3.3 Pair trawling. Source http://www.fao.org/fishery/geartype/307/en

Pair trawling can be used for both demersal species and pelagic species. Pelagic pair trawling has grown in popularity as demersal resources have declined and pelagic resources have increased (Hutchings and Baum 2005, Link et al 2002, Caddy and Garibaldi 2000) plus the returns for effort are higher.

Catching pelagic fish requires faster towing speeds which are generally not achievable by many trawlers and engine upgrades are challenging due to the low profits. Pelagic species are also taken in demersal trawls, especially in shallow water but also as a result of net modifications aimed at making the top of the net ride higher in the water column (so called high lift trawl nets)(Nyguen pers. comm. for Vietnam). There can be some further overlap as midwater trawls can be deployed so close to the seabed that bottom contact does occur.

3.12.2 Danish seining

Danish seines appear to be one of the main types of gear used for the taking of surimi fish in Indonesia, the other being otter trawls. The nets used are very similar to trawl nets which may explain the great level of confusion that exists in Indonesia where Danish seines (known locally as cantrang or dogol) are labeled as damaging whereas research undertaken in other countries shows that they have a lower seabed impact than trawls. This is likely due to the fact that, after the net is set, it is not towed but is hauled back to the boat with a winch (Figure 3.4).

A description of Danish seines can be found at - http://www.fao.org/fishery/fishtech/1003/en

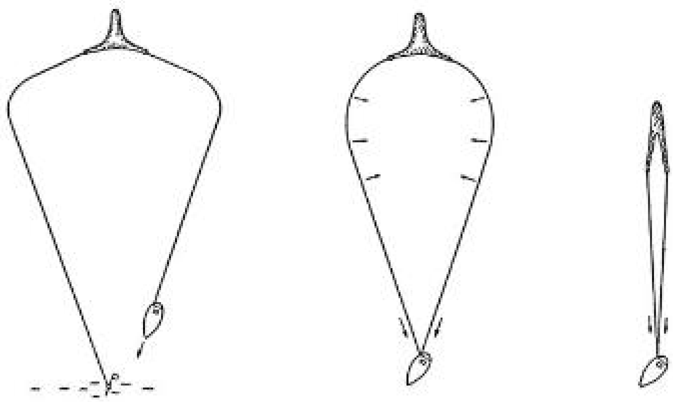


Figure 3.4 Danish seining

## 3.13 Multigear, multispecies and multiproduct fisheries

In previous sections we document how the main fisheries used for the taking of fish for surimi production are clearly multispecies in nature. Most also operate in association with other gear types used by other user groups and management regimes need to be viewed as multigear as well as multispecies.

Many western, developed country fisheries, including tropical trawl fisheries, are commonly focused on a small range of valued 'target' species with a small number of retained bycatch species. The rest of the catch is discarded. Discarding rates in these fisheries can exceed 90% of the catch although with the adoption of bycatch exclusion devices, gear modifications and a variety of input controls (e.g. spatial and temporal closures) these rates have been reduced but even in some well managed fisheries can be of the order 75% (Kennelly 2018). In comparison, many multispecies trawl fisheries in tropical developing countries are believed to have little or no discarding. In part this is due to the fact that discarding has long been viewed as a waste of useable protein (Anon 2000) and markets have developed for almost everything that has been caught. Note that the term 'fish' is used to cover finfish and shellfish.

In broad terms the catch taken on board the vessel may have the following characteristics and markets:

1. Fresh fish for sale in local markets/food service.
2. Fish destined for processing and frozen for domestic or export markets
3. Fish destined for processing techniques such as drying, fermenting, salting, smoking
4. Fish destined for processing via the making of pastes (surimi)
5. Fish destined for processing into fishmeal/oil or locally made fish powder
6. Fish for use as animal feeds/silage/fertilizer or for use in aquaculture directly.

In the past the so called 'trash fish' was called 'duckfish' as it was used for ducks but has also been used for other animals such as pigs. As to how common this is now is unknown. The direct feeding of fish to aquaculture species is very common, especially amongst small scale farmers.

Thus the fisheries could also be described as 'multiproduct' fisheries. This is not simply a semantic term for the following reasons:

- each market outlet has its own constituency and good fisheries management involves the constituents in the management process to develop an understanding of the issues and an acceptance of the management rules. Only involving one group (e.g. those that buy high value fresh fish) simply alienates others and prevents buy-in. Equally importantly, not only do the fish get allocated to markets on the basis of demand and price which is linked to availability, size of fish and quality of handling but some market players operate in several markets. The linkages between the surimi sector and the fishmeal sector are explored in Section 2.8.2.
- the concept of target species and bycatch, which underpins a great deal of fisheries management approaches globally is not a useful construct within which to develop management for these multispecies fisheries, except in some circumstances where fishery managers and stakeholders have agreed that the goals and objectives of the fishery are best met via this approach. In contrast, an exploitation strategy that is expected to deliver a broader range of benefits is more common in tropical developing countries although the management regimes designed to achieve this are far from developed or implemented. The details and consequences of both these approaches and their relevance for the application of the MSC Standard are discussed in Section 6.2.

Many fisheries are 'multiproduct' in that it is rare for there to be only one use for the fish. Some fisheries may have dominant use such as human food or fish meal, examples being the Alaska pollock fishery (mainly processed human food products) and the Peruvian anchoveta fishery (mainly fishmeal). However, the range of products (and beneficiaries) from tropical trawl fisheries (in developing countries) is particularly diverse and engaging with the various users may have major benefits.

## 3.14 Current management challenges

Whilst the bulk of raw material for tropical surimi is sourced from trawl fleets many of the same issues outlined below apply to some purse seine fisheries used for pelagic species. The three key issues are:

1. Many of the trawl fisheries (indeed many fisheries in general) across tropical Asia are termed 'open access' in that there are no controls on the numbers of fishing vessels that the government will licence. An absence of such controls is common in the early development phases of a fishery where the government welcomes all participants. During the early phases of fishery development when stocks are abundant, vessels make good money. However, after a period of time, as stocks decline the Catch Per Unit Effort declines and so do profits. If left unchecked profits decline to zero. As stocks decline and fishers become more desperate they are more inclined to indulge in illegal activities and modify their fishing gear to catch more. A common outcome is resorting to small mesh nets so as to target those fish that normally pass through. This race to the bottom is ultimately very destructive and could be avoided if governments put restrictions on the numbers of vessels, in accordance with the International and Regional (Asia) Plans of Action on fishing capacity. Some governments have moved in this direction and also sought to remove excess fishing effort. Part of the Thailand government's fishery management strategy has focused on removing excess effort to build upon longer standing controls on the issuing of new licences.
2. The susceptibility of fish to capture by the nets varies from species to species. Other things being equal (time and location of fishing activity) the size and shape of the fish greatly influences whether it is retained in the net but abundance may vary from one time of the year compared to another (e.g. monsoon versus dry seasons). Thus the harvesting pressure is not necessarily in proportion to the capacity of the species to fished sustainably. This, coupled with the different vulnerabilities of the species (see above) results in unsustainable fishing pressure on some species but not others. This effect occurs in any fisheries (not just trawl fisheries in Asia) but is particularly acute when fishing pressure is heavy. Figure 3.5, below, extracted from Patil et al (2018) illustrates the challenge facing Pakistan's fisheries where fishing pressure is too high and most species groups are either overfished or being overfished. Some species groups such as the snappers and demersal elasmobranchs are depleted but reducing fishing pressure to sustainable levels for these groups would result in underfishing of many others.

Figure 8: Fishing Yields, Concordant with Stable Stock Levels under Different Levels of Long-Term Effort

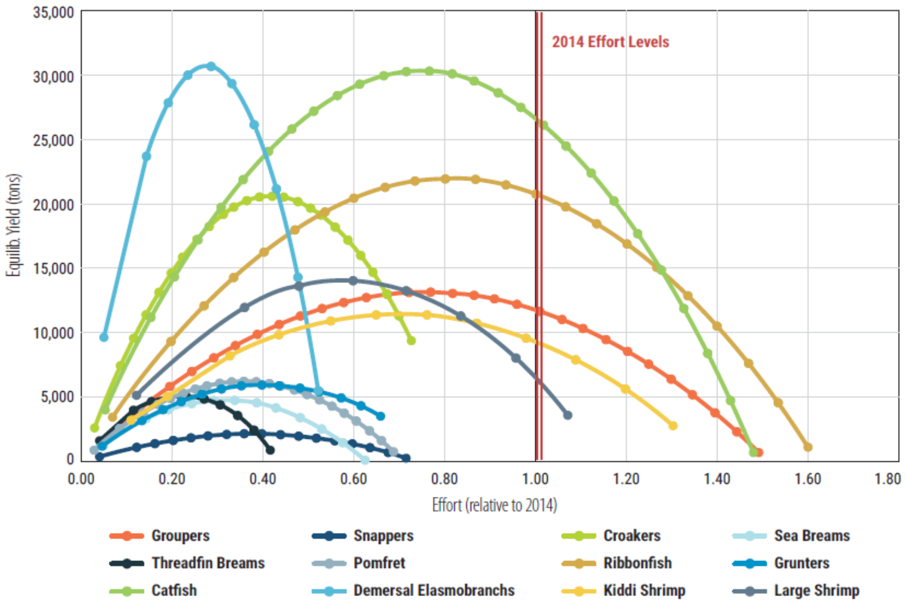



Figure 3.5 – varying catch/effort response curves amongst species groups in multispecies fisheries in Pakistan

3. Ecosystem shifts – the differential pressures on species alters many ecological relationships such as between predators and prey and between competitors. The removal of larger, slower growing and commonly carnivorous species, reduces the pressure on prey which increase in number and provide either new resources for fishermen or place excessive pressure on their food items. The so called 'predator release' effect can substantially increase the availability of lower trophic level species. The left hand side of Figure 3.5, below, shows how yields from the Gulf of Thailand grew after the initial period of fishery development (1963 onwards). In the early years the system was dominated by slower growing species (sharks, false trevallies) but these were quickly depleted resulting in a 'boom' of their prey (small/medium demersals, trashfish etc). As fishing pressure continued to increase the ecosystem became dominated by different groups over time (right hand side).

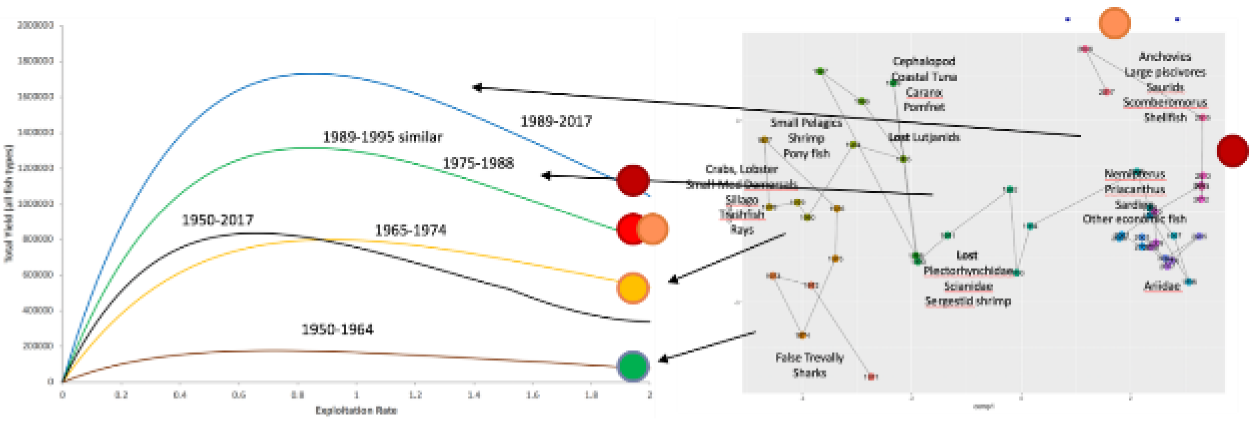



Figure 3.5 – changing species dominance in the Gulf of Thailand over time. Source: Fulton E.A. 2019. FAO MMSY workshop, Bangkok.

As the larger, slower growing species were removed the system provided larger catches. The 1950-1964 ecosystem produced far less than the 1965 to 1974 ecosystem, for example. However, the species that were dominating the productivity were generally small and generally (but not always – shrimps being an exception) lower value. This low unit value may have been compensated for by the increased volumes and the fact that many of these species were used in value added industries (fish meal as one example).

Significantly, for the surimi industry, is how different families of fish have dominated in different ecosystem state. For example, the Sciaenids were dominant in the early 1990's and then the Nemipterids and Priacanthids in the late 1990s and 2000s. Thus the conditions that are favourable for some of the species of importance to the industry are not found in a an undisturbed or lightly disturbed ecosystem. This has important implications for determining the management objectives for the fishery as a whole. A fishery that maximises the production of some important surimi species may well be at the expense of other species which are valued by other groups. This is neither unusual nor undesirable but it does emphasise the need to proceed cautiously in which species to focus on.

## 3.15 Management challenges

The aim of fisheries management is to achieve the goals and objectives of fish resource owners which in most cases are represented by governments acting on their behalf. The goals and objectives can include a variety of aspects such as agreed distribution of benefits, economic development, food security, healthy ecosystems, cultural benefits and more. Whilst the emphasis and mix of each of these varies from country to country (and fishery to fishery) there are global agreements that set out some benchmarks. For example, the United Nations Convention on the Law of the Sea (UNCLOS) requires that harvested species are managed at MSY, as modified by economic, social and environmental factors, and that ecologically dependent species are managed to ensure that they are not at risk of reproductive failure (also known as the Point of Recruitment Impairment – PRI). Elaboration of these basic requirements via other agreements (e.g. the Straddling Fish Stocks Agreement) and/or informal agreements such as the Code of Conduct for Responsible Fisheries (CCRF) have interpreted these requirements as relating to target species and bycatch. Certification standards may interpret these requirements in consistent but more stringent ways.

It should be noted that MSY is a productivity oriented concept (MSC requires "The stock is at a level which maintains high productivity……" but other approaches exist such as Maximum Economic Yield (MEY) where the stock is kept at a less productive but larger biomass, which results in lower fishing costs and greater economic return.

Some multispecies fisheries are managed for a single (or very small number) of species and thus can almost be considered as single species fisheries. For these (such as some shrimp fisheries) there are clear target species (shrimp) which are expected to be managed at MSY or equivalent and the bycatch, whether retained or discarded meets the much lower bar of ensuring that reproductive failure is avoided. Retained species may be at levels that are either above or below (or at) their individual MSY's and, as long as they are above the PRI then these species meet the requirements of UNCLOS and the CCRF (and are thus produced responsibly).

Management regimes that seek to manage multiple species as targets face a number of significant issues. As mentioned above, MSY is a productivity related concept and it does not incorporate ecological influences such as predation. As set out by Walters et al., (2005), Link et al., (2006) and Rindorf et al., (2017) accounting for the interactions between species is important for understanding and setting limits on sustainable yields. Traditional, single species approaches do not account for these interactions and assume that any fishing induced mortality is additional to natural mortality only. In systems with many species the setting of catch limits in this way, such as by adding single species MSY estimates, can overestimate the combined sustainable yield of the combined fishery by 25-50% or more (Fulton et al (2007). Operating the fishery to meet the individual MSY's will quickly result in overfishing.

The potential management responses to this challenge depend greatly on the objectives of the fishery stakeholders and managers. Some scenarios could be considered as follows:

- If the aim is to manage a small number of species at MSY then some existing shrimp fisheries provide workable models. For this approach the species not specified as targets required to meet MSY would be treated as 'bycatch'. In the MSC system, such species could not carry the MSC label.
- Manage a group of similar species by assuming that by protecting the most vulnerable one is protective of others. If the most vulnerable one is maintained at MSY then the others will be maintained at higher biomasses. In the MSC system this would enable more than the most vulnerable species to carry the MSC label. However, this species would act as a 'choke' that could control yields from the entire fishery in that all catches would be constrained to ensure that this species was maintained at MSY.
- Manage the fishery for an overall yield (Multispecies MSY) and accept that most species will not be at their individual MSY (may be above or below). Species that are at their individual MSY may or may not be surimi species.

Each of these options has social and economic implications that would need to be carefully considered. For example, managing the fishery to ensure some sustainable surimi species may come at a cost to the fresh fish sector, or the fish meal sector. Trying to maintain all surimi species at MSY (and thus potentially meeting MSC P1) would be particularly challenging as the existence of vulnerable choke species could reduce overall yields quite considerably and maybe induce ecosystem changes that could influence catches of other non-surimi species. Modelling may provide some insights.

## 3.16 Current management arrangements

Across the 7 countries we have studied, approaches to fisheries management are highly variable and range from some very simple controls on where vessels can fish through a mixture of input controls such as time and areas closures, mesh size limits, limited entry regimes and an increasing variety of reporting and monitoring mechanisms including the use of Vessel Monitoring Systems (VMS). Formal management plans remain rare and no country could be said to be achieving fish stock management objectives, where they are in place.

In response to evidence of overfishing governments have traditionally acted to lower input costs (via subsidies), encourage vessels to fish in unexploited grounds (generally further out to sea) or to sift into other fisheries (e.g. from demersal trawl into purse seining). In the case of China, it has created a large ocean going fleet to fish on the high seas. None of these responses have been shown to take the pressure of previously productive inshore waters.

The most common management measures include:

1. Seasonal closures – China and India are two examples where seasonal closures are used to alleviate fishing effort and either favour fish that are spawning during that period or enable fish to grow to a larger size. China's closure is during the (northern) summer months whilst the closure in western India is usually for the two months of June and July.

2. Permanent area closures – a particularly common type of closure excludes trawl fleets from inshore shallower waters which prevents interactions with small scale vessels, especially those using static gears such as gillnets. These sorts of closures also benefit juvenile fish which can be more common in shallow waters. Examples include Thailand and Malaysia.

3. Licencing systems are widely used. Increasingly, governments are restricting the issuing of new licences to try and control capacity expansion.

In terms of managing to estimates of sustainable yields there is little in place. Where there are stock assessments undertaken at suitable frequencies there do not appear to be explicit attempts to control catches to meet the estimated yields, with the exception of Thailand.

Thailand has adopted the MMSY approach in the management of its fisheries. This approach recognises the complexity of the current mix of dependent industries and communities and does not seek to manage any particular species at MSY. Its sets an overall MMSY for species groups (demersals, small pelagics, tunas, for example) and then establishes a mix of rules aimed at keeping removals as close to this MMSY as possible. Some management rules have been in place for decades such as the seasonal closure which was originally designed to protect the main spawning period of the economically and socially important Indian mackerel. In addition there are inshore trawl closures which were originally designed to separate the trawl fleets and their mobile gear from artisanal fishers, many of whom use static gear. In recent years the government has banned push nets, reduced the trawl fleet considerably, down from a peak of over 14 000 to about 3000 and has also increased mesh sizes. Whilst the full impacts of the changes have yet to become apparent the results are encouraging.

Figure 3.7 below, the amount of effort (measured in trawl hours expended) has been substantially reduced from over 40million hours per year down to the level desired (just over 22 million hours). This has been achieved via the removal of illegal vessels and a ban on push nets. If this level of effort cut is sufficient to take the pressure off stocks then catches should increase as the overall biomass increases.

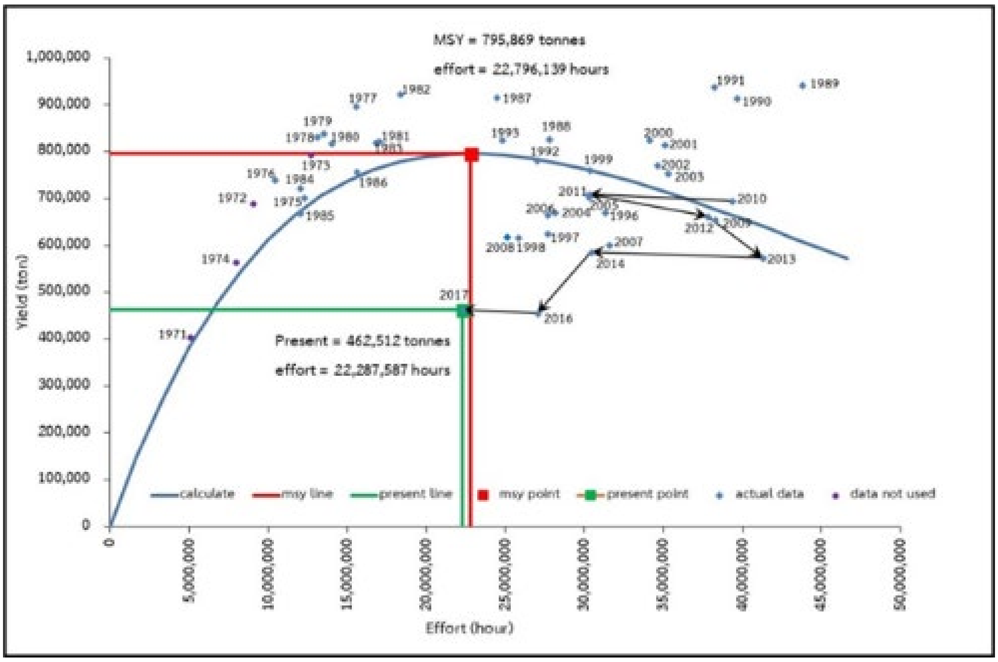



Figure 3.7 – relationship between effort and total yield, Thailand. Source: Fisheries Management Plan of Thailand

## 3.17 Stock assessments

The development of modern fisheries science originally took place in high latitude countries that typically had a small number of species, some of which were extremely abundant, such as cod, pollock, haddock etc.

In seeking to gain an understanding of how many fish could be taken on a long term, sustainable basis, fisheries scientists developed tools that generated estimates of sustainable yield on a species (or even stock) basis (see for example Hoggarth et al 2006). Developing an estimate of the sustainable yield from a stock was purely determined on the basis of the biological characteristics of the species/stock and the nature of the fishery with little regard to the wider role of that species/stock in the marine ecosystem, such as the needs of predators or the potential interactions with competitors.

These tools became increasingly sophisticated as more data from field studies was gathered but the general approach of seeking to define sustainable catches by species/stocks became incorporated into regulation and laws at jurisdictional level and also in international laws and agreements, even despite the well-known challenges associated with having a fishery operating on one species/stock that may be affecting species utilised by another fishery.

Whilst the challenges of multispecies and multistock fisheries were known in the 1950s there was little progress made on developing the tools for understanding and managing them. In the 1960's when developing countries in the tropics were seeking to develop their fisheries it became clear that seeking to develop species-by-species estimates of yields was, except in a few circumstances (mainly high volume species, simply not possible. The large number of species involved meant that doing stock assessments for all of them was simply impossible from a human resources perspective.

Notwithstanding the variety of single species assessment tools that have been applied over the years the biggest influence on the current state of many fisheries is the application of what are termed 'aggregate yield' models which have been widely used in the region over many years to provide estimates of sustainable yield. The term 'aggregate yield' refers to a method for evaluating the sustainable yield of a group of species in an area.

Three key approaches have been applied, depending on what type of data/information is available:

1. In the absence of any survey or catch data, estimates of fish density per unit area can be based on existing information from similar habitats or ecosystem types in other parts of the world (see for example Gulland 1971). So, for example, if an area is known to be primarily coral reef then a rule of thumb estimate of sustainable yield can be derived from other studies of coral reef productivity.

2. Research surveys have been used to generate estimates of the available biomass per unit area. For trawl fisheries this involves measuring the catch in trawl shots in the area of interest and then extrapolating the tonnage taken to generate an estimate of standing stock for the entire area. Correction factors such as the selectivity of the net and the catchability of the species (amongst other factors) need to be considered. Such techniques are used in the absence of any reliable Catch Per Unit Effort data from fishing activities.

   Once the biomass estimates are available then estimates of Maximum Sustainable Yield can be generated (see for example Gulland 1971) where $MSY=0.5*M*B_0$. It is assumed that the surveyed biomass is unfished ($B_0$) and that natural mortality (M) for small pelagics is 1 and for demersal species M is 0.5. This results in MSY estimates of 50% of standing biomass for small pelagics and 0.25 % for demersal fish. So, if the standing stock on the seabed is estimated at 50 tonnes per square kilometer then the sustainable yield is 12.5 tonnes.

3. A third commonly used method is applied when it is possible to collect catch and effort data from a fleet that is fishing the area of interest. Using models developed by Fox (1970) and/or Schaeffer (1957)(and modifications thereof) the MSY is determined to be the point where CPUE is highest. Such models, which were originally developed for single species/stocks, have been regularly applied to multispecies situations where the total biomass (of all species) is plotted against effort.

Option 1 was only ever considered for scoping purposes in the very early days of planning for fishery expansion (where such planning took place). Options 2 and 3 help narrow down the estimates although there are some significant potential sources of error. Option 2 was used in some countries to provide indicative yields for fishery planning purposes (see below for Thailand and Vietnam). Option 3 was, and continues to be used as a management tool (see above).

The use of aggregate yield models has been subject to debate for decades, as it became clear that multispecies fisheries presented very significant challenges to fishery managers due to the information demands and the uncertainties confronted; particularly in developing countries located in the tropics. Options 2 and 3 are very much a pragmatic response to circumstances where fishery scientists and managers find themselves facing:

1. The wide variety of species present makes large numbers of species assessments virtually impossible.
2. The need to access the most productive species in order to benefit the largest numbers of people and generate revenue for development.
3. Capacity issues in terms of staffing and availability of expertise, which may limit the resources that can be allocated to conducting stock assessments across multiple species on a timely and regular basis.
4. The challenges of separating species in catches, which can make species-based assessments impractical to implement in terms of management.
5. Managing any more than a small number of species at their own MSY is not protective of the ecosystem (Walters et al 2005).

The Fox and Schaeffer models used in many of the tropical countries of interest to this report have some advantages and disadvantages when applied to multispecies fisheries. On the positive side they take account of any changes in the structure of fish communities arising from changes in the abundance of predators and prey.

An example is from the Indonesian stock assessment system below:

Figure 3.8 – Data sources and modelling approach used in Indonesia

<table>
<tr><th>FMA</th><th>Small Pelagic</th><th>Big Pelagic</th><th>Demersal</th><th>Reef Fish</th><th>Shrimp</th><th>Lobster</th><th>Crab</th><th>BSC</th><th>Squid</th></tr>
<tr><td>571</td><td colspan="3">Acoustic<br>(Survey Acoustic 2015, Port sampling BRPL)</td><td colspan="6" rowspan="3">Surplus production (equilibrium) Schaefer<br>(Statistic data until 2015 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>572</td><td colspan="3" rowspan="2">Acoustic<br>(Survey Acoustic 2016, Port sampling BRPL)</td></tr>
<tr><td>573</td></tr>
<tr><td>711*</td><td colspan="3" rowspan="2">Acoustic<br>(Survey Acoustic 2017, Port sampling BRPL)</td><td rowspan="2">Non-equilibrium<br>(Statistic data until 2016)</td><td colspan="5">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>712*</td><td>Schaefer-<br>2016</td><td>EQ Fox-<br>2016</td><td colspan="3">Schaefer (Statistic data until 2016)</td></tr>
<tr><td>713</td><td colspan="2" rowspan="2">Acoustic<br>(Survey Acoustic 2016, Port sampling BRPL)</td><td></td><td colspan="6" rowspan="2">Schaefer (Statistic data until 2015 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>714</td><td></td></tr>
<tr><td>715*</td><td colspan="2">Acoustic<br>(Survey Acoustic 2017, Port sampling BRPL)</td><td>Non-equilibrium<br>(Statistic data until 2016)</td><td>EQ Fox-<br>2016</td><td colspan="5">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>716*</td><td colspan="2">Acoustic<br>(Survey Acoustic 2015, Port sampling BRPL)</td><td>EQ Fox-<br>2016</td><td>EQ Fox-<br>2016</td><td colspan="4">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td><td>Non-equilibrium<br>(Statistic data until 2016)</td></tr>
</table>

| | | | |
|---|---|---|---|
| 717 | | Surplus production (equilibrium) **Schaefer** (Statistic data until 2015 [production per species per gear], Port sampling BRPL) | |
| **718*** | **Acoustic** (Survey Acoustic 2016, Port sampling BRPL) | **Schaefer** (Statistic data until 2016 [production per species per gear], Port sampling BRPL) | **Non-equilibrium** (Statistic data until 2016) |

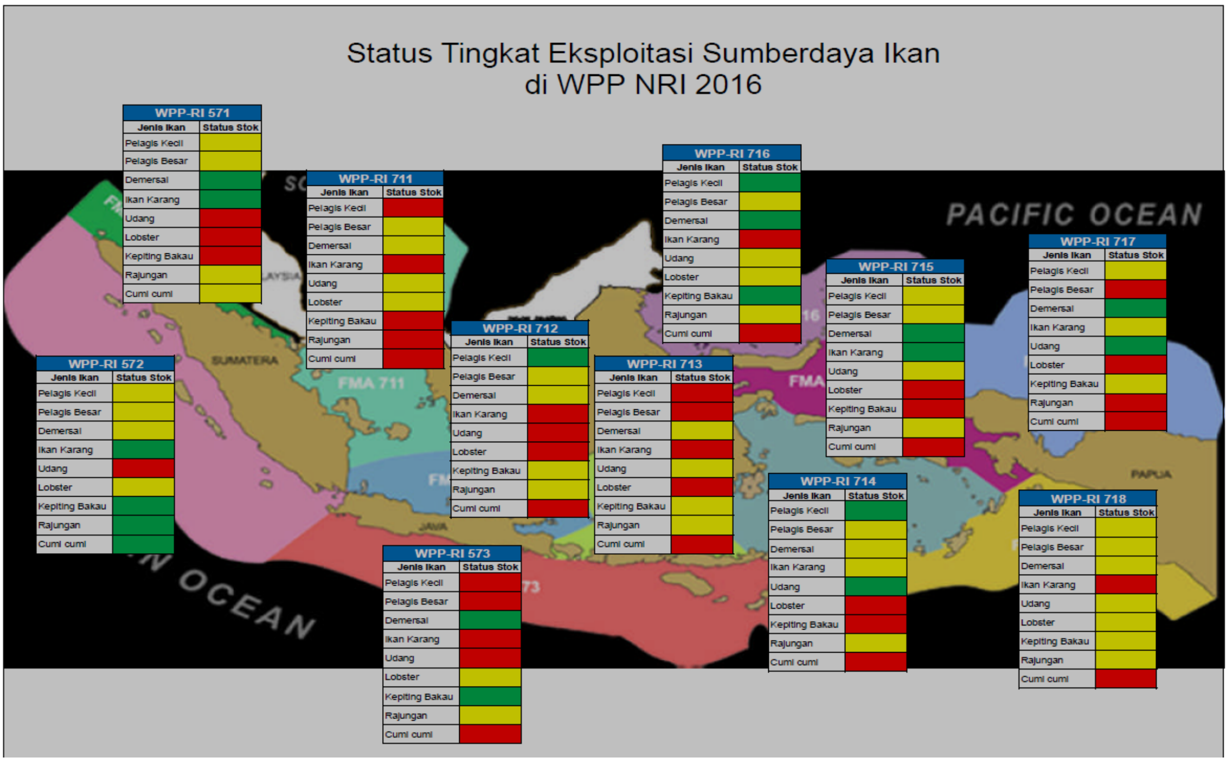



Figure 3.9 Outcomes from the assessment process Source: Suman et al (2018)

Actual yield estimates from Sunan et al (2018) are presented in Section 4.3

Thailand has adopted Multispecies MSY (MMSY) as a target reference point for its main fisheries (demersal and pelagic in both the Gulf of Thailand and the Andaman Sea. Its aim is to reduce effort to a point that will rebuild stocks and enable a sustainable yield from all stocks in the management area. As can be seen from

The Thai government has conducted some individual species based stock assessments. Those that are publicly available are relatively old. Under the current management plan, some species will be exploited at levels above their MSY (generally slower growing species), other will be close to their individual MSYs and the rest will be exploited at lower levels. The latter will include species that are not especially vulnerable to trawl gear and/or are relatively resilient to fishing pressure. In this sense, the overall outcomes are no different to a single species approach except that the single species would drive the management regime, not the overall yield. For example, in some shrimp trawl fisheries there will be some species that have low population levels and those that are robust to trawling. In both cases, the requirements of the UNCLOS are that these species are to be kept at levels above their PRI. In the MSC system the proof point for this is the outcome of the risk based analyses.

Having said the above, there has been considerable effort devoted to undertaking assessments of the status of individual species and it is possible to find assessments of some surimi species in Thailand, China, India and others. By and large the results are far from encouraging. Where the results are within workable timefames (the past 5 years at the very least) we could not find any stock assessments for individual species that indicated a stock in a healthy state but it should be noted that we have spent a limited amount of time searching web based literature and there may be recent assessments held by governments in languages other than English. Some examples that we have found include stock assessments that were made available in 2009 (FAO 2009)(Figure 3.10). For Thailand *Nemipterus hexodon* is listed as fully fished whereas *Priacanthus tayenus, Saurida elongata* and *S. undosquami* are listed as overfished.

| Selected species | | Catch trend | Survey index | Over - capacity | Status | Remark |
|---|---|---|---|---|---|---|
| Threadfin breams | *Nemipterus hexodon* | + | – | O | F | s |
| Bigeyes | *Priacantrus tayenus* | + | – | O | O | s |
| Lizard fish | *Saurida elongata* | – | + | O | O | s |
| Lizard fish | *Suarida undosquamis* | – | + | O | O | s |

Figure 3.10 Status of selected surimi fish species, Gulf of Thailand, 2009

In the case of China, Feng et al (2009) conducted an assessment of the Sparid, *Paragyrops edita,* in the Beibu Gulf (northern Vietnam, southern China and found that in this area this species was at a level of about 12.5% of its pre-fishing biomass.

More detail on country level stock assessments can be found in Chapter 4.

The Asia Pacific Fisheries Commission (APFIC), for a number of years, produced reports on the status of aggregate species groups, including 'surimi fish'. These assessments were based on information supplied by member countries and could be either individual species assessments or groups of species (and higher taxonomic levels).

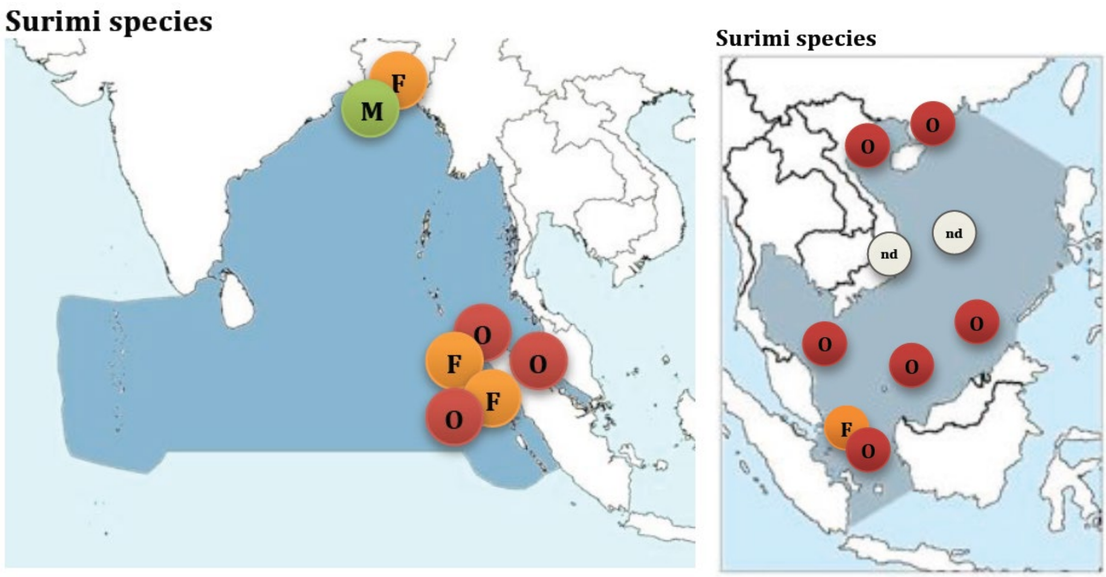



Figure 3.11 Status of surimi species in Asia in 2011 (Source – APFIC 2012).

An example of the application of assessments for species groups can be found for Pakistan. Patil et al (2018) analysed available information on a wide range of species groups, including those used for surimi. There were no species groups for which biomass was at or above Bmsy and for which fishing mortality was acceptable.

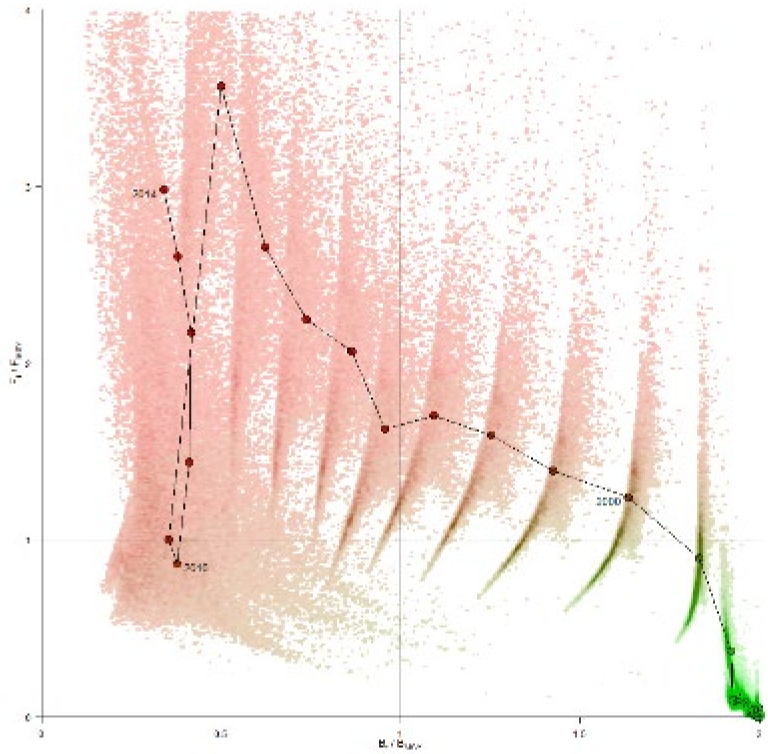


Figure 3.12 Decline in the status of Nemipterids (Nemipterus and Scolopsis) in Pakistan (Patil et al 2018).

## 3.18 Conservation status of species

As with the discussion about overfishing, a consideration of the impacts of the surimi sector on species that may have been identified as being of conservation concern is complicated by the fact that the fisheries involved are not dedicated surimi fisheries and the main fisheries supplying surimi fish may not be the only ones affecting the species of concern. In this section we consider species listed as Vulnerable or in poorer condition by the IUCN and species which are listed on Appendices 1 or 2 of CITES. We have not searched the national legislation of all seven countries but we do have so called Red Lists for Thailand and Vietnam available.

With these caveats noted we have evaluated literature covering species of conservation concern used in surimi and species of conservation concern associated with the main fisheries (broadscale, gear focused).

### 3.18.1 Species used in surimi

Two species listed by the IUCN in categories that require action:

- *Evynnis cardinalis* (threadfin porgy) – listed as endangered (Iwatsuki and Carpenter (2014). This species occurs along the northern coast of Vietnam and in the waters of China, North and South Korea and southern Japan. It has been heavily fished with socks in some areas estimated to be at 12% of their original biomass. It is used in the manufacture of surimi in the region.
- *Nemipterus virgatus* (golden threadfin bream) – listed as Vulnerable (Carpenter et al 2017). This species is distributed from northern Australia through to central China and southern Japan. Ts is listed because it meets a criterion relating to population declines of 30% or more. It is widely used in surimi.

Landings of the golden threadfin have declined significantly, as documented in FAO FishStat (Figure 3.13).

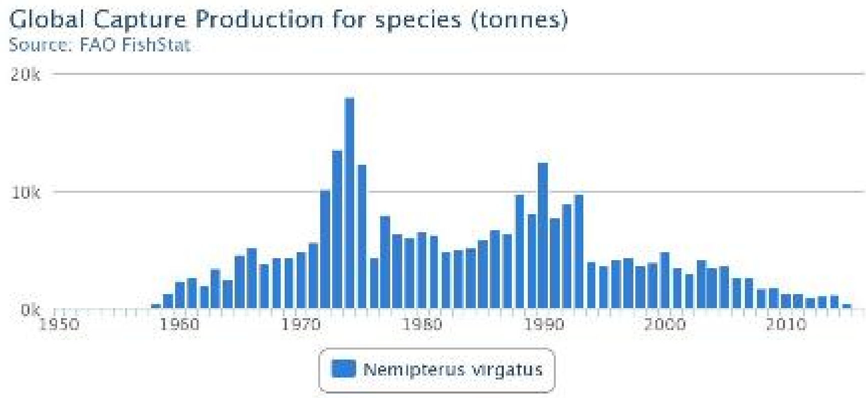



Figure 3.13 Decline in landings of *Nemipterus virgatus*

- *Rhinobatos jimbaranensis* (Jimbaran shovelnose ray)- is listed as Vulnerable (White 2006). It is found around the island of Bali in central Indonesia and is listed due to its restricted range and evidence of decreasing numbers. It was recorded as being present in one out of 29 surimi products analysed using DNA (Galal-Khalaff et al 2016). It is unlikely to be a species that underpins surimi production but does illustrate some of the risks associated with mixed species surimi production. Note that it is mainly taken by gillnet fishermen but this does not imply that an occasional specimen is taken by other gear.

Given the variable status of species within genera and families, its important to try and identify species to the lowest taxonomic level possible. As an example, the closest taxonomic level we could find for the small pelagic group, *Trachurus*, was at the genus level. There are two species within this genus that are IUCN Vulnerable listed (*T. trachurus* and *T. indicus*) and for *T.indicus*, its status depends on which ocean it is sourced from.

We found three groups for which there were only family level references (Carcharinidae – sharks, Polynemidae – threadfins, and Siganidae – rabbitfishes). The family Carcharinidae in particular, has a growing number of species listed as vulnerable, endangered or critically endangered and surimi products with these species included present not only a risk to the shark population themselves but also a market risk.

Finally, each country may have its own list of threatened species. Thailand, Vietnam and China all have Red Books. In the case of *Cyprinus Pellegrini*, a species of carp found in China and recorded in surimi, it does not appear on the IUCN Red List but is listed as Vulnerable in the Chinese Red Data Book of Endangered Species (Shen et al (2009). It may well be a farmed species now. We did not have time to check country level listings of species.

### 3.18.2 Species that interact with fishing gear

Almost any type of fishing gear may interact with species of conservation significance. A simplistic overview of interactions is as follows:

1. Turtles – trawls, gillnets and longlines are known to interact with marine turtles in a negative way unless mitigation actions are taken. Trawls are known to be contributing to the declines in turtles across Asia.
2. Marine mammals (dugongs, whales and dolphins) – trawls are not the main source of fishing related mortality. Gillnets have much greater impact.
3. Seabirds – seabird impacts do not appear to be a major issue in the tropics;
4. Sea snakes – trawls likely to be a major source of mortality but poorly researched;
5. Seahorses and similar species – trawls known to be a major source of mortality.
6. Sharks and rays (including saw sharks, wedge/guitarfishes and manta rays) – trawls are a known and significant source of mortality, along with gillnets.
7. Fish species of concern – we have not conducted an intensive search of databases but a growing number of bony fishes are being listed as Vulnerable or Endangered, Critically Endangered. There are several members of the genus Epinephelus in these categories that are found in the region such as the Hong Kong grouper (E. *akaara*), Brown marbled grouper (E. *fuscoguttatus*) and the longtooth grouper (E. *bruneus*). None of these are known to form the basis for surimi production but its possible they may be detected in mixed species surimi.

Some of the species in the categories listed above have an economic value (sharks, rays, seahorses, sea snakes) and the trawl caught component may be sufficient to have local buyers.

# Chapter 4 Country level overviews

## 4.1 China

### 4.1.1 Development of the surimi industry

Whilst surimi products have been part of local culture for centuries the industrialisation of production began in the mid 1980s with freshwater fish and then with marine fish in the 1990s. Production grew rapidly from about 2002 (China 2013 file).

### 4.1.2 Current production – surimi and surimi seafood

Production of surimi in 2019 was just over 300 000 of which about 230 00t was from marine fish and 70 000t from freshwater fish

Surimi seafood production was estimated at about one million metric tonnes, noting that Chinese surimi products have a low proportion of fish (about 25%) due to the use of meat and vegetables.

### 4.1.3 Imports and exports

Imports of surimi are estimated at 35 000 tonnes and exports at 45 000 tonnes.

### 4.1.4 Companies

The main surimi producers in China are as follows:

- Long Sheng Aquatic Products
- Taizhou Dahua Food Co., Ltd.
- SHANDONG FENGHUA FOOD Co., Ltd
- Hungan Fishery
- Ningbo Fei Ri Marine Industrial
- Ningbo Lan Yang Aquatic Food
- Shishi Huabao Mingxiang Foodstuff
- Shishi Zhengyuan
- Xiangshan Kaiyuan Frozen Auqatic
- ZhongGang Aquatic Food
- Haichuan Aquatic Products
- Hong Hu Shi Jing Li Shui Chan (silver carp)
- XiangShang Shipu Guolong Aquatic

The main surimi seafood producers in China are as follows:

- Anjoy Foods Co. Ltd
- DALIAN YOULIAN SEAFOOD Co., Ltd
- SHANDONG FENGHUA FOOD Co., Ltd
- Xiamen Yuanxiang Food Industry Co.,ltd

### 4.1.5 Main species used

A wide variety of fish species are used for surimi in China and the list below is likely a small fraction. As with other countries the composition of 'mixed fish' surimi is unknown. China is also a large importer of fish for processing and its not clear if all the species mentioned are caught in the waters of China. Nevertheless, al of the species below can be found in Chinese waters:

- White croaker - *Argyrosomus argentatus* (Kusol 2010, Liu et al 2015)
- Hairtail – *Trichiuris haumele* (Kusol 2010, Liu et al 2015)
- Hairtail – *Trichiuris lepturus* – (http://bbs.foodmate.net/thread-822478-1-1.html)
- Sharptooth (conger) eel - *Muraenesox cinereus* (http://bbs.foodmate.net/thread-822478-1-1.html)
- Tongue sole - *Cynoglossus robustus* (http://bbs.foodmate.net/thread-822478-1-1.html)
- Sea breams - *Taius tumifrons, Dentex tumifrons* (Kusol 2010)
- Red gurnard - *Chelidonichthys kumu* (Kusol 2010)
- Small fin gurnard - *Lepidotrigla microtear* (Kusol 2010)
- Lizardfish - *Saurida elongata* (Kusol 2010)
- Lizardfish – *Saurida undosquamis* - (http://bbs.foodmate.net/thread-822478-1-1.html)
- Flathead – (Kusol 2010) - species not mentioned
- Yellow croaker – species not mentioned
- Golden Threadfin Bream *Nemipterus virgatus (*www.cport.net*, Liu et al 2015)*
- Japanese Spanish mackerel *Scomberomorus niphonius* (Pan et al 2018).
- Red mullet (goatfish) - *Upeneus bensasi* (http://bbs.foodmate.net/thread-822478-1-1.html)
- Bigeye - *Priacanthus macracanthus* (http://bbs.foodmate.net/thread-822478-1-1.html)

In addition are the following records which are identified only to family level (sourced from http://bbs.foodmate.net/thread-822478-1-1.html)

| Chinese Name | English Name | Latin Name |
|---|---|---|
| 黑口 | Black croaker | Sciaenidae |
| 鲹鱼（巴拢、铁甲、红尾） | Scad | Carangidae |
| 鲛鱼（沙鱼） | Shark | Carcharhinidae |
| 铜盆鱼 | Sea bream | |

Increasingly China has a large portion of its annual surimi production based on farmed silver carp (*Hypophthalmichthys molitrix* - Yin et al 2017). Silver carp is not the only species used. For example, Longshen Surimi also makes surimi from Big Head carp (*Hypophthalmichthys nobilis)* although the volumes are small due to greater demand for the fish (and higher prices) from the food service trade.

#### 4.1.6 Sources

China is known to source raw material for surimi production from domestic marine waters and from aquaculture. There may also be:

- Domestic freshwater wild caught fish – unclear if farmed or wild.
- Imported whole fish
- Imported farmed fish

#### 4.1.7 Domestic fisheries

The FAO FishStatJ database was interrogated to provide data on reported landings of any species of barracudas, bigeye snappers, threadfin breams, croakers, lizardfishes and goatfishes. China's reported landings of these species groups is in Figure 4.1

| (N | ASFIS spec | FAO major | [2009] | [2010] | [2011] | [2012] | [2013] | [2014] | [2015] | [2016] | [2017] | [2018] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Croakers, ( | Pacific, No | 314061 | 320516 | 367818 | 377071 | 362696 | 372480 | 373575 | 354804 | 332610 | 297321 |
| | Large yello | Pacific, No | 62807 | 63358 | 65234 | 71075 | 91070 | 95515 | 104560 | 79543 | 68890 | 68317 |
| | Silver croa | Pacific, No | 126470 | 131026 | 124935 | 120502 | 120408 | 109471 | 108461 | 102378 | 94412 | 95889 |
| | Threadfin I | Pacific, No | 306456 | 314922 | 323068 | 332192 | 331655 | 411263 | 400604 | 439716 | 374572 | 334314 |

Figure 4.1 – landings of main surimi species groups in China as reported to FAO

The Chinese Fisheries Yearbooks will provide far more detail but these are not available in English. There is no suggestion that all of the landings reported to FAO are used solely for surimi but certainly the combined landings of croakers and threadfin breams alone could easily account for China's current production, at least in terms of the industrial trade. The volume of small-scale production of fish balls and similar products is unknown but likely to be large.

**4.1.8 Stock status**

Broadly speaking China's fish stocks have been under enormous fishing pressure since the mid 1980's and there is abundant evidence of overfishing of sought after species (such as large yellow croaker and hairtails), declines in the average sizes of fish, shifts in the community structure of ecosystems in favour of small, fast growing species and overall declines in fish density (Ye et al 2011). Ye et al (2011) document the rapid expansion in fishing effort in the Northern South China Sea between 1980 and 2000 and the relatively modest increase in catches to 1995 prior to a decline in both landings and catch per unit effort. Based on stock assessments conducted in 2009 (Qiu 2009) they found that all of the demersal species commonly associated with surimi production were either depleted or overexploited:

Figure 4.3 – status of stocks of species that are commonly associated with surimi production (sourced from Ye at al 2011). Note that not every species listed here matches what is known to be used but there is sufficient uncertainty in what is known to be used for this table to be a guide.

| Common name | Latin name | Overcapacity? | Status |
|---|---|---|---|
| Croceine croaker | *Larimichthys crocea* | Yes | D |
| Conger pike | *Muraenesox cinereus* | Yes | D |
| Goatfishes | *Upeneus spp* | Yes | D |
| Threadfin bream | *Nemipterus japonicus* | Yes | D |
| Threadfin bream | *Nemipterus virgatus* | Yes | O |
| Threadfin bream | *Nemipterus bathybius* | Yes | O |
| Mi-iuy croaker | *Miichthys miiuy* | Yes | O |
| Hairtails | *Trichiurus spp.* | Yes | O |
| Silver croakers. | *Pennahia spp* | Yes | O |
| Big-eye snapper | *Priacanthus macracanthus* | Yes | O |
| Big-eye snapper | *Priacanthus tayenus* | Yes | O |
| Threadfin porgy | *Evynnis cardinalis* | Yes | O |
| Greater lizardfish | *Saurida tumbil* | Yes | O |
| Brushtooth lizardfish | *Saurida undosquamis* | Yes | O |

Where D- depleted and O-overexploited

An analysis of trawl data from the 1960s to the 1990s (Wang and Yuan 2008) revealed that The demersal fishery resources in all areas of the northern South China Sea have been overexploited and more severe overfishing occurred in the inshore and offshore waters than in the outer shelf. Much of this overfishing had taken place prior to the development of the industrial surimi industry. The Fujian area is one where there are a number of surimi factories located and where some species of croakers are overexploited (Zhang et al 2020) as are hairtail (Yan 2005) as part of a wider overfishing problem (Lu 2006). Given that many, if not most, species have multiple uses it can't be assumed that the surimi sector is responsible for driving the excessive fishing pressure.

Huang (2005) found that the stock of *Nemipterus virgatus* had declined markedly near the Nansha Islands, with the average catch rate decreasing from 3.32 kg/h to 1.10 kg/h, the stock density from 36.73 kg/km$^2$ to 14.37 kg/km$^2$ and the biomass from 3 178.60 t to 1 053.15 t. The present abundance is only 33.24% of the original. It should be noted that trawl fisheries are not the only ones taking threadfin breams with gillnet fishers also involved (Zhang et al 2005).

Abundance can be variable according to area. A considerable amount of research and stock assessment work (Zhang et al 2015) is being undertaken in the South China Sea where Xu et al (2015) found that the most abundant species in several trawl surveys included bigeye snappers (*Priacanthus macracanthus*), two species of lizardfishes (*Saurida tumbil* and *S. undosquamis*) and hairtail (*Trichiuris lepturus*).

Whilst some species are believed to be robust to high fishing pressure, the take of small fish, especially juveniles, is a source of concern, if only because yields could be higher (Wang et al 2012) if the fish were allowed to grow before capture. Tong et al (2012) found that juveniles dominated the trawl catch in Hainan province and suggested that the trawl fishery be closed whereas in other areas the occurrence of the same issue has resulted in suggestions that mesh sizes be increased (Zhang et al 2006). The heavy fishing pressure can make interpreting productivity of a stock difficult, an issue discussed by Zhang et al (2018) in the context of hairtail which has been heavily fished but the remaining population of far smaller animals is quite productive. A wider issue, and one that is common in multispecies fisheries is the differential fishing pressure on species of different vulnerabilities. Wang et al (2019) found that fishing pressure accounted for a greater influence over changing fish populations than natural oceanographic factors or climate change. An analysis by Szuwalski et al (2017) concluded that production had increased due to the high fishing pressure which had favoured small, fast growing species, a phenomenon seen through Asia (if not elsewhere). This phenomenon has been interpreted as meaning that fishing does not need to be regulated but the species that benefit from this pressure are not predictable and one concern is that the species mix favoured may not only be economically unviable but could prevent the ecosystem from recovering even if fishing pressure was reduced.

### 4.1.9 Current management

Fisheries management in China is both complex and there is little evidence (at least in the English language literature) that it is working. Jin and Cheng (2017) claim that the summer fishing moratorium is having a positive effect but Shen and Heino (2015) claim that the benefits are quickly dissipated after fishing recommences each year. The moratorium was first initiated in the mid 1990's and has bene expanded both in time and in space to include much larger parts of the coast. Jiang et al (2009) found that the moratorium has had little impact on fish community structure but its not clear if this was one of the objectives of the moratorium.

### 4.1.10 Other fishery issues

Not only does China have the largest high seas fleet of fishing vessels it has also moved to expand its jurisdiction into the South China Sea, an area it claims to have historically accessed but this claim was denied by the Permanent Court of Arbitration (https://en.wikipedia.org/wiki/Philippines_v._China). There have been a number of interactions between Chinese coast guard vessels and fishing vessels from Vietnam, the Philippines and Indonesia.

Chinese vessels are also associated with labour rights violations - https://www.thestar.com.my/aseanplus/aseanplus-news/2020/07/09/indonesian-found-in-freezer-on-chinese-fishing-vessel#cxrecs_s. As to how widespread this is inside the China EEZ or on vessels associated with the taking of surimi species is unknown.

## 4.2. India

### 4.2.1 Development of the surimi industry

The first surimi plant was established in the west coast town of Ratnagiri in 1994. By 2005 the industry had expanded and was producing about 40 000t per year (Guenneugues 2018) which is a substantially higher estimate than available in the FAO database (2100t in 2004 and 5830 in 2003 – Vidal-Giraud and Chateau 207). This has continued to grow such that by 2018 production had reached 80 000t (Guenneugues 2018)

### 4.2.2 Current production - surimi and surimi seafood

Current production is about 90 000t of surimi and about 12 000t of surimi seafood

### 4.2.3 Imports and exports

India exports about 80 000t of surimi

### 4.2.4 Companies

The main surimi producers are as follows

- Gadre Marine
- Ulka Seafoods
- Amargagar Seafood
- Nishi Indo Foods
- Naik Oceanic Export
- Kaiko Surimi – India
- Kan Victual
- Yashaswi Surimi
- Authentic Ocean Treasure
- M.D. Brothers (Kan Group)
- Silver Star Exports
- Sea Star Frozen Foods (Shree Tulsi Exports)
- K.R. Sea Foods
- Goan Fresh Marine Exports
- Yashaswi Surimi Marine
- Pesca Marine Products
- Party Time Ice

The main surimi seafood producers are as follows

- Gadre Marine

### 4.2.5 Main species used

One company (Gadre Marine), which is also the oldest in India, lists the species it uses on its website as follows:

- *Nemipterus japonicus*

- *Sardinella spp*
- *Priacanthus spp* – probably P. *hamrur*
- *Saurida tumbil*
- *Lepturacanthus savala*
- *Johnius spp*
- *Epinephelus dicanthus*
- *Parupeneus indicus*
- *Odonus niger*

The company also produces surimi from mixed species. It also uses another Sciaenid - *Otolithoides brunneus* – known locally as Koth.

*Odonus niger* is probably a very recent addition to the species as it has undergone a population explosion in the past couple of years and is now one of the main species caught in India. The reasons for this are unknown.

#### 4.2.6 Sources

As far as can be ascertained the main sources of fish are domestic. According to one company, supplies can be trucked in from hundreds of kilometres away, including from the east to the west coast.

#### 4.2.7 Domestic fisheries

The majority of species used are taken in demersal trawls. Some, such as sardines and ribbonfish may be taken in purse seines. For the most commonly used species (threadfin breams, lizardfishes, bigeyes and croakers) trawls are responsible for over 90% of the take (CMFRI 2019).

Gaining an understanding of landings, in terms of species and areas, is challenging. There are two sources of statistics in India, one set maintained by the Central Marine Fisheries Research Institute (CMFRI) and the second by the national Department of Fisheries. In addition, India also reports landings to the FAO. Both the CMFRI and the Department of Fisheries aggregate species level data to varying taxonomic levels which is understandable but at times it obscures important information. More detailed information is available from the CMFRI, but at significant cost.

Each source of information differs. As demonstrated in Figure 4.3 below not all species are reported to the FAO, for example bigeye snappers. The national department of fisheries does not include the threadfin breams in its fisheries statistics (Anon 2018).

| ASFIS species (Name) | FAO major fishing area (N | [2009] | [2010] | [2011] | [2012] | [2013] | [2014] | [2015] | [2016] | [2017] | [2018] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Barracudas nei | Indian Ocean, Eastern | 8958 | 7836 | 8119 | 5790 | 6599 | 12350 | 19000 | 23900 | 21069 | 29305.86 |
| Barracudas nei | Indian Ocean, Western | 2663 | 5045 | 7329 | 3366 | 3836 | 7259 | 11065 | 13917 | 12268 | 17064.14 |
| Bigeyes nei | Indian Ocean, Eastern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30940 | 46682 | 13807.61 |
| Bigeyes nei | Indian Ocean, Western | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 99800 | 150576 | 44537.39 |
| Croakers, drums nei | Indian Ocean, Eastern | 55060 | 52432 | 63046 | 56374 | 54963 | 32364 | 31383 | 31893 | 30367 | 27377.62 |
| Croakers, drums nei | Indian Ocean, Western | 189655 | 185107 | 200349 | 221290 | 215750 | 129500 | 124000 | 125900 | 119874 | 108073.4 |
| Goatfishes | Indian Ocean, Eastern | 22028 | 20553 | 19022 | 20628 | 25693 | 12400 | 17000 | 16900 | 11335 | 10558.53 |
| Goatfishes | Indian Ocean, Western | 11988 | 11188 | 10053 | 16004 | 19933 | 9685 | 13470 | 13376 | 8971 | 8356.47 |
| Hairtails, scabbardfishes nei | Indian Ocean, Eastern | 25997 | 19629 | 27734 | 26610 | 33315 | 50405 | 44259 | 54200 | 59756 | 48388.49 |
| Hairtails, scabbardfishes nei | Indian Ocean, Western | 74786 | 124981 | 102662 | 83007 | 103921 | 159000 | 133000 | 162900 | 179599 | 145433.5 |
| Lizardfishes nei | Indian Ocean, Eastern | 1705 | 2436 | 2042 | 6994 | 8897 | 19202 | 27838 | 33917 | 20677 | 25017.16 |
| Lizardfishes nei | Indian Ocean, Western | 10308 | 11325 | 6002 | 12955 | 16481 | 35000 | 50000 | 60900 | 37126 | 44918.84 |
| Threadfin and dwarf breams n | Indian Ocean, Eastern | 0 | 0 | 0 | 0 | 0 | 53431 | 62764 | 65699 | 60849 | 70778.19 |
| Threadfin and dwarf breams n | Indian Ocean, Western | 0 | 0 | 0 | 0 | 0 | 83500 | 100000 | 104650 | 96924 | 112739.8 |

Figure 4.3. Landings of main surimi species groups in India as reported to FAO (Source – FAO FishStatJ)

Zacharia and Najmudeen (2017) provide a useful overview of the nation-wide production from demersal fleets by species group (Figure 4.4) below.

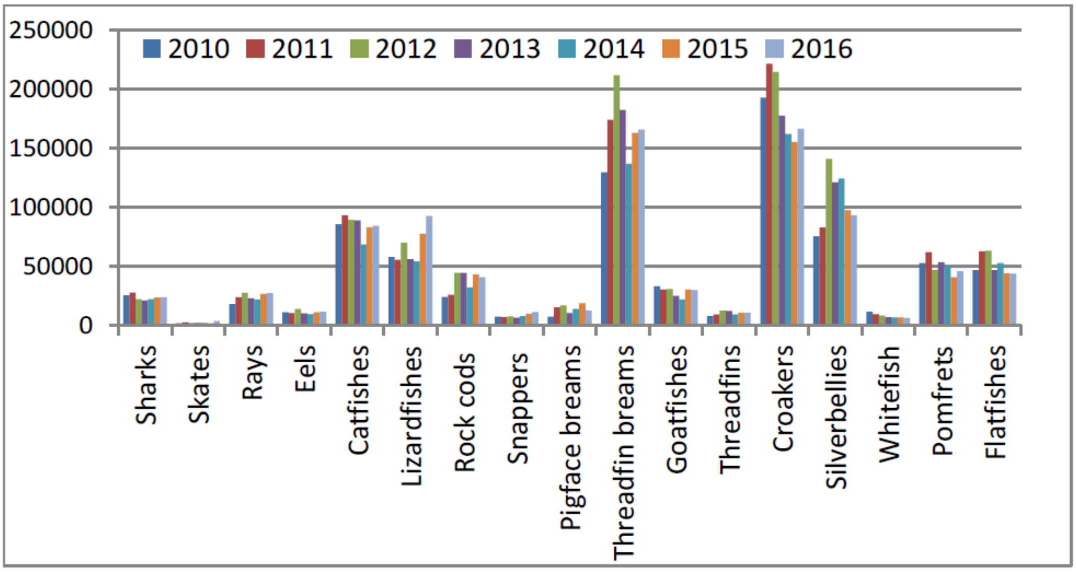



Figure 4.4 Trends in landings of main demersal finfish species during 2010 to 2016.

The CMFRI does not separate bigeye snappers from other groups yet according the Zacharia and Najmudeen (2017) the catch is far from trivial having increased from 43576t in 2015 to 130 000t in 2016.

There is a considerable variation from state to state in the production as displayed below for the threadfin breams. Within this, there is also likely variation in terms of the main species caught. In the 2018-19 annual report the CMFRI has State based reports which cover different aspects of the fisheries. For example, for Gujurat there is a figure for the trawl CPUE but this is not covered in other States. In contrast the dominance of trawl as the main source of landings is covered and varies from 42% to 82%.

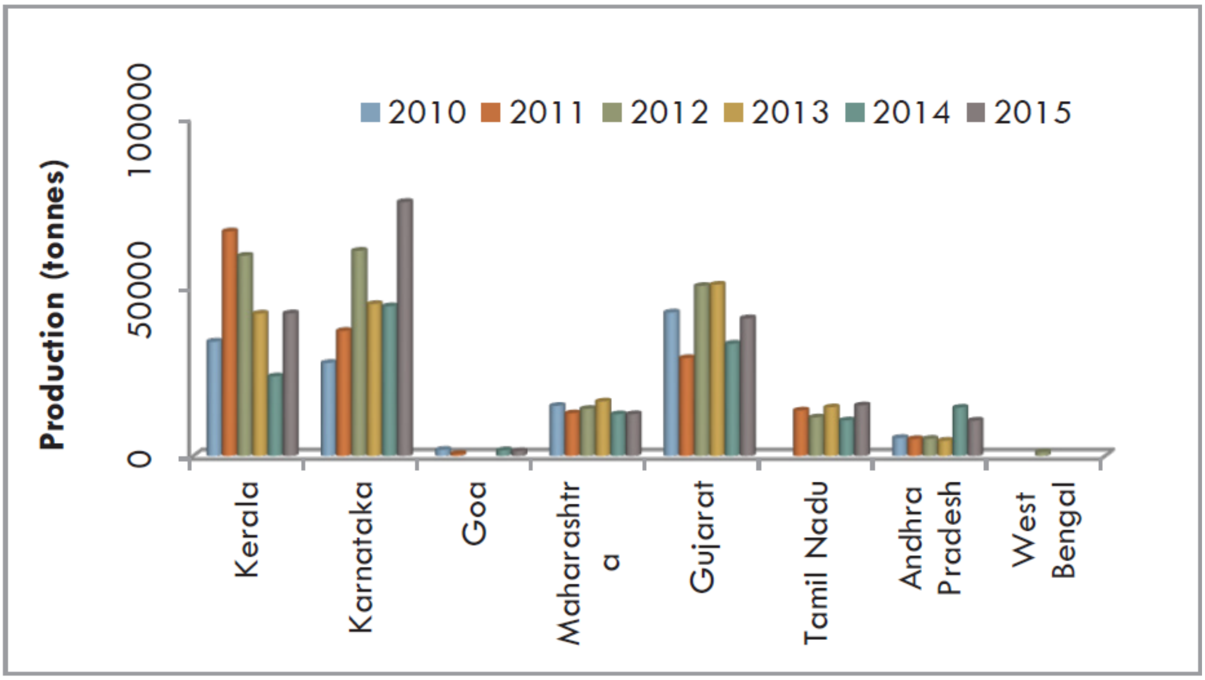



Figure 4.5 State-wise trends in landings of threadfin breams (Source: Zacharia and Najmudeen (2017).

For the threadfin breams there are six species recorded in India (*Nemipterus japonicus, N randalli, N. bipunctatus, N. zysron*, *N. nematophorus* and *N. tolu – also called N. peronii*) but there are also records of others such as *N. mesoprion N. delagoae* and *N. luteus (*this species does not appear in Fishbase)(Sivakami undated). Of these *japonicus* and *randalli* seem to dominate the catches (Zacharia and Najmudeen 2017) but Joshi (2010) found that catches in Kerala State were dominated by *japonicus* (41%) and *mesoprion*. In Maharshtra State in 2018 (CMFRI 2019) the catches were 54% *japonicus*, 38% *randalli* and 8% *bipunctatus*. In Kerala State, to the south *randalli* was dominant (54%) and *japonicus* was 44%.

The lizardfishes are slightly more diverse with 5 species being reported in catches (Zacharia and Najmudeen 2017) out of at least 19 species recorded in Indian waters. Species composition also varies from one coast to another.

The family Sciaenidae (croakers and drums) is particularly diverse. Twenty species in ten genera are recorded for India as a whole and records of landings sometimes only report volumes at the genus level. For example, in the state of West Bengal nine species are recorded in landings (*Johnius dussumieri, Johnius carutta, Johnius borneensis, Otolithes cuvieri, Otolithoides biauritus, Otolithes ruber, Nibea maculata, Protonibea diacanthus, Pennahia anea*). In Maharashtra State, which has surimi production factories the catch of Sciaenids was reported as follows - *Johnioeps* spp. (46.8%), *Johnius* spp. (34.5%), *J. belangerii* (5.27%), *Otolithoides biauritus* (5.2%) and *Otolithes* spp. (5.5%) – most of the catch is reported at the genus level. Its true that not all may be used for surimi.

There is an abundance of information about many of the important species used for surimi and its not possible to review all of it here.

**4.2.8 Stock status**

Sreekantyh et al (2015) noted that that threadfin breams were originally a bycatch in the shrimp trawl fishery in Kerala but found favour for both direct human food and for the surimi industry. Catches increased as fish trawling expanded into deeper water and they called for management measures to be implemented

Najmudeen et al (2014) documented the decline in trawl catch per hour for the south west coast of India and found that the increase in landings was largely due to increased effort both in terms of time spent at sea and a move into deeper waters. In a recent paper Sathianandan et al (2020) evaluated sustainable yields and current catches for the trawl fleets (single and multi day) operating in the south west of India (Kerala to Goa) and determined that there was overexploitation occurring due to excess capacity. The degree varied from State to State and by trawler type. They recommended that the number of multiday trawlers be reduced by 207 and the number of day trawlers by 36.

It should be noted that the use of total biomass as a basis for determining yields can mask changes in species composition and a shift in favour of smaller, faster growing species is a well known consequence of high fishing pressure, a point noted by Mohamed and Zacharia (1997) in their earlier evaluation of the trawl fleet in the same region. Moreover, many of the less common, slower growing species are also higher in value and so as these disappear the value of the catch may also decline (if not buffered by the increased volume of faster growing species). Xavier (2014) studied the trawl fleet in Kerala and found that the economics of the trawl fleet had declined over time.

Looking specifically at the Nemipterids, as they form a relatively large component of trawl catches along the west coast, there area series of studies that document their declining state. Murty et al (1992) conducted a wide-ranging review that covered both the west and east coasts and found that catches were generally sustainable but that there was a need to control effort and increase mesh sizes. Sobhana et al (2011) documented the high percentage of juveniles in the catches and labelled the fishing pressure as 'heavy exploitation'. Juveniles are also taken in the shrimp trawl fisheries as well. In their review of fisheries in Karnataka State, Mohamed et al (1998) list N. *japonicus* as fished at MSY but the lizardfishes were overexploited. Subsequently a study of N. *mesoprion* caught in South West India Manojkumar (2007) found that the exploitation rate was excessive. In terms of specific species. Sreekanth et al (2015) evaluated the status of N. *japonicus* and N. *randalli* off the Kerala coast and determined that exploitation rates were excessively high and the optimum yield could be achieved by reducing effort to 85% of that in place at the time of the study. In their study of N. japonicus off the Gujurat coast, Khileri et al (2017) found that catches were higher than the sustainable yield and called for management controls to be implemented.

Catches of threadfin breams grew from about 20 000 tonnes in the 1980s to 116 000t in 2000 (Murty et al 2003) and the sustainable yield of all species was estimated to be 128 000t in 2000, which was less than the 200 000t estimate for the south west coast alone in Nair et al (1996). Murty et al (2003) also mentioned that an increase in mesh size would be beneficial. Dineshbabu et al (2014) noted how discarding in the fishery had declined as demand for fishmeal had increased but that many of the fish being sent to the fishmeal plants were juveniles of species that had commercial importance in other markets.

#### 4.2.9 Current management

A short description of fisheries management in India can be found at (http://www.fao.org/fishery/docs/DOCUMENT/fcp/en/FI_CP_IN.pdf). Most of the trawl fleet is managed by the national government as fishing takes place outside of state waters. The types of tool used are similar to other countries in the region and include:

- Establishment of an inshore artisanal zone
- Annual fishing ban – generally June and July each year (likely shortened in 2020 to try and provide more jobs due to the COVID related slowdown)
- Mesh sizes
- Licencing/registration
- Limitations on entry to the fisheries via licence controls

There do not appear to be any management plans that link sustainable yields to fishing capacity and removals.

4.2.10 Other fishery issues

https://www.worldfishing.net/news101/industry-news/india-uses-holograms-to-tackle-iuu-fishing

## 4.3 Indonesia

#### 4.3.1 Development of the surimi industry

According to Hikmanyi et al (2017) industrial surimi production in Indonesia began in the late 1995 although its likely that, as with almost all Asian countries, there was local production of fish paste products, for far longer. According to Vidal - Giraud and Chateau (2007) production grew from about 4000t in 1994 to just over 9000t in 2004. By the mid 2000's there were 8 processing plants, mainly clustered in the central northern coast of Java. According to Pangsorn (2009) production in 2005 was an estimated 8000 tonnes, up from about 1800t in 2003. The differences in the figures between these two sources (especially the 2003 production figure which was 1800t for Pangsorn and about 5400t for Vidal-Giraud and Chateau) may be due to different reporting categories. The data reported by Vidal-Giraud and Chateau (2007) was based on FAO statistics which could include other types of frozen processed fish such as fish mince.

According to Ji (2018) the number of plants had grown to 15, again with the main cluster in central north Java.

### 4.3.2 Current production- surimi and surimi seafood

Current production of surimi is about 30 000t.

Local small scale production may well be considerable. One anecdotal source speculated that it may be of the order 50 000t per year but we could find no studies. Traditional Indonesia products " *otak-otak* " and " *pempek* " are two of many traditional products (see Table 1 in Agustini et al 2009) which are made from a wide variety of species. The links to surimi can be found in (https://en.wikipedia.org/wiki/Pempek) and (https://en.wikipedia.org/wiki/Otak-otak).

Processing of fish for production of local surimi style products – port of Juwana, north Java

Heads and guts sent to farmed fish producers.

### 4.3.3 Imports and exports

In 205 the volume of exports was about 41 000t and imports about 2300t (Hikmanyi et al 2017)

Surimi based products are imported into Indonesia. DNA analyses (Abdullah et al 2019) were carried out on some imported surimi products (fish balls, Chikawa) purchased in Indonesia to test for the inclusion of toxic pufferfish (*Lagocephalus* spp). The most common species as the threadfin bream (*Nemipterus bathybius*) and the Cardinal Seabream ( *Evynnis cardinalis)* but also, unusually, mahi mahi (*Coryphaena hippurus).* The country source of the products was not included in the paper by the presence of *E. cardinalis* suggests the source was either north Vietnam or China.

### 4.3.4 Companies

The main surimi producing companies are as follows:

- PT. Java Seafood
- PT. Indonesia Bahari Lestari
- PT. Blue Sea Industry
- PT. Holi Mina Jaya
- PT. Indo Seafood
- PT. Bintang Karya Laut (KML Group)
- PT. Kelola Mina Laut (KML Group)
- PT. Starfood International (KML Group)
- PT. Southern Marine Products
- PT. QL Hasil Laut

- PT. Tridaya Jaya Manunggal

The main surimi seafood producers are as follows:

- KML
- PT Central Proteina Prima
- PT Citra Dimensi Arthali
- PT. KML Plant II (KML Group)
- PT. KML Ichimasa Foods (KML Group)
- PT. Indomina Cipta Agung (KML Group)
- PT Central Proteina Prima
- PT Citra Dimensi Arthali (CDA)

#### 4.3.5 Main species used

Species used for surimi production in Indonesia come from the main families that are common throughout Asia namely the Nemipteridae (threadfin breams and monocle breams). Synodontidae (lizardfishes), Mullidae (goatfishes), Sciaenidae (croakers), Gerriedae (silver biddies), Sauridae (barracudas) and Priacanthidae (bigeye snapper) (Hikmanyi et al 2017), and Leigognathidae (ponyfishes)(personal observation).

Hikmayanyi et al (2017) also include the production of emperors (Lethrinidae)(lencam in Bahasa Indonesia) in their catch statistics associated with the surimi sector. The name lencam applies to a number of species in this family (White et al 2013). Hikmayanyi et al (2017) also record various species of grunts (Pomadasys spp)(listed as gerot-gerot), kerong-kerong (which applies to the Painted Sweetlip, *Plectorhinchus lessonii* and the Dotted Grouper (*Epinephelus epistictus)*, ekor kuni and pisang-pisang (which may apply to various members of the Lutjanidae – snappers, and/or Caesionidae – fusiliers). Whether these species have actually been recorded being used by surimi plants is unknown.

As outlined below there are a number of species in each of these families of fish found in catches and more than likely, each is used for surimi production. At one processing plant visited, there were two species of threadfin breams processed together as they were very similar, and this seems to be common practice.

Threadfin breams as supplied to surimi factory, north east Java

Pony fish as supplied to the same plant

#### 4.3.6 Sources

As far as can be ascertained, the main sources of surimi are demersal species caught in Indonesian waters.

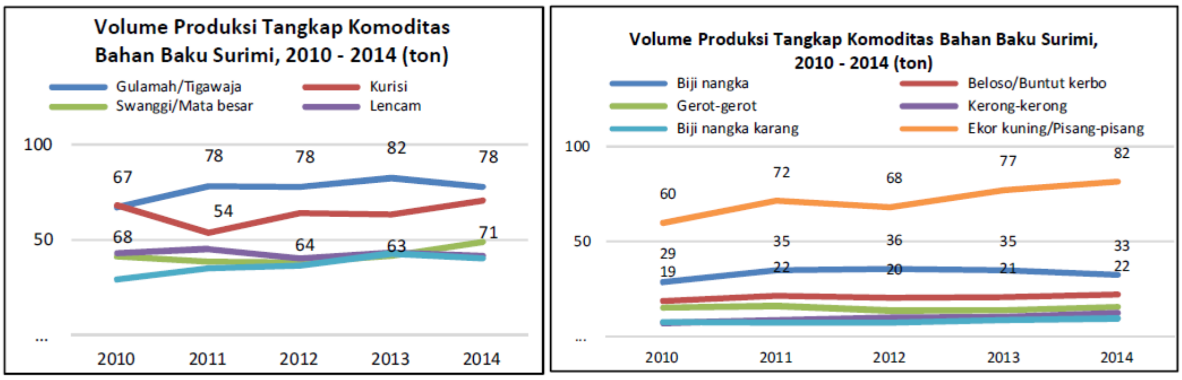
### 4.3.7 Domestic fisheries

Little research work has been conducted on the surimi industry in Indonesia and there is not a good understanding of the species used and from which fisheries they are derived. Anecdotal information and a few research papers suggest that the primary sources of the main species of fish for surimi would be the fish trawl fisheries that operate in the waters of the Arafura Sea and the Danish Seine (known in Indonesia as cantrang or dogol) fisheries the operate in the Java and Natuna Seas to the north of Java and west of Kalimantan respectively.

There is little information on the trawl fishery sources but with regards to cantrang there are a number of studies documenting catch composition, with a few noting the reliance of the surimi factories on cantrang fisheries and analysing the impacts of the 2015 ban on this type of gear and many other gear types (see below).

Sudirman et al (2008) found that the main species taken in cantrang in their study area were Kuniran/goatfish *(Upenus moluccensis)* , Kurisi/threadfin breams *(Nemipterus hexodon)* and Peperek/ponyfishes *(Leiognathus blochi).* Yaser et al (2018) also found that species of goatfish, bullseye, silver biddy, ponyfish, monocle bream (family Nemipteridae) and threadfin bream were commonly caught in cantrang gear in the Java Sea and that surimi plants in north central Java near the large fish processing centre of Tegal, were dependent on this gear type for their supplies of fish. In Rembang Regency, also in North Java, Wijayanto et al (2019) found that catches were dominated by bigeye snappers (Priacanthidae), threadfin breams (Nemipteridae) along with ponyfishes and silver biddies (Gerreidae), the latter also being used in surimi. In west Java Oktaviyani et al (2015) found that dogol (another name for Danish Seine) were dominated by threadfin breams, goatfish, croakers and ponyfish amongst others.

Gaining an understanding of the volume of fish used for surimi production is challenging. Prior to the ban on cantrang fishing gear the industry was producing (exporting) about 30 000t to 40 000t of surimi and the yield for the most common species groups was about 30% (Hikmayani et al 2017). This suggests that about 90 000t to 120 000t per year of fish were used. The figures published by Hikmayani et al (2017)(see Figure 4.6) below are landings derived from KKP statistics. As with other sources of landings data the disposition of the fish is not recorded and for some species groups (especially the tropical snappers – Lutjanidae, Lethirinidae) its likely that most go to direct human food.




**Gambar 3. Volume Produksi Tangkap Ikan Bahan Baku Surimi, Tahun 2010-2014.**
Sumber : Pusat Data, Statistik dan Infromasi, Kementerian Kelautan dan Perikanan, Tahun 2015

Figure 4.6. Volumes of species caught for surimi production prior to trawl/seine ban

For the main families of fish known to be used for surimi the annual production in Indonesia has been of the order 350 to 450 thousand tonnes over the period 2006 to 2016 as collected by the Ministry of Marine Affairs and Fisheries (MMAF)(Anon 2017). These statistics are gathered from all over Indonesia and for all gear types (Figure 4.7). Indonesia supplies data to the South East Asia Fisheries Development Centre

(SEAFDEC) which maintains a database of regional landings.. It enables some species based searches (as compares to Anon 2017). It records landings of the main surimi species as 305 000t and 313 000t in 2014 and 2015 respectively compared to 461 000 and 462 000t for the MMAF data for the same years.

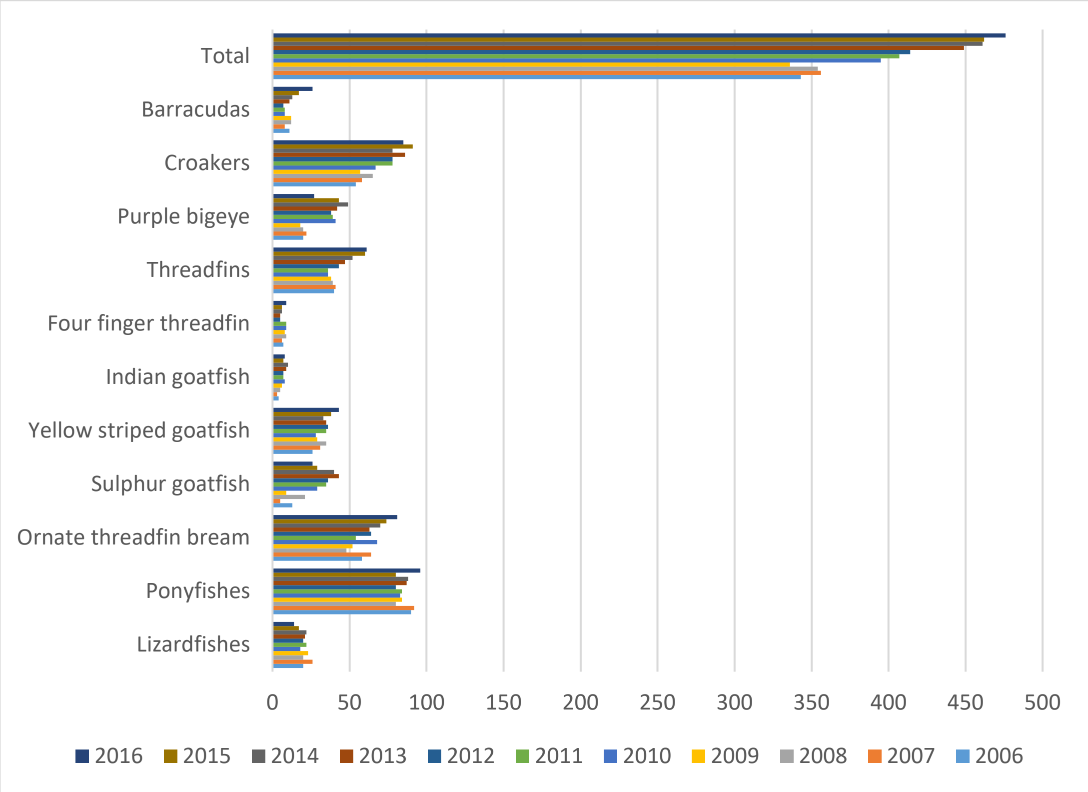



Figure 4.7 Landings of species known to be used for surimi production (Source: SEAFDEC database)

Noting that the ban on trawl and related gear (such as Danish Seine) came in in 2015 the landings of these species groups do not seem to have been affected in 2016 but this may have changed subsequently. Fish trawl catches (of all species, not just surimi species) plummeted from 346 000t in 2014 to 87 000t in 2015 and 67 000t in 2016. Catches in dogol gear increased from 241 000t in 2014 to 350 000t in 2015 before dropping to 183 000t in 2016. Curiously, despite cantrang being a controversial fishing method catches were not reported against this name up until 2015 and were probably reported as dogol (also Danish Seine). Cantrang landings were 53 000t in 2015and 112 000t in 2016.

Landings data are increasingly available for Indonesia and it is possible to find information on landings of particular species or species groups by province and compilations from major ports. Undertaking such a detailed analysis is beyond the scope of this report.

Whilst there is a great deal of uncertainty surrounding the figures its clear that the surimi sector was not the main user of the species caught, accounting for about a quarter to one third of landings of the main species groups used for surimi production.

#### 4.3.8 Stock status

Indonesia has a huge variety of species of fish and invertebrates and, like many countries in the region relies on assessments of stock complexes for most of its fisheries.

For the demersal species, which dominate the sources of fish for surimi a variety of techniques are used to evaluate the status of stocks based on port sampling using enumerators and the application of surplus production models (Schafer and Fox) which are widely used in the region. These were developed for single species assessments but have a long history of being applied to multispecies complexes.

<table>
<tr><th>FMA</th><th>Small Pelagic</th><th>Big Pelagic</th><th>Demersal</th><th>Reef Fish</th><th>Shrimp</th><th>Lobster</th><th>Crab</th><th>BSC</th><th>Squid</th></tr>
<tr><td>571</td><td colspan="3">Acoustic<br>(Survey Acoustic 2015, Port sampling BRPL)</td><td colspan="6" rowspan="3">Surplus production (equilibrium) Schaefer<br>(Statistic data until 2015 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>572</td><td colspan="3" rowspan="2">Acoustic<br>(Survey Acoustic 2016, Port sampling BRPL)</td></tr>
<tr><td>573</td></tr>
<tr><td>711*</td><td colspan="3" rowspan="2">Acoustic<br>(Survey Acoustic 2017, Port sampling BRPL)</td><td rowspan="2">Non-equilibrium (Statistic data until 2016)</td><td colspan="5">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>712*</td><td>Schaefer-2016</td><td>EQ Fox-2016</td><td colspan="3">Schaefer (Statistic data until 2016)</td></tr>
<tr><td>713</td><td colspan="2" rowspan="2">Acoustic<br>(Survey Acoustic 2016, Port sampling BRPL)</td><td></td><td colspan="6" rowspan="2">Schaefer (Statistic data until 2015 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>714</td><td></td></tr>
<tr><td>715*</td><td colspan="2">Acoustic<br>(Survey Acoustic 2017, Port sampling BRPL)</td><td>Non-equilibrium (Statistic data until 2016)</td><td>EQ Fox-2016</td><td colspan="5">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>716*</td><td colspan="2" rowspan="2">Acoustic<br>(Survey Acoustic 2015, Port sampling BRPL)</td><td>EQ Fox-2016</td><td>EQ Fox-2016</td><td colspan="4">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td><td>Non-equilibrium (Statistic data until 2016)</td></tr>
<tr><td>717</td><td colspan="7">Surplus production (equilibrium) Schaefer<br>(Statistic data until 2015 [production per species per gear], Port sampling BRPL)</td></tr>
<tr><td>718*</td><td colspan="3">Acoustic<br>(Survey Acoustic 2016, Port sampling BRPL)</td><td colspan="5">Schaefer (Statistic data until 2016 [production per species per gear], Port sampling BRPL)</td><td>Non-equilibrium (Statistic data until 2016)</td></tr>
</table>

Figure 4.8 – Data sources and modelling approach used in Indonesia

There may well be assessments of individual species undertaken but the relatively small size of landings of individual species and their low value make this unlikely. Figure 4.9 below is extracted from Sunan et al 2018. Potential yields for demersal species (Ikan demersal) for each WPP are listed.

Lampiran 1. Potensi dan tingkat pemanfaatan sumber daya ikan di WPP NRI

*Appendix 1. Potency and exploitation level of fish resources in FMA, Indonesia*

| POTENSI DAN TINGKAT PEMANFAATAN SUMBERDAYA IKAN DI WPP-NRI 2016 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wilayah Pengelolaan Perikanan | | | Ikan Pelagis Kecil | Ikan Pelagis Besar | Ikan Demersal | Ikan Karang | Udang Penaeid | Lobster | Kepiting | Rajungan | Cumi-cumi | Jumlah |
| Selat Malaka | WPP 571 | Potensi | 99.865 | 64.444 | 145.495 | 20.030 | 59.455 | 673 | 12.829 | 13.614 | 9.038 | 425.444 |
| | | JTB | 79.892 | 51.556 | 116.396 | 16.024 | 47.564 | 539 | 10.263 | 10.891 | 7.230 | |
| | | Tingkat pemanfaatan | 0,83 | 0,52 | 0,33 | 0,34 | 1,59 | 1,30 | 1,00 | 0,93 | 0,62 | |
| Samudera Hindia | WPP 572 | Potensi | 527.029 | 276.755 | 362.005 | 40.570 | 8.023 | 1.483 | 9.543 | 989 | 14.579 | 1.240.975 |
| | | JTB | 421.623 | 221.404 | 289.604 | 32.456 | 6.418 | 1.186 | 7.634 | 791 | 11.663 | |
| | | Tingkat pemanfaatan | 0,50 | 0,95 | 0,57 | 0,33 | 1,53 | 0,93 | 0,18 | 0,49 | 0,39 | |
| | WPP 573 | Potensi | 630.521 | 586.128 | 7.902 | 22.045 | 7.340 | 970 | 526 | 3.913 | 8.195 | 1.267.540 |
| | | JTB | 504.417 | 468.902 | 6.322 | 17.636 | 5.872 | 776 | 421 | 3.130 | 6.556 | |
| | | Tingkat pemanfaatan | 1,50 | 1,06 | 0,39 | 1,09 | 1,70 | 0,61 | 0,28 | 0,98 | 1,11 | |
| Laut Cina Selatan | WPP 711 | Potensi | 330.284 | 185.855 | 131.070 | 20.625 | 62.342 | 1.421 | 2.318 | 9.711 | 23.499 | 767.126 |
| | | JTB | 264.227 | 148.684 | 104.856 | 16.500 | 49.873 | 1.137 | 1.854 | 7.769 | 18.799 | |
| | | Tingkat pemanfaatan | 1,41 | 0,93 | 0,61 | 1,53 | 0,53 | 0,54 | 1,09 | 1,18 | 1,84 | |
| Laut Jawa | WPP 712 | Potensi | 364.663 | 72.812 | 657.525 | 29.951 | 57.965 | 989 | 7.664 | 23.508 | 126.554 | 1.341.632 |
| | | JTB | 291.730 | 58.250 | 526.020 | 23.961 | 46.372 | 791 | 6.131 | 18.806 | 101.244 | |
| | | Tingkat pemanfaatan | 0,38 | 0,63 | 0,83 | 1,22 | 1,11 | 1,36 | 0,70 | 0,65 | 2,02 | |
| Selat Makassar - Laut Flores | WPP 713 | Potensi | 208.414 | 645.058 | 252.869 | 19.856 | 30.404 | 927 | 4.347 | 5.463 | 10.519 | 1.177.857 |
| | | JTB | 166.731 | 516.046 | 202.295 | 15.885 | 24.324 | 742 | 3.477 | 4.370 | 8.415 | |
| | | Tingkat pemanfaatan | 1,23 | 1,13 | 0,96 | 1,27 | 0,52 | 1,40 | 0,83 | 0,73 | 1,19 | |
| Laut Banda | WPP 714 | Potensi | 165.944 | 304.293 | 98.010 | 145.530 | 3.180 | 724 | 1.145 | 1.669 | 68.444 | 788.939 |
| | | JTB | 132.755 | 243.435 | 78.408 | 116.424 | 2.544 | 579 | 916 | 1.335 | 54.755 | |
| | | Tingkat pemanfaatan | 0,44 | 0,78 | 0,58 | 0,76 | 0,39 | 1,73 | 1,55 | 0,77 | 1,00 | |
| Teluk Tomini - Laut Seram | WPP 715 | Potensi | 555.982 | 31.659 | 325.080 | 310.866 | 6.436 | 846 | 891 | 495 | 10.272 | 1.242.526 |
| | | JTB | 444.786 | 25.327 | 260.064 | 248.693 | 5.149 | 677 | 712 | 396 | 8.217 | |
| | | Tingkat pemanfaatan | 0,88 | 0,97 | 0,22 | 0,34 | 0,78 | 1,32 | 1,19 | 0,98 | 1,86 | |
| Laut Sulawesi | WPP 716 | Potensi | 332.635 | 181.491 | 36.142 | 34.440 | 7.945 | 894 | 2.196 | 294 | 1.103 | 597.139 |
| | | JTB | 266.108 | 145.193 | 28.914 | 27.552 | 6.356 | 715 | 1.756 | 235 | 883 | |
| | | Tingkat pemanfaatan | 0,48 | 0,63 | 0,45 | 1,45 | 0,50 | 0,75 | 0,38 | 0,50 | 1,42 | |
| Samudera Pasifik | WPP 717 | Potensi | 829.188 | 65.935 | 131.675 | 15.016 | 9.150 | 1.044 | 489 | 58 | 2.140 | 1.054.695 |
| | | JTB | 663.350 | 52.748 | 105.340 | 12.013 | 7.320 | 835 | 391 | 46 | 1.712 | |
| | | Tingkat pemanfaatan | 0,70 | 1,00 | 0,39 | 0,91 | 0,46 | 1,04 | 0,87 | 1,21 | 1,09 | |
| Laut Arafura - Laut Timor | WPP 718 | Potensi | 836.973 | 818.870 | 876.722 | 29.485 | 62.842 | 1.187 | 1.498 | 775 | 9.212 | 2.637.565 |
| | | JTB | 669.579 | 655.096 | 701.378 | 23.588 | 50.274 | 950 | 1.198 | 620 | 7.370 | |
| | | Tingkat pemanfaatan | 0,51 | 0,99 | 0,67 | 1,07 | 0,86 | 0,97 | 0,85 | 0,77 | 1,28 | |
| Jumlah | | | 4.881.498 | 3.233.299 | 3.024.496 | 688.414 | 315.082 | 11.159 | 43.444 | 60.489 | 283.556 | 12.541.436 |

Figure 4.9 Estimated sustainable yields of species complexes by WPP (Source: Suman et al (2018)

Tingkat pemenflaatan = utilisation rate. Where this is greater than 1, overfishing is occurring

There are no areas where demersal species are overfished (Figure 4.10, from Sunan et al 2018), noting that the assessment was conducted after the ban on demersal gear such as trawl and Danish Seine (cantrang/dogol).

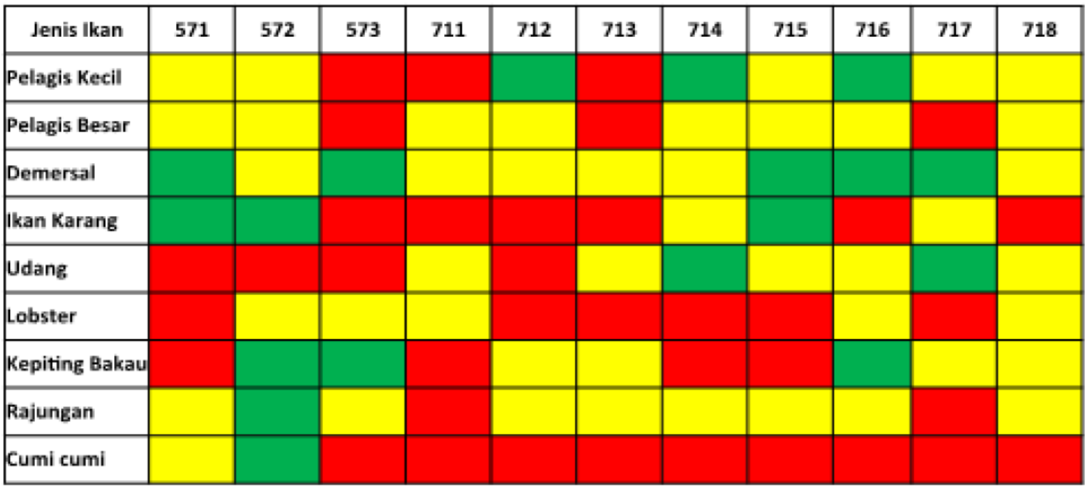



Figure 4.10 Current status of resource groups by WPP

Assessments can be found on smaller spatial scales, see for example Mayua et al (2018) for South Bangka Regency in southeastern Sumatra.

### 4.3.9 Current management

Indonesia has a mix of jurisdictions administering fisheries ranging from the provincial level (and, in some cases at the regency level), through regional level (WPP - Wilayah Pengelolaan Perikanan) and then the national level. The national level focuses primarily on highly migratory species like tunas and national EEZ fisheries. The country is increasingly moving to management on a WPP basis (as evidenced by the stock assessment units above).

Licencing is applied to commercial vessels as well as area based closures. For the demersal fisheries that take fish for surimi, there is a major complication as set out below with the on again/off again approach to implementing bans on mobile gear like trawls and semi mobile gear like Danish seines. There appear to be no controls on numbers of Danish seines (known as cantrang or dogol locally)(see Wijayanto et al 2019) and this has contributed to excess fishing pressure and conflict.

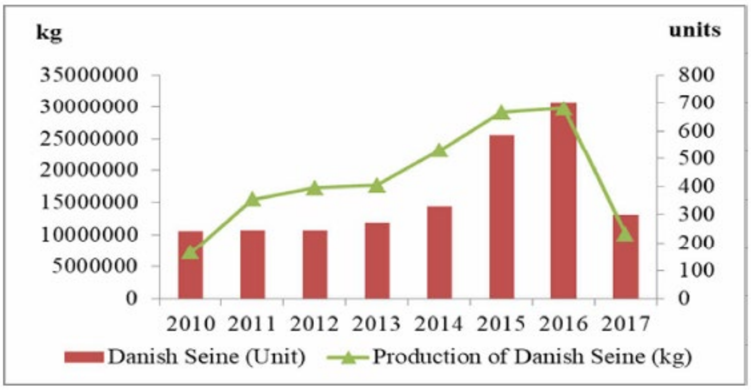



Figure 4.11 Number of licenced Danish seiners From Wijayanto et al (2019).

As to what rules will be put in place now that the 2015 ban has been reversed remain to be seen.

### 4.3.10 Other fishery issues

The major issues facing the industry in Indonesia today relate to uncertainties over supplies and these relate to uncertainties in fisheries management policy, status of stocks and access to fishing grounds in the Natuna Sea. These are outlined in detail as follows:

1. Policy uncertainties

Indonesia’s fisheries are highly diverse, reflecting the wide range of species, variety of fishing grounds and fishing gears and a mix of traditional and modern usages. They are spread over a huge geographic area and expansion has been permitted over a period of decades both in terms of overall numbers of fishing operations, types of gear and geographic spread. Much of this expansion has been poorly controlled and this has resulted in serial depletion on a geographic and species basis which has often created conflict between user groups.

In the 1970’s the development of the trawl fisheries was permitted to occur with few controls and this fueled such a degree of conflict with existing users that, as the number of trawlers increased, rather than control the number, the government chose to implement a ban in 1980. The ban was mainly aimed at demersal otter trawls but was more widely interpreted. However, over the next few decades not only did fishermen develop variants on the trawls that evaded the ban, they also resorted to other gears that fished for demersal species but were not trawls. The most common was the Danish seine, a demersal seine net that was ideal for the relatively shallow sandy habitats that supported a wide variety of species such as goatfishes, threadfin breams, lizardfishes and the like. There were various forms adopted in Indonesia where they went by local names, dominated by cantrang and dogol.

By the late 1990's the number of cantrang/dogol vessels was beginning to rise but little was done to restrict the number of licences nor the sizes of the vessels and again the cycle of conflict and demands for bans were rekindled. Despite the lack of any research on habitat impacts and the fact that Danish seining was known to be less impactful than otter trawling (REFS) this gear was widely painted as being environmentally destructive. One contributing factor was the use of small mesh nets which took their toll on juvenile fish but almost every other gear in Indonesia has the same problem. In 2015 the government implemented a ban on not only the Danish Seine gear but a huge variety of other nets including trawls and purse seines.

Whilst the ban was ignored in many quarters it had a significant impact on the surimi sector which shed thousands of jobs (Hikmayani et al 2017). A change in fisheries minister has reversed the ban but whether the fundamental issues surrounding effort control remain unresolved. The previous minister gave away thousands of gillnets, assuming that they were environmentally friendly but this is an open question, especially given the lack of controls over fishing effort.

Uncertainty over the medium to long term policy environment will be a constraint on investment or an incentive to seek a quick return on capital. Managed properly the fisheries have the potential to provide long term jobs, both on fishing vessels and in processing factories. In the recent past many surimi fish were simply exported to Thailand for processing, thereby exporting jobs, something that Indonesia is keen to create.

2. Status of stocks

As mentioned above, the status of many stocks in Indonesia is cause for concern.

Fisheries management remains an issue in Indonesia. In recent years Indonesia has revised its approach to stock assessment which has resulted in a substantial increase in potential harvests. Given the huge number of species the reliance on aggregate yields (also called Multispecies Maximum Sustainable Yields – MMSYs) based on groups of species (e.g. demersals, small pelagics, large pelagics etc) is understandable and this approach is used in other Asian countries with large numbers of species, such as Thailand. However, care needs to be exercised to ensure that vulnerable species are not driven to population levels below their Point of Recruitment Impairment (i.e. below levels where the stock may not be able to recover). Whilst there will be trade-offs in any fishery and it is not possible to manage all stocks at their individual MSY, the general lack of management plans and mechanisms for managing harvests is a source for concern.

A second concerning issue is the fact that the Indonesian government appears to have added the MMSY's for the species groups together to give an overall MSY for the country. Setting of MSY's on a species by species basis over-estimates the available yield because predation and other ecologically relevant factors are ignored. Adding them together can overestimate MSY by 25 to 50%, thus contributing to overfishing. Whilst its true that the current approach to setting MMSY's mitigates this to a degree there are interactions between some of the species groups that need to be considered, possibly via some ecosystem modelling.

3. Access to fishing grounds – especially the Natuna Sea

The Natuna Sea, which lies between western Kalimantan and eastern Peninsula Malaysia is one of the key fishing grounds for the demersal species important for the surimi industry. It is also part of a much wider geographic area which extends north to Hainan (China) and east to the Philippines which has been annexed by China. Known as the South China Sea it has been fished for centuries by people from surrounding countries and its annexure by China, on the basis of claimed historical usage by Chinese fishermen, has been deemed illegal by the United Nation's Permanent Court of Arbitration following a case brought by the government of the Philippines.

Although China's annexation has not affected the whole of the Natuna Sea its clear that the loss of fishing grounds and the taking of fish by Chinese vessels, will have an impact on the availability of fish for Indonesia.

Finally, Indonesia has not been immune from the IUU and forced labour issues which have dogged the region for many years. Whilst the government has had a high profile stance on IUU fishing Much of the focus has been on illegal fishing by foreign vessels

https://www.iom.int/sites/default/files/country/docs/indonesia/Human-Trafficking-Forced-Labour-and-Fisheries-Crime-in-the-Indonesian-Fishing-Industry-IOM.pdf

https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---declaration/documents/publication/wcms_214472.pdf

## 4.4 Malaysia

### 4.4.1 Development of the surimi industry

The surimi industry started to develop in Malaysia in 1990 (Pangsorn 2009) and appears to have grown rapidly but the main raw materials appear to have been imported. Vidal-Giraud and Chateau (2007) claim that production was 8000t in 2007 but Pangsorn et al (2007) claim that Malaysia was producing 93 700t of surimi in 2006. Rahman (2009) notes that in 2006 Malaysia imported nearly 450 000 tonnes of fish and that the surimi industry was viewed as a key processed seafood export industry. The industry appears to have contracted considerably with Wong (2018) noting two figures for exports 18 693t and 6448t but not providing detail on domestic production. (PASCAL – need help on this)

### 4.4.2 Current production - surimi and surimi seafood

Current production of surimi is about 20 000t

### 4.4 3 Imports and exports

Exports are about 6500t and imports about 14 000t

### 4.4.4 Companies

The main surimi producers are as follows:

- QL Foods (QL Group)
- QL Endau Marine Products (QL Group)
- QL Marine Products (QL Group)
- Dahfa Foods Manufacturing
- KTS Food Industries
- Global Ocean Seafood
- Fudo Surimi

The main surimi seafood producers are as follows:

- QL Foods

- QL Figo (Johor) Sdn Bhd
- Seapack Food

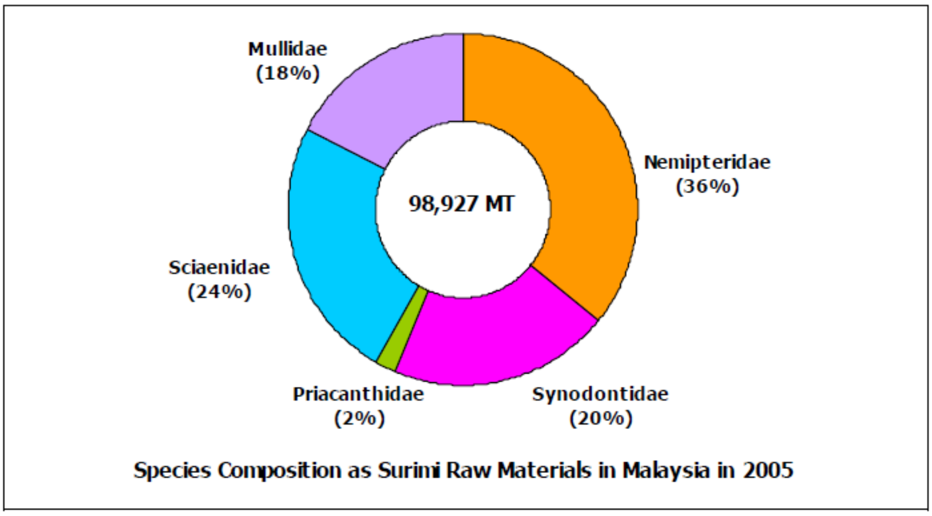
**4.4.5 Main species used**

The species used for making surimi come from the same common families of fish seen throughout Asia. According to Rahman (2009) the following range of species is used:

- Threadfin Bream (*Nemipterus spp*.)
- Oxeye Scad *(Priacanthus spp.)* – likely bigeye snapper not oxeye scad
- Goatfish (*Upenneus)*
- Jewfish *(Pennahia or Johnius spp.)*
- Lizard fish *(Saurida spp.)*
- Barracuda *(Sphyreana)*
- Ribbon Fish *(Trichiurus)*

Within each of these families there are likely to be multiple species and an exact and up-to-date species list has not been found.

Pangsorn et al (2007) record the following breakdown of species used in 2005 – note that the list of fish families differs from that provided by Rahman (2009).



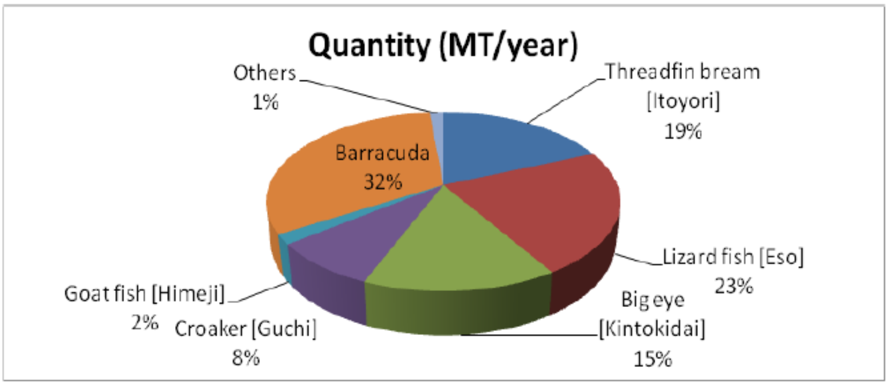




Figure 8: Percentage of raw materials used in Surimi processing plants in Malaysia.

Figure 4.12 Difference between reported landings and use at surimi plants in Malaysia (Source Pangsorn et al 2007 – data from 2005)

#### 4.4.6 Sources

There is no mention of sources of raw material other than domestic wild capture fish

#### 4.4.7 Domestic fisheries

Malaysia has a relatively large area of fishable EEZ with grounds on both the eastern and western sides of the Malay peninsula and off the coast of Sarawak. The area bordering the southern South China Sea and the Gulf of Thailand provide the largest area of trawlable ground which is suitable habitat for the types of demersal species sought for surimi. According to Suuronen et al (2020) Malaysia has one of the largest trawl fleets in the region with over 6000 registered vessels (in 2012). Out of its reported fish landings of 1 447 638 tonnes some 45% was supplied by the trawl fleets.

For the main families of fish used for surimi the most recent landings statistics can be found at - https://www.dof.gov.my/index.php/pages/view/82. For 2018 the reported landings were as follows:

| Bahasa malay | English – family | Tonnage | percentage |
|---|---|---|---|
| Biji | Goatfishes – Mullidae | 19 000 | 9 |
| Gelama | Croakers - Sciaenidae | 43 000 | 21 |
| Kerisi | Threadfin breams - Nemipteridae | 50 000 | 25 |
| Mengkerong | Lizardfishes - Synodontidae | 48 000 | 24 |
| Alu-alu | Barracudas – Sphyraenidae | 8 000 | 4 |
| Temenggong | Big eye snappers - Priacanthidae | 15 500 | 8 |
| Timah | Hairtails – Trichuridae | 18 000 | 9 |
| Totals | | 201 500 | 100 |

Figure 4.13 Reported landings of species commonly used for surimi production – 2018.

Photo 1 Hairtail or ribbonfish – *Trichuris* sp

Photo 2 Trashfish – Port of Mersing, SE Malaysia

Given that domestic production is only 20 000t its clear that the majority of trawl caught fish from these families have uses other than surimi.

#### 4.4.8 Stock status

Much of the information publicly available on stock assessments for demersal species in Malaysia is old. The most comprehensive report is dated 2003 (Abu Talib et al 2003). Searches of journals such as the Malaysian Journal of Fisheries provided some updates (e.g. Hadil et al 2011) but more recent assessments do not seem to be publicly available.

Abu Talib et al (2003) found some dramatic declines in CPUE in their detailed review of trawl survey data. Majid (1983)( http://www.fao.org/3/ac750e/AC750E10.htm#ch10) describe a litany of problems in seeking to reign in fishing effort after the original open access period.

#### 4.4.9 Current management

In response to well documented declines in fish resources Malaysia has implemented a variety of management measures aimed at limiting catches (Anon 2015). Some of these measures are generally applicable most types of fisheries whilst others are specific to the trawl fleets and include:

- Regulating the issuance of fishing gear and fishing vessel licences to limit fishing effort;
- Restructuring the ownership patterns of fishing licences;
- Registration of fishers;
- Management of a zoning system based on the tonnage of fishing vessels, type of fishing gears used and ownership patterns;
- Conservation and rehabilitation of the marine ecosystems through the establishment of marine protected areas and deployment of artificial reefs;
- Imposition of specification for trawl nets, namely:
    - Cod-end mesh size not less than 38 millimetres
    - Mesh size in other parts of the net not exceeding 5 metres
    - Head rope length not exceeding more than 40 metres.

#### 4.4.10 Other fishery issues

Malaysia appears to continue to suffer from the consequences of an open access regime implemented five decades ago. Nuruddin (2013) spoke of the challenges associated with seeking to increase mesh sizes to 38mm to reduce the catch of juvenile fish. This was recommended in 1981-1982 which became law in 1985 but enforcement attempts did not begin until 2006. These attempts met with protests by fishermen which further delayed implementation whilst consultation was conducted. Another attempt was made to implement the law in 2013. Nuruddin (2013) was clear that jointly working with fishermen would have been a better approach.

Illegal fishing  has been identified for a number of years as a significant problem (Anon 2008) and seemingly remains a major issue:

> *According to the DoF, while approximately 980,000 tonnes of the country's seafood worth between RM3 billion and RM6 billion was lost each year as a result of illegal fishing activities, only 50 per cent of fish caught from national waters makes its way to the local market and the rest are untraceable.* (https://www.malaymail.com/news/malaysia/2019/09/04/fisheries-dept-malaysia-loses-rm6b-a-year-to-illegal-fishing/1787016)

The same newspaper article stated that:

> *Researchers from the South-east Asian Fisheries Development Centre (SEAFDEC) have found that fish supplies in the country are at a critical level……..*

Anon (2008) also documented a large number of foreign crew members on fishing vessels but did not mention any of the labour issues which have dogged SE Asia in more recent years.

## 5.5 Myanmar

#### 4.5.1 Development of the surimi industry

Myanmar has a small surimi industry with the first factory being constructed in 1994 (Anon 2015b). According to SEAFDEC (2009) production grew from just under 800tonnes in 2001 to over 1500t in 2005, almost all of which was exported.

In 2007 it was estimated to produce 3000t per year (Vidal-Girard and Chateau 2007), an amount which has changed little, if not declined for next 20 years.

#### 4.5.2 Current production – surimi and surimi seafood

Current production is about 2000 to 3000t

#### 4.5.3 Imports and exports

Current exports are about 2000 to 3000t

#### 4.5.4 Companies

The surimi production companies are

- Min Zar Ni
- Pyilonechantha Trading
- ASK Andaman Ltd

#### 4.5.5 Main species used

The species used are sourced from the same tropical fish families which are common throughout Asia, namely the Threadfin breams, Goatfishes, Croakers, Big eyes, barracudas and Lizardfishes (Anon 2015, Vidal-Girard and Chateau 2007, Pangsorn et al 2007). Kyaw (2009) provides a little more detail in mentioning some specific species such as *Saurida elongata*, *Pennahia anea* and *Johnius amblycephalus*. Both Kyaw mention the use of the shad, *Illisha megaloptera*, a small pelagic species common throughout coastal areas of the Indian Ocean.

#### 4.5.6 Sources

Whilst little is known about the industry it would appear that most of the raw materials are sourced from domestic fisheries.

#### 4.5.7 Domestic fisheries

Myanmar supports a relatively large trawl fleet but gaining an understanding of the total volume of fish caught, the proportion that is used for surimi and the catch composition is extremely difficult. Production data reported to the FAO is highly aggregated (generally reported as NEI or Not Elsewhere Incorporated) and very variable.

In the 2015-2016 fiscal year, the total production of fish was 5.59 million metric tons of which 3.0 marine tonnes was marine fish (Department of Fisheries, 2017). According to SEAFDEC (2017) catches have grown at the rate of 10% year on year from 2000 to 2014. Marine landings have almost doubled in less than a decade.

| 2005 Surimi production | Raw material required | Threadfin Breams | Lizard fishes | Goat fishes | Croakers | Bigeye snappers | Barracudas |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5000 | 17500 | 10500 | 1050 | 2450 | 280 | 700 | 350 |

Source: APFIC (2010) – based on data in Pangsorn et al 2007

For the area off Myeik in southern Myanmar, in a study of trashfish production, Myo et al (2018) found that the volume of trashfish produced by trawlers was in the range 60 000 to 80 000t per annum over the period 2013 to 2017. They estimated that this represented about 40% of the catch in that region which suggests a total catch of 150 000 to 200 000t per year. More widely, Booth and Pauly (011) attempted to reconstruct Myanmar's catch from 1950 onwards but this was not able to identify trawl catches and used species breakdowns in neighbouring Thailand and India to generate an estimate of the main species group, which included threadfin breams and croakers, amongst others.

Another source of potential data is estimates of IUU catches. These are obviously highly speculative if not contentious and may not relate to particular fisheries. BOBLME (2015) estimated illegal catches at between 350 000t and 1.6mmt. There was no estimate of the gears or species involved. In their study of IUU fishing Funge-Smith et al (2015) only considered a subset of markers for this type of activity and estimated that in 2014 some 572 000 tonnes of fish were illegal sent out of Myanmar, primarily to Thailand and especially the port of Ranong. There was specific mention of trawlers supplying carrier vessels and low value species destined for the surimi and fish meal processing industries. The surimi industry in Myanmar itself takes a fraction of the catch.

There are a number of studies of catch composition based on research trawls which may broadly reflect the composition of commercial trawls. Thapanand-Chaidee et al (2010) conducted trawl surveys in southern Myanmar and found the catches dominated by *Sauridae undosquamis* (lizardfish), *Priacanthus macracanthus* (bigeye snapper), goatfishes (Mullidae) and threadfin breams (Nemipteridae) noting that there were 113 species caught overall. A similar mix of species was documented by Chokesanguan et al (undated) as part of their study on fish excluder devices in the central region of the country. Catch composition has not only varied over the years, as documented by the research vessel Fritjof Nansen (Krakstad et al 2013, 2014 and Stremme, 1981) but varies geographically and according to the monsoon season.

Photo 3 Trash fish being unloaded in port of Myeik, Myanmar

Fish for surimi reportedly unloaded at another site

#### 4.5.8 Stock status

Stock assessments in Myanmar are virtually non-existent, particularly in respect of individual species. There have been various assessments of total catch per trawl hour over the decades primarily by research vessels but also by some commercial vessels (Pe 2004). By and large Catch Per Unit Effort (CPUE) has declined significantly over the years. Pe (2004) also reports declines in the average sizes of individual fish caught as well as anecdotal reports of certain species disappearing form the catches. Both these observations are consistent with the symptoms of overexploitation that have occurred in many other countries. It should be noted that some species groups of importance to the surimi sector such as the threadfin breams and the lizardfishes seem to have been affected to a lesser degree than others which seems consistent with information regarding their lower vulnerability.

The 1979/80 survey (Stremme et al 1981) estimated a total exploitable biomass of 1.8million tonnes with a sustainable yield of 700 000tonnes. The estimate of total biomass for the 2013/15 survey was only about 500 000 tonnes. Given the estimates of IUU fishing occurring (see above) the rapid depletion of fish stocks appears to be continuing.

Noting that there may be some differences due to interannual variability, seasonal influences, different locations and trawl configuration there remain indications of major declines in biomass for both demersal and pelagic species (Kradstad et al 2014, 2015), see below:

| | | | |
|---|---|---|---|
| **Myanmar** | 1979–1980 | 670 to 946 kg/hr | Fritjof Nansen Survey |
| | 1983–1989 | 184 to 253 kg/hr | FRV Chulaborn, FV251, Commercial data |
| | 1996–1998 | 96 to137 kg/hr | Commercial fishing |
| | 2006–2007 | 90 kg/hr | MV SEAFEC Survey |

#### 4.5.9 Current management

The Department of Fisheries has, for many years, enforced a licensing system to limit entry to the fisheries. Anybody who wants to carry out fishing, is required by law to have a fishery license which carries with it conditions on how, when and where fishing can be carried out. Myanmar's Marine Fisheries Law (1990) sets out the country's legal framework for the management of fishing capacity and there is also law relating to fishing rights of foreign fishing vessels (1989). In addition, there are regulations in place to implement the country's commitment to the management of fishing capacity. These include:

- a prohibition on the building or importation of new fishing vessels;
- prohibition of fishing in high seas;
- transforming of trawls into other fishing gears is allowed but other fishing gears cannot be transformed to trawls;
- flag State and port State measures including the installation of VMS and implementation of Catch Certificate scheme.

Action plans include:

- promotion of effective inspections for all fishing vessels at sea;
- installation of VMS in all fishing vessels for effective MCS system;
- use of TEDs and JTEDs in trawl fishing vessels; and
- conduct of surveys on fishing capacity of each fishing gear group.

In 2014 the government of Myanmar stopped issuing permits for foreign vessels to fish in its waters (Aung 2014) and it has also started to implement a closed season (generally June to August but this can vary). This closed season started as being a full ban but the impacts on trawlers was significant and the ban was modified (San 2015). The ban became partial with effort being reduced by about a third but this has expanded and by 2018 there will be a full ban implemented (Hla, T. personal communication). According to

Aye and Win (2013) the regulated mesh size for offshore trawl vessels is 2 inches (5cm) and for shrimp vessels 1.5 inches (3.8cm). Registered need to have a colour coding depending on their region of registration

#### 4.5.10 Other fishery issues

The two main issues facing the industry have been introduced above, namely the very high level of illegal fishing which is undermining the industry in terms of the future availability of raw material and pricing (is this true Pascal). The area between southern Myanmar and the north western coast of Thailand has been identified a one of the largest IUU hot spots in the region (Funge-Smith et al undated) with 400 - 500 trawlers alone moving over half a million tonnes of fish (in 2014 alone) across the border. As to how much the situation has improved in the past 5 years is unknown.

Whilst illegal fishing is likely a significant contributor to the depleting stocks of fish in Myanmar's waters the lack of management plans and effort controls is also a source of concern. BOBLME (2011) ranked Myanmar the lowest amongst the BOBLME countries on all facets of fisheries management relating to the FAO Code of Conduct for Responsible Fisheries, namely:

- Field 1 (Management procedures),
- Field 2 (Framework – data and procedures),
- Field 3 (Precautionary management),
- Field 4 (Stocks, Fleets and Gear),
- Field 5 (Social and Economic),
- Field 6 (Monitoring Control and Surveillance),

Preston (2004) reviewed management arrangements in the wider Bay of Bengal region as part of a report on straddling stocks and identified a number of impediments to good management which were contributing to the decline in fish stocks around the region;

- overfishing.
- destructive fishing of various kinds
- fishery monitoring, control and surveillance arrangements are inadequate,
- pollution and unmanaged coastal development
- processes for ensuring that stock assessment data are integrated into the fisheries management decision-making process are under-developed;
- there is an unrealistic expectation that stock assessment can provide robust, highly reliable measurements, rather than estimates;
- despite most fishery resources being shared among two or more countries, there are few bilateral or multilateral attempts to assess and manage stocks;
- fishery statistics for the region are insufficiently accurate in terms of the main species caught. A large proportion of the region's catch is classified as miscellaneous categories, generic groupings, or 'unidentified'.
- taxonomic inconsistencies mean that where the catch is identified, the same organism may be reported as different species, or different organisms reported as the same species, among BOB countries;
- the availability of fishery-independent data is declining due to high costs
- apart from the tuna and allied species, there is little or no attention being given in the region to the management of shared or straddling stocks.
- most countries continue to exploit fishery resources within their waters without information on what additional exploitation may be occurring elsewhere on the same stocks;
- stock assessment capability in the region is limited in qualitative terms.
- there is a need for better communication between fishery scientists and decision-makers,

- there is a need for more rigorous and objective fishery management arrangements to reduce the degree of discretion by senior decision-makers, and introduce the consensus views of fishery stakeholders. This should be done through the development of fishery management plans for key fisheries, focussing on shared stocks.

Poor enforcement undermines well intentioned efforts to cut effort and catches. According to Pe (2004) the licensing of vessels and banning of trawling within 5-mile offshore the Rakhine and Tanintharyi coastal regions and 10-mile offshore the Ayeyarwaddy delta coastal region have not been successful due to inadequate monitoring and enforcement.

## 4.6 Pakistan

### 4.6.1 Development of the surimi industry

Limited information available.

### 4.6.2 Current production - surimi and surimi seafood

Current surimi production is about 10 000t

### 4.6.3 Imports and exports

No information available

### 4.6.4 Companies

The main current surimi makers are as follows:

- PK International Foods
- Kanesiro
- Qadri Noori Enterprises

### 4.6.5 Main species used

As with other countries in the region there is a wide variety of species occurring within each of the main families of fish used for surimi. As but one example is the croaker family (Sciaenidae) in which 44 species have been recorded, some of which are far more abundant than others. The goatfishes (Mullidae) which are important in surimi production in countries such as Malaysia, are present in Pakistan but have not been reported on in stock assessment information and its unknown if they are used for surimi.

Company websites mention species such as croakers, lizardfishes and threadfin breams. With regards to the latter it is likely that the more common species (*Nemipterus japonicus* and N. *randalli*) are the most commonly used and may be mixed.

### 4.6.6 Sources

Domestic fisheries are a known source. Whether companies import and process fish or surimi is not known.

### 4.6.7 Domestic fisheries

Pakistan has a coastline of about 1000klm and a wide continental shelf, especially in the east near the border with India. This shelf habitat supports many of the species important for surimi production in Asia. Fanning et al (2010, 2016) have reviewed many of the studies of fish and fisheries and documented the main species caught.

The FAO FishStatJ database provides the following response to a search on the main families used for surimi (with the possible exception of porgies – Sparidae).

| Country (N | Species (N | [2005] | [2006] | [2007] | [2008] | [2009] | [2010] | [2011] | [2012] | [2013] |
|---|---|---|---|---|---|---|---|---|---|---|
| Pakistan | Barracuda: | 3464 | 3979 | 4951 | 5001 | 7235 | 6030 | 6671 | 6175 | 6351 |
| Pakistan | Croakers, ( | 15858 | 14686 | 14618 | 14697 | 13557 | 19981 | 19602 | 19395 | 19635 |
| Pakistan | Greater liz | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pakistan | Porgies, se | 2115 | 2465 | 2625 | 2745 | 2101 | 2099 | 1781 | 1855 | 1936 |
| Pakistan | Threadfin I | 7592 | 7198 | 7324 | 7411 | 1676 | 1654 | 2809 | 3799 | 3854 |
| Totals - Quantity (ton | | 29029 | 28328 | 29518 | 29854 | 24569 | 29764 | 30863 | 31224 | 31776 |

Figure 4.14 Landings of main surimi species as reported to FAO for Pakistan

Additional detail can be found on the FAO country profile page

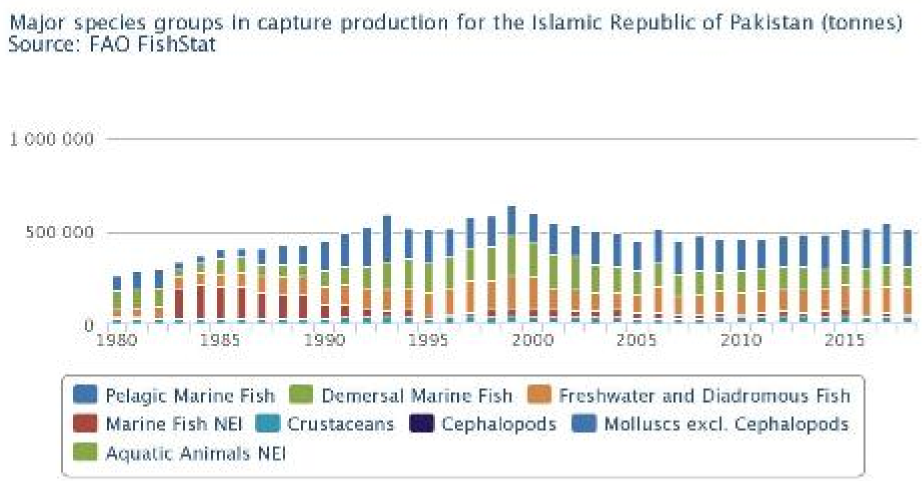



Figure 4.15 main species groups in capture fish production, Pakistan

Reported landings of demersal species have ranged from 47 000t to 209 000t since 1980 and appear to have been relatively stable since 2000. However, this apparent stability appears to be due to increases in the numbers of fishing vessels and masks some serious depletion of key stocks (see below). The use of pelagic species, such as hairtails for surimi is not well documented, as is also the case for sardines and barracudas.

**4.6.8 Stock status**

A number of stock evaluation exercises have been carried out since the 1960's (six since 1977), the most recent one being conducted over the period 2009 to 2015 (Fanning et al 2010 but especially Fanning et al 2016) which paints a bleak picture of the status of almost all species, in particular demersal species (Figure 4.16 below)

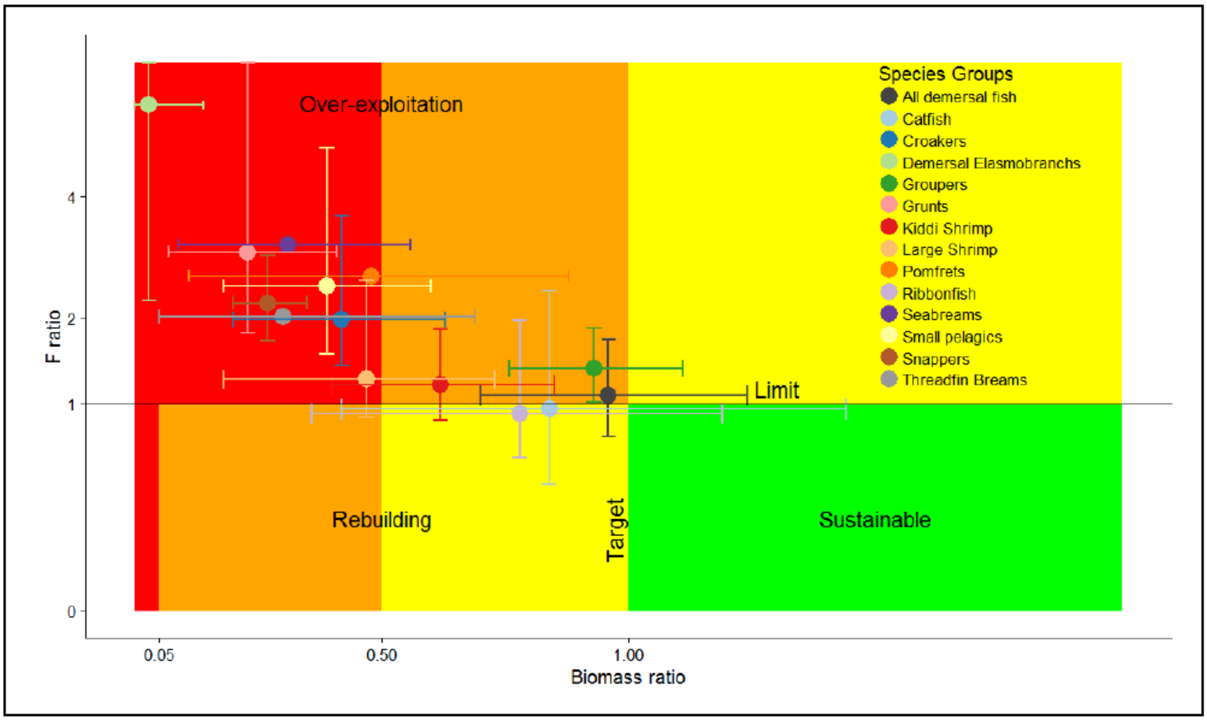



Figure 4.16 Status of main species groups in Pakistan

Early trawl surveys in the 1950's and 1960s (refs) document an abundance of fish in offshore fishing grounds. Stock assessments were conducted in the late 1970s and early 1980s and comparison between these and assessments in the 2010's suggest that all the key species groups have seen declines of 79% to 97%.

Threadfin breams and croakers were amongst the most abundant species in terms of biomass per unit area. Fanning et al (2016) refer to the threadfin breams as opportunistic and note their increase in abundance from the 1960s but even their greater resilience to fishing pressure than some other species has been insufficient to prevent serious depletion. In terms of threadfin breams the two species caught included N. *japonicus* and N. *randalli*. The relative abundance varied from place to place, as demonstrated in Figure X

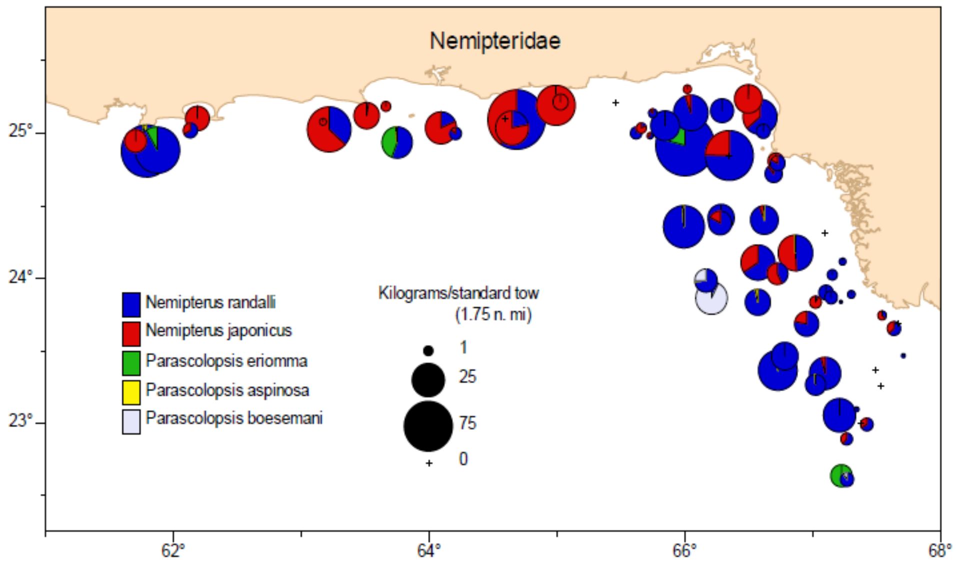



Figure 4.17 Relative abundance by area of 5 members of the Nemipteridae, Pakistan

#### 4.6.9 Current management

Up to date information on fishery management arrangements in Pakistan could not be found. Laws and policies can be found listed in (http://www.fao.org/fi/oldsite/FCP/en/pak/body.htm) which includes mention of a two month shrimp trawl closure from 1 June to 31 July each year. There is also mention of VMS being installed in offshore vessels (De Young 2006) and also other management measures but its unclear as to whether these are recommendations or have been implemented. Its likely that excess fishing effort remains a significant issue given what is known about the status of stocks and a recommendation by Fanning et al (2016) that there be a 50% reduction in effort.

#### 4.6.10 Other fishery issues

A wide variety of issues have contributed to the status of the seafood industry in Pakistan, not all of which are related to overexploitation although this is very much a factor (Mohsin et al 2019, Patil et al 2018, Muhammed et al 2014).

Patil et al (2018) quote a study of the status of fishery resources in Pakistan by the FAO in 2016 (Fanning et al 2016 – referenced here but does not appear to be available on line).

From a surimi industry perspective, the value of key species is either no recognised or not known by the fishery researchers and they are dismissed as low value fish, especially the lizardfishes. For example in regards to threadfin breams – "*They have limited market value as food fish and are also used for fish meal production*." . But the very next sentence states "*Threadfin breams are commercial fishes which are popular on local markets due to their excellent firm flesh and good flavour*."

Yet World Bank reports are looking for opportunities for domestic fish processing.

Muhammed et al (2014) comment on the declining state of fishery resources, stating it was dwindling to the 'disastrous level' and called on the development of sustainable fisheries policies. Marine seafood production had declined from 602 000t to 467 000t over the period 207/08 to 2012/13 but price increases had resulted in the value of exports (total seafood) increasing from USD217m to USD331m over the same period. According to Muhammed et al (2014) the use of illegal nets is rife and '80%' of the fish landed go to fishmeal plants.

## 4.7 Thailand

4.7.1 Development of the surimi industry

The surimi industry developed in Thailand in the early 1980's following the development of the trawl fisheries in the Gulf of Thailand in the early 1960's (Pangsorn, 2009). Both the number of plants and the production volume grew rapidly such that by 2005 Thailand was producing about 150 000t per year and comprised 43% of total production in South East Asia. However, this peak was followed by a long decline such that by the 2017 production had dropped to 52 000t (Guenneugues 2018). Much of the raw material was comprised of fish that were previously sent for fishmeal and the development of the surimi industry created more value due to the higher price paid for surimi fish. Demand for raw material was not only satisfied by fish caught in Thailand but also by imports from countries such as Indonesia, Malaysia and Myanmar (Vidal-Giraud and Chateau 2007) and ( **Survey and Information Collection on Surimi Industry and catch data in Thailand from 20– 24 March 2006)**. According to Vidal-Giraud and Chateau (2007) about 60% of the fish used for surimi production in the mid 2000s in Thailand came from Indonesian waters.

Some companies had their own vessels, others operated joint ventures but there has also been an illegal trade in trawl caught fish, especially from Myanmar to Thailand (Funge-Smith et al 2015) (see below).

#### 4.7 2 Current production - surimi and surimi seafood

Production in Thailand in 2019 was 60 000t (Guenneugues 2019)

#### 4.7.3 Imports and exports

Surimi exports are about 28 000t

Surimi imports are about 50 000t

Surimi seafood exports are about 33 000t

#### 4.7.4. Companies

The main producers of surimi are as follows:

- Andaman Surimi
- Anusorn
- Mana Frozen Foods
- BS Manufacture
- Apitoon Enterprise Industry
- Sea Royal Marine Food Product
- Pacific Marine Food Products
- Starfish
- Lucky Foods (Thai)
- Siamchai International Food
- Kantang Seafood (KSF)
- Thaveelarp Fisheries Ltd. Part.
- Chaicharoen Marine (2002)

The main producers of surimi seafood are as follows:

- Lucky Union Foods
- Kibun Thailand
- Smile Heart Foods
- PM Foods
- Surapon Food
- Mahachai foods
- Sea Royal
- PFP
- S.KHONKAEN FOODS
- Tahveevong Industry Co Ltd
- Pacific Fish Processing (PFP)
- S. KHONKAEN FOODS
- Tahveevong Industry
- B.S. Manufacturing
- A.P. Frozen Foods (Apitoon Group)
- A&N Foods (Apitton Group)
- Big Kitchen
- Starfoods Industries

### 4.7.5 Main species used

According to SEAFDEC (2009), Siriraksophon et al (2009), Park (2005) and company websites the types of fish used for surimi in Thailand are diverse and include species of threadfin breams (*Nemipterus* spp), bigeye snappers (*Priacanthus* spp), goatfishes (e.g. *Upeneus* spp), croakers (e.g. *Johnius* spp, *Pennahania* spp), lizardfishes (*Saurida* spp), Ribbon fishes (hairtails)(*Trichiurus* spp), sardines (various genera), barracudas (Sphyraenidae) and monocle breams (*Scolopsis* spp but possibly other genera). Curiously, despite the widespread use of goatfishes (Mullidae) they are not reported as a group by the Thai Department of Fisheries.

SEAFDEC (2009) groups species by family and, as mentioned by Park (2005) it is not uncommon for species to be processed together if they are similar. The monocle breams do not seem to be reported on separately but may be covered under their family name (Nemipteridae), along with the threadfin breams (also Nemipteridae).

Pangsorn (2009) listed the relative contribution of the main species groups as follows

- Threadfin breams – 40%
- Big eyes 15%
- Lizardfishes - 20%
- Goatfishes – 15%
- Others – 10%

In addition, there is a long tradition of fish pastes being used for local foods (especially the fish, squid and cuttlefish balls which are ubiquitous in Asia). Suwarangsi (1988) mentions the use of bigeye *(Priacanthus tayenus)*, ribbonfish *(Trichiurus haumera)*, Tongue sole *(Cyanoglossus macrolepidotus),* spotted flathead *(Thysamophrys crocodilus)* and Blackspotted trevally *(Caranx leptolepis).* Some of the information is old and changes in pricing, species availability, species misidentification/reclassification make the generation of a full species list almost impossible.

### 4.7.6 Sources

Thailand has sourced fish for surimi from both its domestic waters and from outside. In the Thailand Exclusive Economic Zone (EEZ) there are two two main marine fishery zones, the Andaman Sea on the west coast and the Gulf of Thailand in the southeast. Both areas are a source of fish for surimi production. Thailand also reports catches for vessels fishing in adjacent waters. For example, Reporting Area B includes the waters of Malaysia and Indonesia on the Gulf of Thailand side of Thailand. According to Anon (2015c), in 2015 larger (>25m) Thai trawlers reported croakers (2092t), threadfin breams (3530t), lizardfish (4208t), hairtail (758), bigeyes (3086t) and barracudas (654t).

In the past Thailand has also imported frozen fish for surimi production from countries such as Indonesia. Indonesia has prevented this practice and efforts to reduce IUU fishing have also reduced other sources of supply.

Evidence that substantial quantities of fish processed in Thailand are sourced externally can be found in FAO (2009) which states:

> *The FAO Regional Office for Asia and the Pacific (RAP) provided data for threadfin bream to show that the majority of reported catch in the Gulf of Thailand came from waters outside the Gulf.*

### 4.7.7 Domestic fisheries

Figure 4.18 shows how the catch of species destined for surimi production has grown in the past forty years with a very substantial increase (tripling) in the early 1990's. This increase was due to increases in catches of all major species groups (see Figures X, X and X). During the period 1990 to 2005 the production of threadfins grew from 30 000 to 110 000 tonnes, lizardfish from 20 000 to 70 000 tonnes, bigeyes from 20 000 to 110 000 tonnes, and croakers from 15 000 to 45 000 tonnes. Note that these figures do not include other families of fish such as Mullidae, Trichuridae and Clupeidae (and possibly others). The lack of inclusion could reflect the absence of reporting arrangements, lack of information on the disposition of fish and/or changes over time in species used.

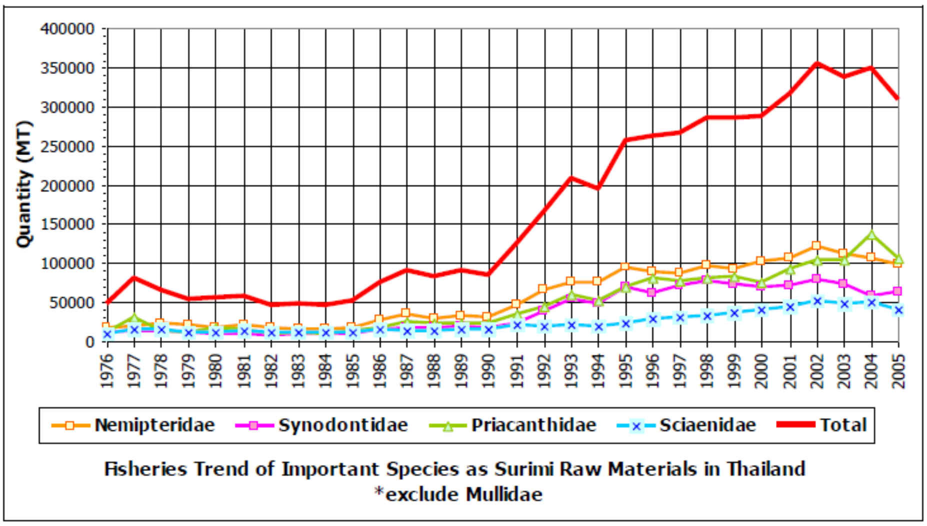



Figure 4.18 Landings of main surimi species during industry development period

In recent years however, catches have declined substantially – down from a high of over 350 000 tonnes in 2004 to about 130 000 tonnes in 2009 (assuming the species groups are the same)(Figure 4.19 – sourced from Department of Fisheries landings data).

| Country (I | Species (Name) | Fishing area (Name) | [2005] | [2006] | [2007] | [2008] | [2009] | [2010] | [2011] | [2012] | [2013] | [2014] | [2015] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thailand | Barracudas nei | Indian Ocean, Eastern | 4880 | 4906 | 3716 | 5536 | 4574 | 7725 | 6742 | 4883 | 6472 | 4302 | 4385 |
| Thailand | Barracudas nei | Pacific, Western Central | 10373 | 7600 | 8033 | 6393 | 6158 | 7624 | 9917 | 13822 | 10455 | 12113 | 14690 |
| Thailand | Bigeyes nei | Indian Ocean, Eastern | 36188 | 37755 | 33712 | 12617 | 11780 | 16687 | 13493 | 12992 | 14390 | 9914 | 6049 |
| Thailand | Bigeyes nei | Pacific, Western Central | 85007 | 75118 | 71458 | 19658 | 19235 | 21198 | 20944 | 22949 | 21697 | 22090 | 17090 |
| Thailand | Croakers, drums nei | Indian Ocean, Eastern | 16409 | 16546 | 13841 | 13727 | 12792 | 10893 | 4187 | 4932 | 6678 | 723 | 986 |
| Thailand | Croakers, drums nei | Pacific, Western Central | 33308 | 31485 | 29989 | 13355 | 14259 | 14251 | 9238 | 12334 | 11999 | 11082 | 6248 |
| Thailand | Largehead hairtail | Indian Ocean, Eastern | 6799 | 7372 | 6060 | 3189 | 3489 | 2793 | 2983 | 3030 | 2935 | 561 | 2472 |
| Thailand | Largehead hairtail | Pacific, Western Central | 8652 | 7234 | 7189 | 3287 | 3092 | 4521 | 7207 | 5261 | 5663 | 5636 | 3419 |
| Thailand | Lizardfishes nei | Indian Ocean, Eastern | 3649 | 3330 | 5185 | 13232 | 12881 | 15911 | 10334 | 11639 | 12628 | 12636 | 12880 |
| Thailand | Lizardfishes nei | Pacific, Western Central | 49389 | 42459 | 37563 | 15053 | 14038 | 16243 | 22322 | 25194 | 21253 | 28342 | 20229 |
| Thailand | Monocle breams | Indian Ocean, Eastern | 0 | 0 | 0 | 0 | 0 | 745 | 693 | 791 | 743 | 830 | 1636 |
| Thailand | Monocle breams | Pacific, Western Central | 8 | 6 | 57 | 0 | 47 | 1337 | 2649 | 1613 | 1862 | 7276 | 11000 |
| Thailand | Threadfin breams nei | Indian Ocean, Eastern | 23936 | 27278 | 28250 | 15127 | 17093 | 17357 | 11271 | 12860 | 13811 | 16338 | 11629 |
| Thailand | Threadfin breams nei | Pacific, Western Central | 80700 | 69305 | 64211 | 25024 | 25799 | 24938 | 38113 | 40409 | 34388 | 38940 | 25239 |
| Totals - Quantity (tonnes) | | | 359298 | 330394 | 309264 | 146198 | 145237 | 162223 | 160093 | 172709 | 164974 | 170783 | 137952 |
| Source | | | FishStatJ | FishStatJ | FishStatJ | FishStatJ | FishStatJ | FishStatJ | FishStatJ | FishStatJ | FishStatJ | Thai DoF | Thai DoF |

Figure 4.19: landings of the main families of fish used for surimi – note that goatfishes are not reported. Date sourced from FAO (FishStatJ). These are reported catches and the proportion that goes to surimi production is not separately identified.

### 4.7.8 Stock status

Thailand has a long history of overfishing which is not unique to Thailand, nor South East Asia. In the 1950's the production of fish in Thailand was about 100 000 tonnes sourced entirely from small scale fisheries. The development of the industrial fisheries was designed to increase the wealth for local fishers, increase exports and develop value added industries in Thailand. In the 1960's and 1970's this industrialisation, in the absence of suitable fisheries management controls, not only resulted in the production of huge volumes of low value bycatch but it also rapidly resulted in the depletion of many higher value species. The depletion of the higher trophic level species (such as groupers) resulted in an increase of their prey which, for many years, were used to feed land based animals such as ducks. In the late 1970's and early 1980's the desire to add value to these species resulted in the development of the surimi industry (and other value added sectors) and many of the species that once went for fishmeal were redirected to these higher value sectors.

Overfishing has been occurring in the Gulf of Thailand for decades. Kongprom et al (2003) found that the biomass of most demersal species (as represented by *Nemipterus* species, *Priacanthus* species and *Saurida* species) had declined by over 90% during the period 1961 to 1995. Even if some degree of fish down is a feature of a well-managed fishery (commonly 50% – 70% of original biomass is reduced to reach a maximum sustainable yield of biomass of about 30-50% of the original) the situation in Thailand demonstrates that the fishery has been operating in an unsustainable way for many years. Figure 4.20 demonstrates how catches were higher than estimated sustainable yields for many surimi species in the 1990s. Catch per unit effort had declined from almost 300kg/hour in the 1960's to 20kg per hour in the 1990s. During the period 1970 to 1984 the CPUE was relatively stable at about 60kg/hr but declined markedly from 1985 onwards (Supongpan and Boonchuwong 2010), which coincide with the development of the surimi industry.

| **Fish species** | **1994 catch Tonnes** | **MSY (tonnes)** | **Area** | **Reference** |
|---|---|---|---|---|
| *Nemipterus* spp | 55850 | 20900 | Gulf of Thailand | FAO 1995 |
| *Nemipterus hexodon* | | 17615 | Gulf of Thailand | Isara 1996 |
| *Nemipterus hexodon* | | 21697 | Gulf of Thailand | FAO 1995 |
| *Saurida* spp | 35593 | 20900 | Gulf of Thailand | FAO 1995 |
| *Saurida undosquamis* | | 21903 | Gulf of Thailand | FAO 1995 |
| *Saurida elongata* | | 2250 | Gulf of Thailand | FAO 1995 |
| *Priacanthus* spp | 44680 | 17400 | Gulf of Thailand | FAO 1995 |
| *Priacanthus tayena* | | 55915 | Gulf of Thailand | FAO 1995 |
| *Nemipterus* spp | 19260 | 5909 | Andaman Sea | Patiyasevi 1997 |
| *Priacanthus* spp | 7614 | 1100 | Andaman Sea | Patiyasevi 1997 |
| Croakers | 15396 | 5909 | Andaman Sea | Patiyasevi 1997 |
| Barracudas | 5487 | 2407 | Andaman Sea | Patiyasevi 1997 |

Figure 4.20 documented catches versus estimated Maximum Sustainable Yields in the 1990's. (extracted from Supongpan and Boonchuwong 2010)

The consequences of the excessive catches can be seen in the decline of available biomass. Whilst some decline in biomass is inevitable in any fishery the declines in the Gulf of Thailand are more attributable to an absence of effective management rather than a deliberate fishdown to a sustainable biomass.

The growth in fishing pressure can be seen in the exploitation ratios (ratio of total mortality to fishing mortality where total mortality is equal to natural mortality plus fishing mortality) for some species used for surimi production (Figure 4.21). The rapid increase in catches in the early 1990's is reflected in the high exploitation ratios. Many fishery managers aim to keep exploitation ratios under 0.5. Some scientists claim that may tropical species can handle higher exploitation ratios but even if this is the case the figures are still very high especially given the excessive fishing capacity and other evidence of declining availability.

| **Data from Kungprom et al 2003** | **Exploitation ratio** | | |
|---|---|---|---|
| **Species** | **1975** | **1985** | **1995** |
| *Nemipterus nematophorus* | 0.43 | 0.57 | 0.98 |
| *Nemipterus hexadon* | 0.28 | 0.40 | 0.97 |

| | | | |
|---|---|---|---|
| *Nemipterus mesoprion* | 0.33 | 0.46 | 0.96 |
| *Nemipterus peronei* | 0.29 | 0.40 | 0.92 |
| *Priacanthus tayenus* | 0.43 | 0.21 | 0.95 |
| *Saurida elongata* | 0.45 | 0.24 | 0.87 |
| *Saurida undosquamis* | 0.46 | 0.24 | 0.89 |

Figure 4.21 Growth in exploitation ratios for surimi species

As a result of the management reforms that have been undertaken in recent years (see below) there is some limited evidence of rebuilding of fish stocks in general.

**4.7.9 Current management**

The Thailand Department of Fisheries (DoF) has long sought to bring the fishing sector under control and has had some notable successes in the past 5 years with a large reduction in the number of trawlers, a significant effort to control Illegal, Unregulated and Unreported (IUU) fishing and other measures such as an increase in mesh size. The reforms are, as yet, incomplete and evidence of stock recovery is currently weak but the government has taken the sorts of steps that have proven effective in other jurisdictions.

Due to the multispecies nature of the fisheries it is unlikely that each species will have a regular stock assessment and catch controls. The DoF has opted for establishing a Multispecies Maximum Sustainable Yield (MMSY) and has determined what level of effort (in terms of millions of trawl hours expended) will be permitted. Figure 3.7 above shows how trawl hours have been reduced but catches are below the MMSY as stocks have not yet rebuilt, a process that may take a few years (Kulanujaree et al 2020).

There are a number of spatial and temporal closures in place which are not specifically aimed at surimi species. Saikliang (2014) sets out the history of some of the older closed areas/seasons and the Thai Fisheries Management Plan has expanded the number. Trawl mesh sizes have also been increased.

In terms of surimi species, the consequences of the restructuring on stock status and availability will take some time to become apparent. The larger mesh size will not only remove the small fish from the catch but these are largely used for fishmeal. There should be more and larger fish in general but it is very difficult to predict what will happen to individual species. Given that the surimi industry is able to make use of just about any species its likely that there will not be any significant negative impacts. Indeed, it is more likely that fish availability should increase, possibly substantially.

**4.7.10 Other fishery issues**

The development and poor management of Thailand's fisheries have created a plethora of issues both within Thailand and in neighbouring waters for decades. In the early days, recommendations to restrict the number of vessels were ignored which resulted in the rapid depletion of stocks in Thai waters so vessels moved to adjacent countries to fish. Prior to the passage of the United Nations Convention on the Law of the Sea (UNCLOS) these vessels could fish legally up to 12 nautical miles from the coast of countries such as Vietnam, Cambodia, Myanmar, Indonesia and Malaysia. From the mid 1980's onwards these countries moved to claim sea territories out to 200 nautical miles and sought to give priority access for their own national fleets. Thai vessels either moved out, set up joint ventures with local companies or fished illegally.

Illegal fishing is rife throughout SE Asia and is being driven by a wide range of issues, not the least of which is overfishing, which is driving fleets to seek fish where ever they can. The border between Thailand and Myanmar was identified as one of the largest IUU hotspots (APFIC year) with the catches being dominated by fish destined for surimi, fishmeal, frozen block and some small pelagics. The main destination for the fish was Ranong, Thailand.

Faced with declining fish stocks and rising costs the fleets sought to cut costs where ever possible. Cheap labour was imported to work on the vessels and then in the processing plants which resulted in widespread labour abuses.

The combination of the extent of illegal fishing and the labour abuses have driven change in the fishery driven by governments and the private sector. In 2015 the EU issued Thailand with a yellow card which drove much of the focus on reducing IUU fishing. Private sector initiatives such as the Seafood Taskforce (website) have brought together Thai and foreign (largely US and EU) companies, trade associations, NGOs and agency staff in a multipronged effort to boost compliance with the law in both the fishing and processing sectors. These efforts are not focused exclusively on the surimi sector but it is included.

## 4.8 Vietnam

### 4.8.1 Development of the surimi industry

Obtaining information on many aspects of the seafood industry in Vietnam is challenging. The government does not collect data on landings and production data for some key commodities, such as fishmeal (and surimi) are not collected.

Pangsorn (2009) reports on the growth of the number of surimi factories in South East Asia and it seems that the industry first developed in the mid 1990's and grew slowly until production reached an estimated 20 000t in 2002 (Park 2005).

According to Vidal-Giraud and Chateau (2007) Vietnam's production had grown to 32 000 tonnes by 2005 (but also see Guenneugues 2019). This estimate was not based on production data but on import data in three key markets Korea, Japan and Thailand.

### 4.8.2 Current production  - surimi and surimi seafood

The industry now exports over 180 000t of surimi per annum.

Vietnam produces 'w few thousand tonnes' of surimi seafood

### 4.8.3 Imports and exports

Exports of surimi are about 180 000t

### 4.8.4 Companies

The main surimi producers are as follows:

- Aoki Surimi
- Ngoc Tuan Surimi
- Bac Dau surimi
- Hai Thanh Surimi
- Dalu surimi
- Kisimex
- Tam Phuong Nam
- Coimex
- Nguyen Tien
- Long Hai Surimi
- Kicoimex
- Tien Dat Processing Seafood
- Truong Long processing Seafood JSC

- Hai Long surimi
- Cases Surimi
- Viet Long Kien Giang
- Seaprimexco Vietnam
- Khanh Hoang Seaprexco Limited
- Viet Truong
- Ngoprexco
- Lichuan Food Products (Vietnam)
- Phuong Dong

The main producers of surimi seafood are as follows:

- Lichuan Food Products (Vietnam)
- V&V (Mayumi brand)
- COIMEX
- DANIFOODS

#### 4.8.5 Main species used

Vietnam has a long coastline that is characterised by wide continental shelves in the north and south and a narrow central shelf. This, coupled with oceanographic differences has a major influence over the dominant surimi species in the north, central and south as shown by Guenneugues (2019). In the south the threadfin breams (Itoyori) and lizardfishes (Eso) dominate and these species have more in common with tropical species living on the seabed of the continental shelf. In the north, the seabreams (maybe *Evynnis cardinalis* – Son and Thuoc 2003) are largely warm temperate species which are also common in Chinese waters but are also seabed dwelling species. This differs from the trawl survey work of Ha (2009) which recorded threadfin breams and lizardfishes but not the seabreams. In the central part of the country, open water (pelagic) species are more common as there is little continental shelf for demersal trawling.

Mention of conger pike from southern Vietnam in ( Survey and Information Collection on Surimi Industry and catch data in Vietnam, 12 -17 June 2006 )


Figure 4.22 Main fishing grounds for surimi species, Vietnam

Pangsorn (2009) list the most common species groups used as 'king snapper' (Itoyori – probably Nemipteridae)(24%), lizardfishes (23%), bigeyes (19%), white croaker (19%) and others (15%). It was not explained what species comprised these groups nor how the data were collected.

Individual species are not always abundant with large variations geographically, from year to year and according to season (Ha 2009, Son and Thuoc 2003)

**4.8.6 Sources**

Due to the poor catch documentation it is difficult to ascertain from where the fish are sourced, although it is likely that the majority are sourced from Vietnam waters. Having said this, Vietnamese vessels are increasingly being apprehended fishing illegally in the waters of neighbouring countries (see below). Whilst these vessels may not be fishing specifically for surimi species or to supply surimi plants the nature of the fishery activities and the vessels suggests that the catch may go to a variety of processing plants.

**4.8.7 Domestic fisheries**

Vietnam has a very large fishing fleet comprised largely of small scale vessels. Most of the industrial fleet is comprised of trawlers and trawls are the main gear used to catch demersal species such as lizardfishes, goatfishes, threadfin breams, bigeye snappers and croakers.

In Vietnam the number of trawlers in 1997 was 18240, in 2007, 22094 and in 2008, 24091 (Nguyen and Thi 2010) and 22 554 in 2010 (Funge Smith et al 2012).

| **Otter trawls** | **Areas** | **2007** | **2008** |
|---|---|---|---|
| | The North | 4,266 | 4,755 |
| | The Center | 3,207 | 2,666 |
| | The Southeast | 6,473 | 6,447 |
| | The Southwest | 3,631 | 2,558 |
| | ***Sub-total*** | ***17,577*** | ***16,426*** |
| **Pair trawls** | The North | 915 | 976 |
| | The Center | 934 | 2,419 |
| | The Southeast | 810 | 2,489 |
| | The Southwest | 1,858 | 1,781 |
| | ***Sub-total*** | ***4,517*** | ***7,665*** |
| **Total:** | | **22,094** | **24,091** |

Figure 4.23 Table 3.4 Number of trawlers by types and areas in Vietnam during 2007 – 2008. Source: Nguyen and Thi (2010)

Whilst the data in Figure 4.23 are somewhat out of date, and the mix of vessel types has probably changed, the dominance of trawling in the southern regions of Vietnam (55% of vessels) links with the larger areas of trawl ground and the larger number of surimi and fishmeal plants.

### 4.8.8 Stock status

In terms of exploitable stocks Gulland's 1968 estimate included 250 000t for both South West Vietnam (Gulf of Thailand coast) and Cambodia. According to data (from 1974 or earlier) quoted in Panayotou and Jetanavanich (1987) the standing stock for the area offshore the Mekong Delta (236 000klm sq) was 1.383 million tonnes with a potential yield of 553000t. Thuoc et al (2000) estimated the total standing stock of Vietnam's marine fish to be 3.3 to 3.5 million tonnes creating a potential yield of 1.5 to 1.6 million tonnes. Son and Thuoc (2003) partitioned the estimate of biomass in to about 2 million tonnes of pelagic species and 1.4 million tonnes of demersal fish with the rest being comprised of other species such as crustaceans.

Nguyen (2005) and Nguyen (2009) review a number of studies from the Gulf of Tonkin (northern Vietnam adjacent to China) at various times (1959 to 1962, 1979 to 1988, 1990-1998, 1996 onwards and his own work in 2001 to 2004). These studies may have included both demersal and pelagic stocks or just one type and they may have included more than just the Gulf of Tonkin.

Daug et al (2002) used a research trawler to survey the waters in the northern, central and southern (only the southeast) parts of Vietnam at several depth strata (two in each of the north and central region and three in the south) over two years, which covered the monsoon and dry seasons. All of these factors had an influence on estimates of standing stock but, overall, the estimate for the 20-200m depth zone for the east coast of Vietnam was 700 000t. Hasan et al (2000) surveyed the pelagic resources of the coast (including the south west) out to the limits of the EEZ using sonar and calculated that the biomass was an estimated 9.26million tonnes.

Ha (2009) reported on the biomass of key surimi species based on a survey of all trawlable grounds in Vietnam in 2004 and 2005. The biomass estimates for 2005 were aggregated across species (within groups) and were listed as follows – lizardfishes (57 000t), threadfins (30 000t), croakers (18 000t), goatfishes (17600t) and bigeye snappers (37 000t). The largest biomass was in the southeast of Vietnam which has the largest area of trawlable continental shelf.

Ha and Nguyen (2017) reported on coast wide trawl surveys undertaken in 2013 and 2016. For the northeast monsoon period in 2016 the demersal biomass estimates for the south east (190 000 sq klm) and south west (92 000 sq klm) were approximately 216 000t and 159 000t, respectively. The comparison of the estimate provided above (Panayotou and Jetanavanich 1987) of 1.383 million tonnes for the south east and this latest estimate is stark although the whether the 1974 estimate is just for demersal species or includes pelagic species as well is unknown. For the southwest the estimate for the 0-50m depth strata was about 100 000t which compares to Gulland's 250000t for the same depths, but for Cambodia and Vietnam combined.

Son et al (2005) refer to trawl surveys undertaken between 1994 and 2005:

- Otter trawl Survey 1996-1997, M/V HL408-600 HP, ALMRV/RIMF.
- Pair trawl Observer Program in Ba Ria-Vung Tau province, March-April 2004, BV7299TS-BV7858TS, 450-380 HP, RIMF.
- Pair trawl Observer Program in Nghe An province, Sep 2004, CH03-CH06, 300-300 HP, RIMF
- Pair trawl Observer Program in Nghe An province, December 2004, CH04-CH06, 300-300 HP, RIMF
- Pair trawl Observer Program in Nghe An province, December 2004, CH03-CH05, 300-300 HP, RIMF

Whilst there are few quantitative reviews of overfishing in Vietnam (at least in the English language literature), a number of papers have commented on the impacts of overfishing in the inshore fisheries as far back as 1973 (Le 1997) and subsequently (Thuoc and Long 1997, Long 2003) as well as the offshore fisheries (UNEP 2007). Le (1997) commented on the thousands of trawlers that were fishing the inshore areas. According to UNEP 2007, during the decade after 1988, the density of demersal fish resources in south-eastern waters declined by 93.7% in waters shallower than 30m, and by 60.57% in waters deeper than 30m.

As was experienced in Thailand, Vietnam has experienced significant declines in CPUE with catch (in tonnes per horsepower per year) declining from about 1.0 to 0.35 over the period 1981 to 2002. Total horsepower increased about ninefold whilst catch only increased fourfold.

Van Tung (2014) claimed that overcapacity in the trawl fleet in southern Vietnam was at 56%. Hung (2018) evaluated trawl fishing effort and biomass in south eastern Vietnam and found that over the period 2008 to 2012 that there had been a general deterioration in the status of the fishery area accessed by larger vessels (>90hp) and little change in the status of the areas accessed by smaller vessels (which remained overfished). This outcome may reflect the results of government policy aimed at shifting fishing effort from overfished inshore areas to the offshore.

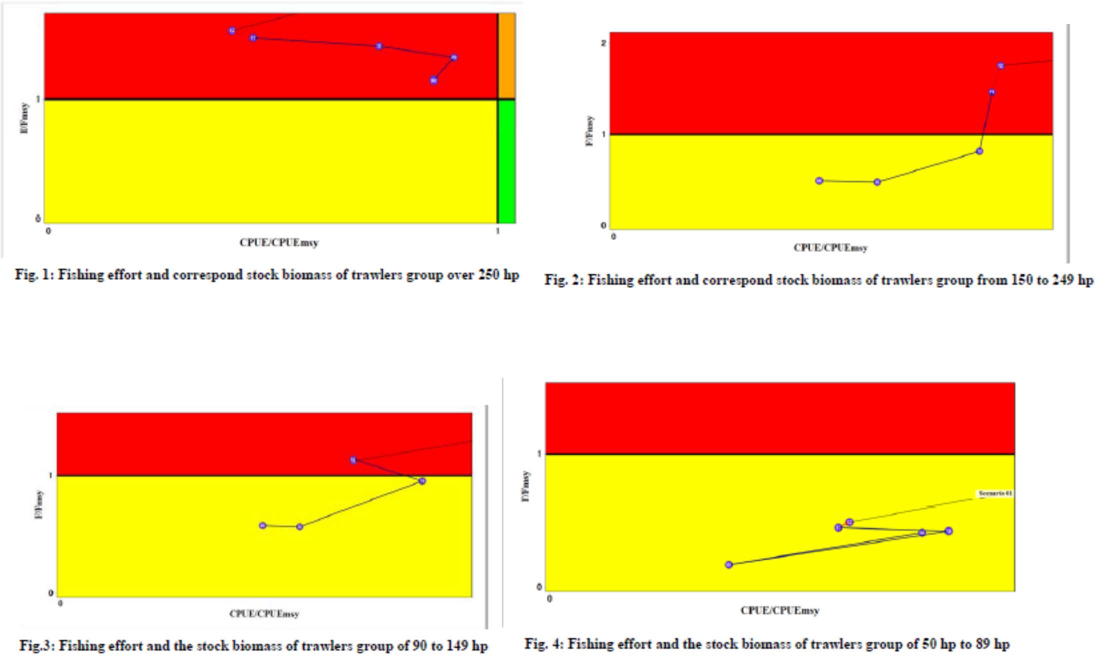



Figure 4.24 Fishing effort and stock biomass in South East Vietnam (Hung 2018)

In recent years the Asia Pacific Fisheries Commission (APFIC) has published overviews of the status of species complexes in member countries (see, for example, Funge-Smith et al 2012). These status maps are highly generalised and, unfortunately the source documents are not referenced. However, they do reflect the available literature which documents the widespread nature of overfishing both in terms of spatial scale and range of species. It is notable that Vietnam does not report data (Figure 4.25).

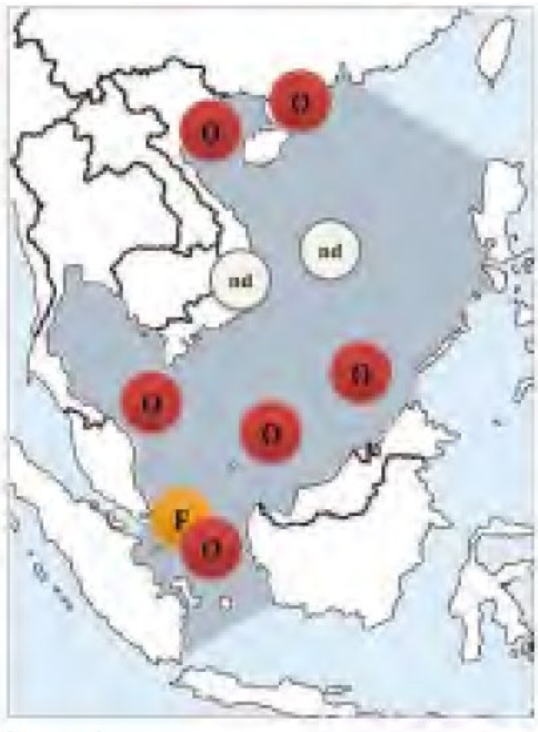


Figure 4.25 Status of surimi stocks. Note lack of reporting for Vietnam.

**4.8.9 Current management**

Management arrangements for fisheries in general in Vietnam are relatively limited. Licencing of vessels is required. There is also some zoning which limits access to particular areas by vessels of prescribed sizes. There is also a commitment by government to limiting the number of trawlers but fishery management plans are rare.

**4.8.10 Other fishery issues**

Overfishing has been an issue for a number of years. The effects are most prevalent in inshore areas but the overall impacts have been masked by a mixture of factors such as the construction of larger vessels to enable travel to new fishing grounds and probably changes in the ecosystem to favour faster growing, smaller species. The industrial fisheries in Vietnam were developed a several decades after those in Thailand and the pattern of development, ecosystem alteration and resource depletion are very similar. A significant difference is the fact that there is little room for expansion as neighbouring countries are not only experiencing similar issues but are increasingly intolerant of incursions from foreign vessels (https://www.seafoodsource.com/news/supply-trade/illegal-fishing-heats-up-diplomatic-exchanges-between-vietnam-malaysia-and-indonesia). In addition, Vietnam is experiencing a major challenge due to the annexation of large areas of fishing ground in the South China Sea by China. The sinking of Vietnamese vessels will force fishermen into already overcrowded and overfished areas.

The widespread occurrence of Illegal, Unregulated and Unreported (IUU) fishing has resulted in Vietnam being issued a Yellow Card by the European Union and this has driven a number of initiatives aimed at controlling the fleets (https://www.thestar.com.my/news/regional/2020/03/05/vietnam-to-beef-up-fight-against-illegal-fishing). However, there does not seem to be a commitment to reducing excess capacity as is taking place in Thailand. With fishermen being squeezed by declining fish resources, access constraints and rising costs they have reverted to other mechanisms for reducing costs such as questionable labour practices (https://ejfoundation.org/resources/downloads/ReportVietnamFishing.pdf)

Note that none of these issues are focused on the surimi industry specifically. The vessels involved can be trawlers, longliners, purse seiners or others but the multispecies nature of, especially, the demersal trawls makes it likely that there are illegal fish being supplied to surimi plants but given that small pelagic species are also used, illegal supply cannot be ruled out.

There is increasing evidence of the use of child labour in association with the illegal fishing

https://www.youtube.com/watch?v=vvUN-YSUOIA

Overfishing – ref Vietnam and Singapore - https://www.channelnewsasia.com/news/cnainsider/fish-balls-singapore-unhealthy-meat-itoyori-paste-surimi-bobo-12516872

# Chapter 5 - issues and challenges

## 5.1 Introduction

Like any industry the surimi sector has its own ways of doing business which, where feasible and appropriate, need to be incorporated into the ways the Sustainable Seafood Movement works. The SSM has much to offer the surimi sector in terms of supporting a transition to sustainable use, especially those arms of the movement that support structured programs aimed at improving fisheries management.

There is abundant evidence that this sector uses fish from fisheries which have some significant management challenges and this is complicated by the high species diversity and complex supply chains. As to how the current SSM model can works with these fisheries requires some thought. There is little value in finding a few small examples that fit traceability and fisheries management expectations if scaling up is unworkable. Consideration needs to be given to designing a system which can work at sufficient scale to drive fisheries reform.

The tropical surimi sector grew out of attempts by some governments in the 1980's to make greater use of catches in trawl fisheries which had been developed to either supply shrimps or high value finfish for export markets. Many of the species now used for surimi were directed to the fishmeal plants which grew rapidly in number to utilize low value fish. These plants helped foster the burgeoning shrimp farming industry and the supply of cheap fish for fishmeal not only helped supplement the incomes of fishermen (especially as catch rates were in decline) but helped the balance of payments by replacing imported fishmeal. The development of the surimi industry not only added value to low value species but encouraged fishermen to better handle the fish as they were now for human use, not animal use.

## 5.2 Traceability

### 5.2.1 Complex supply chains

As demonstrated previously a wide variety of fish species are used in the production of tropical surimi. Whilst there are some widely distributed species, there are also some which occur in particular regions and species and volumes may vary both within years and between years. It is thus not workable to generalize about 'tropical surimi'.

Supply chain complexity starts when the fish come onboard the vessel. As the fish may be directed into any one of the direct food fish trade, processed trade or animal feed sectors depending on price, size, species and quality, it may be handled onboard in different ways. For example, fish destined for human consumption (either directly or processed) will be stored in ice or (occasionally) in refrigerated holds. Fish deemed more suited to animal feed may well be stored without any cooling. Depending on how far away the fishing grounds are located and the sizes of the vessels involved, it may be that fish are transferred to carrier vessels for transfer to the port of landing.

Unloading carrier vessel, Vietnam

Unloading trawler, Thailand.

### 5.2.2 Catch documentation and monitoring

As occurs in developed countries (e.g. tropical shrimp fisheries) the possibility of logging all species (and volumes) in the catch coming onboard the vessel is simply not feasible. Captains may be required to fill out logbooks but from a traceability perspective the level of detail, even for valued species, may not be sufficient.

Figure 5.1 below is an extract of a captain's declaration for species supplied from a Vietnamese vessel to a processing plant in Thailand. Note how the lizardfish is identified to species level but the threadfin breams only to genus.

Section II Mục II:

| Fishing vessel Tàu cá | | | | | | Product description Mô tả sản phẩm | | | | | | | | Master/ owner of the fishing vessel thuyền trưởng/ chủ tàu cá | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name, Registration No Tên, số đăng ký | Type: Small */ Normal ** Loại Tàu nhỏ * Tàu thông thường ** | Home port Cảng nội địa | Call sign Hô hiệu | Inmarsat, fax, Tel No (if issued) Inmarsat, Fax, điện thoại (nếu có) | Fishing licence No, period of validity: Số giấy phép ,giá trị đến ngày | Catch area (s) and date Vùng và thời gian khai thác | Name of Species Tên loài | Type processing authorized on board Loại chế biến được cấp phép trên tàu | Date of landing Ngày lên cá | Total catch of the vessel Tổng khối lượng khai thác của tàu cá (kg) | Catch processed from the total catch Khối lượng nguyên liệu đưa vào chế biến từ tổng khối lượng khai thác (kg) | Processed fishery product for export Khối lượng sản phẩm chế biến xuất khẩu (kg) | HS code of the exported product Mã của sản phẩm xuất khẩu | Name Tên | Date and signature Ngày và chữ ký | Stamp Dấu |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
| BV 5367 TS | ** | Phuoc tinh port | N/A | N/A | 0904/2009/ KTTS- 30/08/2012 | FAO 71 ĐNB 2 29/06/2012 06/07/2012 | *Nemipterus spp (Cá đồng)* | N/A | 08/07/2012 | 6460 | 6440 | 4600 | 03049900 | Võ Cam | [signature] | |
| | | | | | | | *Saurida undosquamis (Cá mối)* | | | 8958 | 8946 | 6300 | | | | |
| BV 9118 TS | ** | Vũng tàu port | N/A | N/A | 1167/2011/ KTTS- 30/09/2012 | FAO 71 ĐNB 2 30/06/2012 05/07/2012 | *Nemipterus spp (Cá đồng)* | N/A | 08/07/2012 | 7625 | 7614 | 5400 | 03049900 | Bùi Văn Vân | [signature] | |
| | | | | | | | *Saurida undosquamis (Cá mối)* | | | 5269 | 5254 | 3700 | | | | |
| | | | | | | | | | Total Tổng | 28312 | 28254 | 20000 | | | | |

Figure 5.1 Extract from captains declaration - Vietnam

In this example from Thailand the same pattern is evident.

| Fish Species ชนิดพันธุ์สัตว์น้ำ | Weight used from the catches (kg) น้ำหนักสัตว์น้ำที่ใช้แปรรูป (กก.): | Type of processing authorized on board (if applicable): การแปรรูปบนเรือ (ถ้ามี) |
|---|---|---|
| THREADFIN BREAM *(Nemipterus tolu, Nemipterus nematophorus, Nemipterus furcosus, Nemipterus hexodon)* | 12,208 | N/A |
| LIZARDFISH *(Saurida elongata)* | 11,371 | |
| *Remarks: In case of catches used from more than one fishing vessel, please use APPENDIX 1* | | |

Figure 5.2 Extract from captains declaration - Thailand

Even in areas where the vessel lands the whole catch, it may be offloaded in different areas. For example, it may be that fish for direct human consumption are offloaded at a designated landing site but other components, e.g fish for animal feed, are offloaded somewhere else. If the factory has direct water access then the fish may be offloaded directly to the factory (which may also occur in some cases for surimi plants). Fish may also be transported great distances for processing. In previous years fish caught in Indonesia were shipped to Thailand. In India, fish may be trucked across the country, meaning that fish may come from multiple fisheries.

Bigeye snappers for surimi, Vietnam

Fish for fishmeal plant sent up river

Mixed species for fish meal, Myanmar

Surimi fish unloaded on other side of port

Once the fish are landed they may or may not go directly to the surimi plant. In some cases (e.g. India and Indonesia) there may be some pre-processing of the fish such that heads and guts are removed for sale to the fishmeal plants prior to the rest of the fish being sent to the surimi plant. IN the case of India this process is controlled by middlemen. One implication is that it may not be feasible to know exactly what species are being used even if there was a need/interest to do so (noting that it seems to be common industry practice to treat similar species (e.g. threadfin breams) together.

Pre-processing of fish, Indonesia

Fish being unpacked at surimi plant, Indonesia

At the landing sites there may or may not be information collected for fisheries management purposes. The port manager may require information to be supplied but it may be aggregated (examples include Indonesia, India, Vietnam and Thailand) and the fisheries authorities may deploy enumerators to monitor landings. Again, the level of aggregation and detail will vary, simply because of the numbers of species involved. Public reports may have far less detail than is held in departmental databases (see for example the Central Marine Fisheries Research Institute annual report and website in India).

In general terms fish will move to the highest price until demand is satisfied and then move to the next. The animal feed sector receives fish that are either poorly handled or surplus to other requirements.

The surimi sector is very market driven and demand is influenced by product attributes such as colour and gel strength in addition to price and availability. In order to deal with shortages producers will blend surimi made from different species to meet the customer requirements as best they can. For example, if threadfin breams for making higher value surimi are in short supply the producers may add in another species but only to the extent that the perceptions about the high value product are not compromised. This is different to the manufacturing of lower grade mixed species surimi.

We could find little information about mixed species surimi.

Traceability and disclosure about ingredients in the products is increasingly being required by supply chain companies and government regulators. This is important for a variety of reasons:

1. Cultural requirements – in the making of surimi seafood fish is commonly mixed with other protein sources such as beef and pork. The use of pork, in particular, needs to be disclosed especially in many Asian countries with large Muslim populations;
2. Human health considerations - people with food sensitivities or allergies (for example, shellfish) need to be made aware of what may be in a mixed surimi product;
3. Product safety and trace backs – if food safety issues are discovered then accurate and timely tracebacks help identify the source quickly and can limit the costs, as opposed to more generic product recalls;
4. Reducing incidence of illegally caught raw material in the supply chain, thus assisting in the fights against IUU fishing.

## 5.3 Fishery level issues

The majority of fishery level issues relate back to the lack of good fisheries management and many Asian countries do not have in place the basic tools required to control catches to sustainable levels.

1. Ignoring scientific advice about the need to limit the numbers of vessels in the early phases of fishery development. In the early 1960's when Tiews (quoted in Butcher 2002) advised the government of Thailand that there were sufficient fish resources in the Gulf of Thailand to sustain a viable trawl fishery his advice was that the number of vessels should be strictly limited as there were already signs of depletion 5 years after the trawl fishery began. Instead there were no controls and at one stage in the mid 1980's the number of known vessels (and there was suspected to be a significant number of unlicenced vessels) was in the vicinity of 14000. Governments in the region adopted the common global practice of 'open access' whereby there were no limits on vessel numbers so as to encourage participation and investment.
2. Not undertaking effort cutbacks when there was clear evidence of unacceptable declines in catches and Catch Per Unit Effort. At best, countries such as Thailand and Malaysia have implemented limited entry regimes where there are major limitations on the issuing of new licences. Indonesia has been through two periods of allowing effort to get out of control and then implementing total gear bans, the most recent one in 2015 (and subsequently reversed). This approach is very disruptive and misses the opportunity to have productive industries (in fishing and processing) as well as protecting small scale fishers.
3. Not undertaking stock assessments with sufficient frequency. Some countries such as Thailand and India collect data on a regular basis but Myanmar and Pakistan do not. Thailand has a clear and rational basis for making use of the data collected for fisheries management purposes.

4. Failing to proactively control Illegal, Unregulated and Unreported (IUU) fishing for both domestic and foreign vessels. National governments have become more proactive in this area, especially in response to external pressures from importing countries/blocs such as the EU and the US. Indonesia has famously seized foreign vessels fishing illegally in its waters and set them on fire.
5. Not having the transparent and accountable governance structures, including consultation arrangements with key user groups. Having these in place helps build trust and ownership of both the problems and solutions. Thailand and Vietnam have made progress in this area and Indonesia has also started to make some advances.
6. Not having fishery management plans and adequate and accountable management objectives (biological, social and economic). The best developed are in Thailand where all the main commercial fisheries are in the second round of their five-year planning cycle.

As is apparent from the discussion above there is a great deal of diversity in the capacity to manage fisheries and degree of progress across countries in the region and this is reflected in reviews of the performance of country fisheries against the FAO Code of Conduct for Responsible Fisheries (Pitcher et al 2009, Hosch et al 2011). Some countries (e.g. Thailand and India) have detailed and lengthy data sets and are far from data poor. Corruption has also been identified as an issue and this likely affects decision making over the issuing of licences and the ability of fisheries agencies to reduce the numbers of vessels/catches if required. Some of the countries that supply tropical fish rank lowly on the global corruption index (www.transparency.org).

A significant contributing factor is the lack of clear management models for multispecies fisheries. Whilst the challenges associated with multispecies fisheries in general, and trawl fisheries in particular, have been known for many decades (see for example Sainsbury 1982) the provision of authoritative advice has been lacking. Whilst some tropical trawl fisheries are managed to maximize the production of shrimps and are managed as single (or close to) single species fisheries this approach has not worked in countries where the whole catch is valued and there is little discarding. The Asia Pacific Fisheries Commission's Guidelines for Tropical Trawling (FAO 2014) provided a major step forward in seeking to support efforts to sustainably manage trawl fisheries in Asia. Its clear that these 'multiproduct' fisheries require an approach to management that is not based on the traditional target/bycatch dichotomy and whilst various species may be closely monitored as indicator species (Sparre 2000, Newman et al 2018), a management approach that focuses on overall yield rather than the yields of individual species is not only more practical but likely more beneficial for the ecosystem and a lot more in keeping with the objectives and aspirations of governments in the region (see for example Hilborn et al 2004, Zhang et al 2016).

Whilst the issues may seem daunting there can be no doubt that the industry could and should have a vested interest in fisheries management reform.

## 5.4 Social issues

There is a wide variety of issues considered to be 'social' issues in fisheries. Whilst the recent global dialogue has focused on labour issues. There have been long running disputes between fishing sectors going back decades, if not further. Conflict has grown (Salyso et al 2006, Pomeroy et al 2007) as fisheries have expanded with little attention being paid to orderly or planned development that takes into account the aspirations or needs of existing fishing communities in terms of either their need for fish or development/work opportunities. Where it is practiced at all, fisheries management has been reactive at best, and has commonly been driven by violence or protests such as the various anti-trawl movements in the late 1970's and mid 2000's. Despite knowledge of the poor consequences of so called 'open access fisheries' governments have generally failed to limit access to the fisheries or, when they have done so, they have not removed the excess fishing effort. Whilst the multispecies nature of the fisheries has buffered the short terms consequences of excess fishing effort (by allowing non-targeted species to boom when predators/competitors are overfished) the scale and nature of the participation in fishing is gradually overwhelming the ability of marine ecosystems to continue to deliver.

The lack of control over who can participate in the fisheries has played out at varying scales ranging from the very local disputes between neighbours to disputes between gear types and disputes between countries. One of the root causes of IUU fishing is the incentive to cheat created by open access fisheries regimes that dissipate profits to zero. Fishermen have resorted to illegally accessing closed areas, the avoidance of licencing/registration, corruption, illegal mesh sizes, smuggling (fuel, wildlife, guns and drugs) and the use of slave or poorly paid labour (UNODC 2016, Anon 2008, Rose and Tsamenyi 2013, Rose 2014, Butcher 2002, Topsfield 2017) as profits become negative and government subsidies become unworkable.

The pressures of poor fisheries management leading to zero nett profits coupled with demands for ever cheaper fish and poor enforcement of basic human rights has created a 'perfect storm'. In Thailand, at least in Thailand, the conditions for some long overdue fisheries management reforms have been created but a long and painful period of adjustment lies ahead. Such reform periods have been confronted in many other countries (e.g. US, UK, New Zealand and Australia, amongst others) but the results have been healthier fish stocks and ecosystems, more profitable fishing businesses and a reduced tendency to indulge in illegal activities.

# Chapter 6 CRC members Theory of Change and the surimi industry

## 6.1 The industry/sustainability landscape

In this chapter we document what is known about the views of the industry in the context of the requirements of the CRC members prior to making some suggestions as to a way forward. In previous chapters we document the substantial differences between the sustainability status of the coldwater species (e.g. Alaska pollock, New Zealand hoki and Pacific whiting, amongst others) and the tropical species. The former are largely either certified to the MSC Standard or in a Fishery Improvement Project. The MSC Standard is available for small pelagic species that could be used for surimi, especially where the fisheries are focused on one or a small number of species and where stocks are in good shape. In the case of farmed, freshwater species, there is an existing and growing volume of fish certified to the ASC and BAP standards, primarily Pangasius and standards are available for other key species, including silver carp. The challenge is the tropical species where, even if the MSC Standard can be successfully applied to the source fisheries, the poor status of these fisheries will dictate a long-term investment in fisheries improvement work.

A key component of the market based approach to driving improvements (see below) is gaining the support of industry. In order to evaluate the potential for this approach to be developed we surveyed the views of companies involved in either the production of surimi or the production of surimi seafood. A copy of the relevant questionnaires for each category is at Appendix X.

6.1.1 Surimi producers

A total of eleven (11) companies from four different countries participated in the survey, namely; India (5), Vietnam (4), China (1) and Malaysia (1). According to these companies at least 55 species are used for the production of surimi, noting that some are mentioned as species groups (e.g. Johnius spp – and there are many species within this genus) and some countries, which likely have different species, did not respond.

All eleven companies make surimi from a single species. In addition, nine companies make surimi from mixed species. Mixing species are made based on the manufacturer's interest or per customer request. Any species can be mixed. Ten (10) companies mix the fish before deboning while two companies mix screw press meat or mixing fish before deboning.

The fish can be sourced from considerable distances, both in terms of fishing grounds and after landing. According to one producer in Vietnam fish can be sourced from over 160klm away but its also the case that fish may be trucked from over 1000klm away (e.g. in India). In the India case fish may be trucked from the east coast of India to the west coast for processing and thus the fish come from quite different management zones. Only one company mentioned the use of imported fish.

The mostly commonly mentioned gear types used for the capture of fish are trawls and purse seines, which accords with information on landings more widely in Asia as these gear types are generally the source of industrial volumes. Respondents from both China and India mentioned the existence of a fishing season (probably a reference to the summer closures) and only one company mentioned mesh sizes in nets (20mm). The size of fish used is generally quite small with companies having their own standards for minimum size and weight of fish, even if there are no minimum size limits imposed by government. Some examples of these requirements include:

- >12cm (India Company 1),
- >30 g for Threadfin bream/>50g for other fish (India Company 2),

- >50g (I3), 25-50g (India Company 4),
- >8cm (Malaysia Company 1),
- 25-60g (Vietnam Company 1), and
- >10cm or >20g (Vietnam Company 4).

Companies have observed a variety of changes in recent years in regards to the fish they source. By and large there is a view that:

- The average size of fish has declined by about 30%
- Landing volumes have declined by as much as 50%
- In some cases the species mix has changed significantly (by as much as 50%)
- Some companies thought that the fishing grounds had moved further away.

These are general views and not consistent across all companies noting the different countries in which they operate, and the small number of respondents in some countries, one in each of China and Malaysia, for example. Some observation accord with other evidence such as the change in species mix in parts of India. The past two fishing seasons have been characterised by huge catches of red toothed triggerfish (*Odonus niger*) which have found a variety of uses including surimi and fishmeal.

Viewed individually, there could be a variety of explanations for each of the observations. For example, a decline in landings volumes may be due to overfishing, natural seasonal factors or changes in market demand. However, taken together, there is compelling evidence that overfishing is a major problem, a conclusion supported by the available scientific evidence set out in previous chapters.

Company views about the future of the industry range from the outright gloomy (a 'sunset industry') through 'stable' to a more upbeat 'increasing due to more species being used for surimi'. There does appear to be an underlying concern about the level of depletion of fish resources with some looking to transition production to alternative sources such as aquaculture and small pelagics. Only one company is known to have established a Fishery Improvement Project (Gadre Marine in India) but others are part of wider coalitions that are participating in FIPs in Thailand. For example, the Thai Sustainable Fisheries Roundtable is participating in FIPs in Thailand and their membership includes the Thai Frozen Foods Association, which has surimi production companies amongst their membership.

6.1.2 Surimi Seafood production companies

A total of nineteen companies from four different countries participated in the survey of surimi seafood producers. They are Japan (5), S Korea (3), Thailand (2), France (2), Spain (1), Malaysia (1), China (1), Hong Kong (1), Indonesia (1), Ukraine (1), and Russia (1).

Top four (most popular) surimi the participants use by species are Threadfin bream surimi, Threadfin bream mixed surimi, Alaska pollock, and Ribbon fish in a descending order. However, there is a distinctively different species preference by region/country. Top four species in descending order are:

- Japan: Alaska pollock, Ribbon fish, Threadfin mixed surimi, and Lizardfish
- S Korea: Ribbon fish, Threadfin bream, Threadfin bream mixed surimi, Alaska pollock
- SE Asia: Threadfin bream, Threadfin bream mixed surimi, Mixed surimi, Lizardfish
- Europe & Russia: Alaska pollock, Pacific whiting, Flying fish/pelagic fish, Threadfin bream
- West Europe: Alaska pollock, Pacific whiting, Saithe, Flying fish/Pelagic fish

- East Europe & Russia: Mixed surimi, Alaska pollock, Flying fish/Pelagic fish, Threadfin bream,

Sixteen companies use surimi made from fish from the North Pacific indicating they use Alaska pollock and/or Pacific whiting.  Eleven companies use surimi made from fish from the Western Indian Ocean whilst nine companies use surimi from the South China Sea sourced fish.

The companies were asked a number of questions about resource sustainability, their perceptions and what level of importance they ascribe to sustainability as part of their approach to business. With the exception of two companies (one in each of Japan and Russia - with their comments “not sure”) all indicated Alaska pollock, Pacific whiting, Saithe, Silver carp, Hoki, and/or sardines are sustainable.  Almost all companies thought all tropical species are “not sustainable”. Ten companies responded that sustainability can be a primary concern for the long-term survival or prosperity of their companies. Nine companies answered that sustainability is something that needs to be considered in response to the demand of the market. Customer/consumer awareness was cited as the source of a growing concern about sustainability for nine companies. Retailer pressure around sustainability was cited by eight as a constraint that cannot be ignored or under-estimated.

With regards to consumers, resource sustainability is one of several factors that influence a purchase decision.  Figure 6.1 ranks the four main factors mentioned by companies, with the number one purchase decision is being based on the quality and price of the product. A purchase decision based on the sustainability of the product is the lowest.

| | C1 | F1 | F2 | H1 | ID1 | J1 | J2 | J3 | J4 | J5 | K1 | K2 | K3 | M2 | S1 | T1 | T2 | R1 | U1 | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The **quality o**f the product and its **price** | 2 | 4 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 1.63 |
| The **origin** of the product and the **reputation** of the producer | 1 | 3 | 3 | 1 | 2 | 2 | 4 | 2 | 1 | 2 | 2 | 4 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 2.26 |
| The **name of the fish** and its **impact** towards the consumers | 3 | 2 | 2 | 4 | 4 | | 2 | 4 | 1 | 3 | 3 | 1 | 2 | 4 | 4 | 1 | | 2 | 3 | 2.65 |
| Independent proof (e.g. via **certification)** of the fishery in relation to sustainability | 4 | 1 | 1 | 3 | 3 | | 3 | 3 | 1 | 4 | 4 | 3 | 4 | 3 | 2 | 4 | | 4 | 4 | 3.00 |

Figure 6.1 Factors influencing purchase decisions – all regions

Similar results were found for regions except Western Europe (France and Spain). As shown below, independent proof (certification) related to sustainability was the number one decision factor.

| | F1 | F2 | S1 | AVG |
|---|---|---|---|---|
| The **quality o**f the product and its **price** | 4 | 4 | 1 | 3.00 |
| The **origin** of the product and the **reputation** of the producer | 3 | 3 | 3 | 3.00 |
| The **name of the fish** and its **impact** towards the consumers | 2 | 2 | 4 | 2.67 |
| Independent proof (e.g. via **certification)** of the fishery in relation to sustainability | 1 | 1 | 2 | 1.33 |

Figure 6.2 Factors influencing purchase decisions – Western Europe

Despite the lower ranking of sustainability fourteen companies were willing to consider making efforts to encourage their source fisheries to become sustainable. This was not the only type of effort considered. For example, twelve companies would consider pushing their management to look for alternative sources of raw material, based on the advice of scientists and fishery specialists that in the long term, the raw material used to process the surimi products is unsustainable. Ten companies would consider the use of alternative fish resources even though these may not be popular among the public.

There is generally a lot of media about fisheries sustainability and not just related to fishing. For example, a recent article claimed that climate change would lead to a decline in the productivity of Alaska pollock.

Thirteen companies agreed that further development of surimi production from Northern Blue Whiting or Pacific Whiting may be a good solution, assuming that both of these species are in good shape. Note that climate change impacts on other species, such as small pelagics, was not canvassed.

Other initiatives for which comments were sought included the use of farmed fresh water fish which fourteen (14) companies supported as a replacement for marine fish. Seventeen companies agreed that surimi from small pelagic fish can be advantageously used to produce certain products such as fried surimi seafood in combination with white fish surimi. Both these alternatives assumed that the supplies were sustainable.

Overall, a move towards sustainability was seen as positive with all (eighteen) but one of the companies agreeing that supporting the transition to sustainability helps both their production and the fishermen as well as maintaining supply chains. They believe this approach is worthwhile for their company. However, there were reasons why such a transition may not be easy, of which the top three were:

- Thirteen companies thought a barrier to move to sustainability would be price related - sustainable surimi being more expensive than non-sustainable surimi.
- Eight companies viewed that a barrier to move to sustainability would be consumers' ignorance regarding the problems of sustainability
- Eight companies viewed that a barrier to move to sustainability would be lack of availability of sustainable resources.

Overcoming these disincentives would be enhanced by:

- Twelve companies replied that pressure from retail distribution that forces processors to reject surimi seafood made with non-certified origin.
- Eleven companies suggested that an increase availability of sustainable surimi would be influential; and
- Ten companies replied that increasing consumer's awareness regarding the issue of sustainability would be helpful

In broad terms the issue of sustainability is well and truly on the radar screen of surimi seafood producers. For many, they are global players, well tuned into the seafood sector dialogues and they would have been exposed to marketing by successfully certified fisheries and aware of the issues in the tropics. Most have indicated a receptiveness to being a part of the solution, which is encouraging and provides a base to work from.

## 6.2 Market based incentive approach to improving fisheries management

Improving the sustainability performance of global fisheries is a goal shared by many, including CRC members. The pathways to this goal are divers but CRC members believe that the seafood industry (from fishermen through to retailers and consumers) have a role to play in generating the willingness amongst regulators and fishermen to undertake the reforms required. Whilst the exact words may vary from organisation to organisation the overall Theory of Change model is well described by Anon (2007)(Fig 7.1)

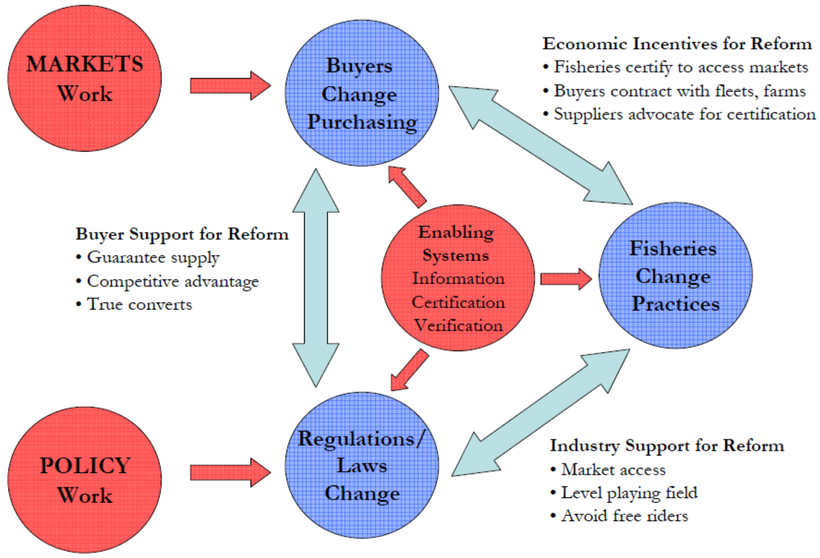



Figure 6.3 Basics of the sustainable seafood Theory of Change

The main elements of this model have been adopted and adapted by different seafood sectors and organisations over many years. Whilst there are many examples of collaboration between fishermen and regulators (generally called comanagement) and between fishermen and others (such as NGOs) the defining feature of the model described in Figure 7.1 is the involvement of the post-harvest sector, including processors, distributors and retailers (referred to as the 'market'). This variant reflects several realities, the first being that players in the whole supply chain have a stake in good fisheries management, and much to lose if management is ineffective. A second reality is that the seafood trade is highly globalized with seafood being the most traded primary product in the world.

A common, but not essential, feature of the model is the use of a sustainability standard to guide assessments of what is needed to in terms of management reform and also a verification tool. The most widely used standard is the MSC Standard for Sustainable Fisheries but others, such as the Marin Trust Standard and the US Fair Trade Fisheries Standard can also be used. Other systems such as ASIC Fish and ISO14000 based systems (e.g. the GreenChooser) have similar requirements but not codified as formal standards. Given the growing availability and use of farmed fish as a source of surimi the model needs to be adapted (which is not difficult) to include farm standards and improvements towards these standards.

Comanagement is one mechanism for transforming a fishery towards sustainable use. When the supply chain is involved the process has been termed a Fishery Improvement project or FIP. FIPs are but one tool that supply chain participants choose to operationalize their commitments to driving sustainable use (see Leadbitter and Benguerel 2013).

The number of FIPs developed globally has grown steadily over the past ten years. Most of these work to the MSC Standard due to the requirements of supply chain participants. A small but growing number work to the requirements of the Marin Trust standard (a standard for fishmeal and oil factories with CCRF based requirements for the source fisheries) and The Gulf States Certification Program has also been developing FIPs. Much of the information on the effectiveness of FIPs has been derived from analyses of those FIPs listed on FisheryProgress.org, which is almost exclusively MSC related. FIPs that adopt other standards do not have a dedicated reporting area and their number is currently too low to draw conclusions about effectiveness.

In broad terms the analyses of FIPs shows that:

1. FIPs work – Cannon et al (2018) demonstrated that fisheries engaged in FIPs performed better than those that are not;

2. FIPs perform better at data collection than policy reform (Crona et al 2019). The reasons for this were not analysed in detail and could be varied.

The Sustainable Seafood movement and the use of tools like FIPs were pioneered by the sector focused on supplying fish for the fresh/frozen markets. In volume terms the fisheries that have made most progress towards sustainability are industrial scale, single species fisheries typified by so called 'groundfish' such as Alaskan pollock, various species of hakes and whitings, hoki and cod. By and large, these fisheries are located in the waters of developed countries, supply markets in the EU, UK and Us which have the greatest interest in sustainable sourcing and, particularly importantly, are easiest to manage in accordance with the global requirements and expectations as set out in the UN Convention on the Law of the Sea and the FAO Code of Conduct for Responsible Fisheries (see Section 5.X). In the tropical waters of developing countries there has also been considerable progress on the sustainability status of some tunas, especially skipjack but again this is generally an industrial scale and largely single species fishery.

The surimi sector has been indirectly involved in this transition as the cold water groundfish fisheries have been the dominant sources of surimi for decades. However, in the markets of interest to the Sustainable Seafood movement, at least until relatively recently, surimi was not viewed as a product form that could engage consumers in a discussion about sustainability as other processed products such as fish sticks or canned tuna. In part this was due to the fact that surimi in the key Sustainable Seafood Movement markets of the US, UK and EU is very much a low value product that has little visibility.

As the Sustainable Seafood movement has moved to engage Asia, especially the more populous markets in China and Japan, the opportunity to look more closely at surimi has arisen as this form of seafood is not only immensely popular but treated as a high value product when manufactured into particular products that commonly have long cultural roots (Chapter 1).

In previous sections we have set out the nature of the tropical surimi industry, noting that surimi made from tropical species is but one component of the total usage of this form of seafood, particularly in Asia which is the overwhelmingly dominant market for surimi in general and tropical surimi in particular.

In previous sections we have provided evidence that:

- The production of tropical surimi is a significant (about 70%) proportion of total global surimi production
- The countries that produce most tropical surimi are China, Vietnam and India, followed by Thailand, Malaysia, Indonesia, Pakistan and Myanmar
- The countries that produce the most surimi seafood products are China, Japan and South Korea.
- The countries that consume the most surimi products are China, Japan and South Korea.
- Surimi can be made from wild capture fish, farmed fish and the trimmings from fish processing (wild and farmed);
- There is a very large number of wild capture species involved as surimi can be manufactured from any species of fish;
- The most commonly used species in tropical surimi are the threadfin breams, croakers, lizardfishes, bigeye snappers, goatfishes, hairtails/ribbonfishes and some small pelagic species such as sardines and flying fishes. Over one hundred species have been recorded.
- Overfishing is a serious and widespread problem in all countries that harvest tropical fish for surimi (if not virtually all other seafood products)
- The main fishery sources for tropical surimi fish are the trawl fisheries which are ubiquitous in Asia. To a lesser degree purse seining and gillnetting are also sources. Only Malaysia and Thailand have made serious efforts to ensure that their trawl fisheries are adequately controlled.

- The tropical multispecies fisheries present some significant challenges for not only fisheries managers but fishery assessment systems and standards which are largely designed around single species approaches. Care needs to be exercised in seeking to impose single species approaches on these fisheries for not only ecological reasons but for social and economic reasons.
- Multispecies trawl fisheries are also multiproduct fisheries. These fisheries can be managed in different ways to optimise yields that suit the objectives set out by fishery stakeholders.
- In any given fishery the same species can be used fresh/frozen, processed (e.g. into surimi) and/or used for fish meal depending on the size, demand and quality of the fish.
- Processing wastes from the surimi sector are commonly used for the production of fishmeal either at the same factory or at dedicated fishmeal factories.
- The production of mixed fish surimi is becoming increasingly common as producer look for ways of extending the use of increasingly scarce high value species such as threadfin breams. There is also surimi made from mixes of species but there is little information available on this;
- Supply chains are very complex. Fish may be transferred to carrier vessels in some countries, the buying arrangements can be complex, there may be mixes of species used in the surimi and the surimi may be traded internationally prior to the making of surimi seafood products.

The rationale for the engagement of the CRC and its members in the tropical surimi industry are as follows:

1. There is a clear need from a resource sustainability perspective – tropical developing countries supply a significant proportion of the world’s seafood, have the highest proportion of catches listed as NEI (Not Elsewhere Incorporated) and are poorly represented in the pantheon of well managed fisheries (certified or not);
2. There is a clear need from social and economic perspectives – overfishing is putting livelihoods at risk, both on the water and on land. Whilst there is commonly a focus on the impacts of overfishing on fishers, there are also impacts on those employed in processing plants, who are commonly women. Resource scarcity and cost cutting is fueling illegal activity and poor labour practices.
3. There is a clear need from a regional geopolitical perspective – overcapacity and overfishing is a source of concern for regional stability, both within some countries (such as eastern Indonesia) and between countries where fishing disputes can aggravate existing tensions such as those between India and Pakistan and between a number of nations fishing in the South China Sea.
4. The general issues are well known in government and intergovernmental circles. The issues of overcapacity and IUU fishing, for example, have been known for many years and the subject of agreements such as the Regional Plans of Action. Country governments are increasingly moving to develop and implement management plans for their fisheries and there is also considerable effort being directed towards resolving some of the labour issues.
5. The surimi sector is as amenable to the same method of approaching the issues as other sectors in that there are transboundary players that import and export surimi and surimi seafood. CRC members have an established presence in key markets like Japan, Korea and China and can approach these companies to discuss the issues and how they can contribute towards solutions.
6. As with the groundfish sector the surimi industry has an annual forum run via the Jae Park Surimi School where issues of wider industry interest can be canvassed and discussed.

There are, however, some issues that need to be considered prior to recommending that supply chain partners push for fishery management improvements, especially if these are to be focused on achieving the MSC Standard. The basis for this comment is as follows:

1. For a species/stock to carry the MSC label it has to be managed at MSY or equivalent. This means that the fishery as a whole has to be managed in a way to deliver this outcome. For some fisheries, such as the Northern Prawn fishery in Australia, which is managed to optimize prawn (shrimp) production the management arrangements to deliver this restrict what other species can be

landed resulting in the discarding of about 75% of the catch, an outcome that is deemed acceptable by the wider Australian society. For some tropical developing countries the societal objectives may not be aligned with the harvesting of particular species for certification and the tradeoffs in terms of either lost catches or inability to manage other species for MSY.
2. The MSC multispecies approach is based upon putting in place management to ensure that the most sensitive species (for which certification is sought) is managed at MSY, and then assuming (via a logical process) that related species of interest are at least at MSY. This may have far reaching consequences for overall fishery yields as this arrangement sets up ‘choke’ species which restrict harvests of other species in order to protect the most sensitive one. The MSC system currently works this way for P2 species in that all species have to be managed at levels above PRI in order to meet international norms (which, by their very nature, are applicable to fisheries certified or not). However, P2 species can’t carry the MSC label and thus the implications of seeking certification are less consequential.
3. Even greater complexity may arise if Principle 1 status is sought for a species which may not confer protection for others and thus all may have to meet the MSY criterion. Managing multiple species at MSY may well result in overfishing (Walters et al 2005, Rindorf et al 2017 ) and, indeed, modelling suggests that seeking to manage all species at their individual MSY’s can overestimate system yields by 20-50%. Factories tend to use a variety of species, both within genera and across families. Volumes of any particular species can be small and so to get the throughput and justify the costs of certification fisheries may be expected by the supply chain to seek certification for as many species as possible.

These are not trivial issues. For some, leaving more fish in the water may be a good idea. In the US considerable quantities of fish are left in the water and economic opportunities foregone (McQuaw and Hilborn 2020). For a wealthy society where there are other economic opportunities for coastal rural dwellers and where imports can make up shortfalls in supply (noting that this is simply transfering the problems to countries less able to manage their fisheries), leaving fish in the water may be an acceptable outcome. Whether leaving more fish results in a ‘healthier’ ecosystem is a separate issue worth pondering noting that leaving more of some species in the water but not others may result in ecosystem shifts. In Australia, where multispecies fisheries are common, quota managed choke species result in under catching of other species and the same is true in less species rich environments such as the Eastern Atlantic and North Sea (Baudron and Fernandes 2015). For developing countries, not only are there fewer choices for fishermen and fish dependent communities in terms of alternative sources of income but the current extent of overfishing will make for painful cuts, just to ensure that species meet international norms. Furthermore, as set out by Hilborn et al (2012) and Cheung and Sumaila (2008) overly conservative catches not only affect jobs but food security as well. These difficult choices have resulted in the development of concepts such as ‘pretty good yield’ whereby not only are species fished at less than their MSY but others can be fished at any level above PRI. This results in an acceptable overall fishery yield, as opposed to the maximum yields of some species of interest.

Having said the above, managing the multispecies trawl fisheries to maximise surimi fish output may have some economic and social benefits for the following reasons:

1. Many of the species of importance, such as the threadfin breams, have low vulnerability to fishing pressure and may actually benefit from harvest strategies that manage their predators at levels below their MSY, an approach, which whilst rational, may generate some controversy.
2. Higher biomasses of high productivity species would have benefits for local user groups.
3. Most studies of the economic benefits of fishery exploitation focus on returns to fishers but the surimi industry is a value added industry and has wider benefits in communities where processing facilities are located.

4. Processing of surimi fish creates a resource for the aquaculture sector. Fishmeal production is not only an economically beneficial activity but so too is feed production and farming itself.
5. So called 'surimi fish' are not just used for surimi. Almost all of the species we have identified have a mix of local usages, including fresh, dried, salted. Good fisheries management includes the establishment of fair allocation arrangements and non-surimi usages could benefit from rebuilt stocks as well.

The key message is that these fisheries are, in many ways, quite flexible in how they can be managed. The ecosystems in which they are deployed are diverse and support a huge variety of species, with different life history characteristics and different values for local and global markets. There are some tough choices to make:

1. Low levels of exploitation overall can better protect ecosystems but the number of human beneficiaries can be very low;
2. Very selective removal of valuable species may not necessarily be the best exploitation strategy as there is a growing literature questioning the value of high selectivity (at least in some circumstances – Garcia et al 2012);
3. Very high levels of exploitation may involve the greatest number of people in the capture fisheries but it comes at the cost of higher levels of local species extirpation and greater ecosystem instability;
4. Strategies that maximise profitability (MEY) are more protective of stocks and ecosystems than those that maximise food production and participation.

Having some discussions about what may the overall goals would be wise as having one group seeking low ecosystem impacts may be acting counter to another seeking maximum food production and both outcomes may be sustainable.

## 6.2 Engagement strategy ideas

In this study we have identified issues for further consideration. There are too many variables and uncertainties to support the identification of a single pathway engagement strategy. A fundamental dilemma that needs to be considered is the fact that managing these fisheries in a sustainable way may not lend itself to the application of the current MSC Standard for the reasons set out above. Managing the sustainable production of surimi fish in accordance with some of the emerging advice on multispecies fisheries may be entirely possible, but some species/stocks may not meet the requirements of Principle 1. Furthermore, even if sufficient volume of certifiable fish could be identified there are some equity aspects that need to be considered to ensure that management arrangements do not cause unnecessary adverse effects on other user group, especially small-scale fishers.

Irrespective of whether there can be certifiable fisheries found there is still an urgency to having a dialogue with the industry about the current and potential future state of fishery resources.

Some suggested initiatives that may help promote better management of these fisheries could include

### 6.2.1 Engaging industry

Based on the results of the questionnaires there is existing receptivity in some companies to a discussion about sustainability. Not only are some companies experiencing supply shortages which, in some cases, are due to the direct or indirect consequences of poor fisheries management, but others are well aware of the global debate about sustainable fisheries and what this means in terms of opportunities and risks.

Some initiatives could include:

- presentations to the Jae Park Surimi School meetings, workshops,

- establishment of a working group (noting that there was a Surimi Roundtable operating in Thailand in 2012),
- direct discussions with companies that are already players in the sustainable seafood movement.
- Raise the need for better management of the tropical fisheries in forums such as Sea Boss where companies such as Nissui have a significant role;
- Find and engage in industry/community events that are oriented around surimi seafood products – e.g. Kamaboko Road to 1000 (https://www.nikkama.jp/).

**6.2.2 Bringing the issues to life in a visual way**

The source fisheries are complex and it is commonly difficult to visualise the consequences of changes in management. However, models such as Ecopath with Ecosim (EwE) can be used to explore the potential consequences of changing inputs (such as numbers of vessels, mesh size changes, days fished, closed seasons etc) so as to better engage non-scientific stakeholders. EwE can also handle economic aspects and so the potential impacts of management changes on industry economics could also b explored.

**6.2.3 Engage related sectors of the industry – find win-win solutions**

Making connections to other industry players in this space. There is a close connection between sectors that supply fresh fish, processed fish for human consumption and fish for animal feed (primarily aquaculture). All of these sectors would benefit from better management of the fisheries and options for management and stock rebuilding and win/loss scenarios could be minimised by mixing industry needs with some modelling. For example, the fishmeal sector is engaged at least in some countries and could be further involved in looking at the fisheries as a whole. Declines in the availability of small fish over the short term (if mesh sizes are increased) should be balanced out by increasing stocks and by the increased availability of processing wastes from the surimi sector. Maybe some economic modelling would be useful to bring this aspect into full view by participants.

**6.2.4 Evaluate wider benefits**

Notwithstanding the current interest in labour issues the current standards really only apply to fishery level considerations and do not consider flow through benefits from seafood processing. Large numbers of people employed in surimi production plants will have lost their jobs as a result of poor fisheries management.

- Encourage the industry to demonstrate the wider benefits in developing countries of the flow-on benefits of better managing all the production from their fisheries and processing them in-country, and how this could help them achieve their SDGs.

**6.2.5 Performance tracking**

- Have an annual 'State of the Industry supplies' report as SFP does for the reduction fisheries
- To achieve this there will need to be a move away from the single species approach. The same is also true for Seafood Watch assessments. Possibly a mix of MMSY and indicator species would be the best way forward.

#### 6.2.6 Develop a workable improvement pathway

As pointed out previously, single species management approaches are generally unworkable and some careful thought needs to be devoted to exploring the potential consequences of the MSC 'weak stock' multispecies approach.

- Some discussion about intermediate/alternative approaches would be wise, including whether multispecies fisheries could have an assessment tree that allowed species above PRI to carry the MSC label.
- Modelling of the potential consequences of different multispecies approaches may help understand the potential social and economic consequences. This could possible be undertaken as part of any exercises aimed at exploring management options with stakeholders. Data rich countries such as Thailand and India would be useful starting points.
- Undertaking due diligence on the economic and social impacts of seeking MSC certification or moving fisheries into FIPs for which MSC certification was an expected endpoint. A due diligence exercise goes beyond undertaking a Pre-Assessment.
- Changing certification requirements to enable species managed at levels below their individual MSY's to be certified. There may be options with interpretations of MSY which, according to international norms can be modified by ecological, social or economic factors. There may also be avenues in interpreting the MSC requirements for 'stock complexes'.
- Gain a better understanding of supply chains and how the current single species oriented product composition and traceability systems could be retooled

#### 6.2.7 Ensure traceability systems are fit for purpose

Tropical surimi is, arguably, a very different product to anything previously tackled by the sustainable seafood movement. The systems developed over the past two decades are largely designed to work with single species products, which links to the fact that the vast majority of certified fisheries are single species fisheries.

- Asking questions about the relevance of systems that do not cope well with product mixes, for example, would help to stimulate a discussion about what can work and thus bring the power of market driven changes to bear on the supply fisheries.
- Consider altering the tolerance on product mixes – review the 5% rule. This rule was once 0.5% but was altered around the time that skipjack tuna was becoming available.

#### 6.2.8 Looking ahead to new drivers of sustainable seafood production

- Discuss with the industry about the opportunities for the promotion of sustainable aquaculture as the use of farm based sources of raw material increases.
- Evaluate the potential for 'joint ventures' between the sectors that source fish from multispecies fisheries so as to increase the demand for a transition to sustainable use and avoid the potential for one sector to pus sustainability issues on to others. This has not been done for coldwater species but the need was probably not as apparent.

## References

Abdullah, A., Sativa, H.A., Nurhayati, T. and Nurilmala, M. (2019) Utilization of dna *barcoding* for label search various of commercial surimied fished products. JPHPI 2019, Volume 22 Number 3 Using DNA *barcoding* for label traceability, Abdullah *et al.* Indonesian Fishery Product Processing Society, 508

Abu Talib, A., M. Mohammad Isa, I. Mohamad Saupi and Y. Sharum. 2003. Status of demersal fishery resources of Malaysia. p. 83 - 136. In G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R.A. Valmonte-Santos, C. Luna, L. Lachica-Aliño, P. Munro, V. Christensen and D. Pauly (eds.) Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries. WorldFish Center Conference Proceedings 67, 1 120 p.

Adhawati, S. S., Baso, A., Malawa, A. and Arief, A.A. (2017) Social study of cantrang (Danish trawl) fisheries post Moratorium at Makassar Straits and Bone Gulf, South Sulawesi Province, Indonesia. AACL Bioflux, 2017, Volume 10, Issue 5.

Adhawati, S.S., Baso, A., Malawa, A. and Arief, A.A. (2017) Comparative Study of Economic Value Post Cantrang Moratorium on the Waters of the Gulf of Bone and Makassar Straits, South Sulawesi Province International Journal of Oceans and Oceanography ISSN 0973-2667 Volume 11, Number 2 (2017), pp. 201-215

Agustini, T.W., Darmanto, Y.S. and Susanto, E. (2009). Physicochemical properties of some dried fish products in Indonesia. Journal of Coastal Development, Volume 12, 73 – 80

Anon (undated) Research on indicators of forced LABOUR in the Supply Chain of Fish in Indonesia: Platform (*Jermal*) Fishing, Small-Boat Anchovy Fishing, and Blast Fishing. Verite (www.verite.org)

Anon (2000). Sustainable contribution of fisheries to food security. RAP Publication: 2000/23, Asia Pacific Fisheries Commission, FAO, Bangkok.

Anon (2008) Case Study on Illegal, Unreported and Unregulated (IUU) Fishing off the East Coast of Peninsular Malaysia. FINAL REPORT October 2008, Sea Resources Management Sdn Bhd, APEC Secretariat, Singapore

Anon (2015) National plan of action for the management of fishing capacity in Malaysia – Plan 2. Department of Fisheries, Malaysia, ISBN 978-967-0633-07.

Anon (2015b) Value chain analysis and competitiveness strategy: marine capture fisheries: Myeik and Yangon, Myanmar / International Labour Organization, ILO Liaison Officer for Myanmar. – Yangon.

Anon (2015c) THE MARINE FISHERIES STATISTICS 2015 BASE ON THE SAMPLE SURVEY. Department of Fisheries, Ministry of Agriculture and Cooperatives, Fishery Statistics Analysis and Research Group, Fisheries Development Policy and Strategy Division, 9/2560 No. 9/2017

Anon (2017). Capture fisheries statistics of Indonesia by Province 2016. Planning Division, Directorate General of Capture Fisheries, Ministry of Marine Affairs and Fisheries, Jakarta.

Anon (2018) Handbook on fisheries statistics 2018. Department of Fisheries. Ministry of Fisheries, Animal Husbandry & Dairying Govt. of India, September 2019, New Delhi.

Aung, S.Y. (2014). Myanmar bans foreign fishing from its waters. https://www.asiasentinel.com/econ-business/myanmar-bans-foreign-fishing/

Aye, K.M. and Win, K.K. (2013) Trawl fishery Management, Myanmar. APFIC Regional Expert Workshop on Topical Trawl Fishery Management 30 September – 4 October 2013, Phuket, Thailand.

Baudron, A.R and Fernandes, P.G. (2015). Adverse consequences of stock recovery: European hake, a new "choke" species under a discard ban? Fish and Fisheries , 2015, 16, 563–575

Benjakul S, Visessanguan W, Tanaka M. 2004. Induced formation of dimethylamine and formaldehyde by lizard fish kidney trimethylamine-N-oxide demethylase. Food Chemistry, 84(2): 297-305.

Bianchi, G. (1985) Field guide to the commercial marine and brackish-water species of Pakistan. FAO species identification sheets for fishery purposes. Prepared with the support of PAK/77/033 and FAO (FIRM) Regular Programme, FAO, Rome.

BOBLME (2015) Review of impacts of Illegal, Unreported and Unregulated fishing on developing countries in Asia. BOBLME-2015-Governance-15

Booth S., and Pauly D (2011). Myanmar's Marine Capture Fisheries 1950–2008: Expansion from the Coast to Deep Waters. pp. 101–134. In S. Harper, D. O'Meara, S. Booth, D. Zeller, and D. Pauly, eds. *Fisheries Catches from the Bay of Bengal Large Marine Ecosystem since 1950*. Sea Around Us Project. www.seaaroundus.org

Butcher, J.G. (2002). Getting into Trouble: The Diaspora of Thai Trawlers, 1965-2002. International Journal of Maritime History, Vol. XIV, No.2 (December 2002), 85-121.

Cannon, J., Sousa, P., Katara, I., Veiga, P., Spear, B., Beveridge, D., & Van Holt, T. (2018). Fishery improvement projects: Performance over the past decade. *Marine Policy*, *97*, 179-187.

Cao, L., Chen, Y., Dong, S., Hanson, A., Huang, B., Leadbitter, D., Little, D.C., Pikitch, E.K., Qiu, Y., de Mitcheson, Y.S., Sumaila, U.R., Williams, M., Xue, G., Ye, Y., Zhang, W., Zhou, Y., Zhuang, P. and Naylor, R.L. (2017). Opportunity for marine fisheries reform in China. PNAS, Vol. 114(3):435–442

Carpenter, K., Matsuura, K., Collette, B., Nelson, J., Dooley, J., Fritzsche, R. & Russell, B. 2010. *Nemipterus virgatus* (errata version published in 2017). *The IUCN Red List of Threatened Species* 2010: e.T154900A115250542

Chen, J. 2020. Surimi and surimi seafood production in China. Personal communication.

Chen, Z. and Qiu, Y. (2005) Stock variation of *Parargyrops edita* (Tanaka) in Beibu Gulf. South China Fisheries Science. Vol 1, No. 3

Cheung, W.L. and Sumaila, U, R. (2008) Trade-offs between conservation and socio-economic objectives in managing a tropical marine ecosystem. Ecological Economics, 66: 193 – 210

Chokesanguan, B., Ananpongsuk, S., Ae, K.M., Ko, W.K. and Yingyuad, W. (undated) Study on juvenile fish and trash excluder devices (JTEDs) in Myanmar. SEAFDEC Training Department, TD/RES/100.

CMFRI (2019). Annual Report 2018-19. Central Marine Fisheries Research Institute, Kochi. 320 p

De Ridder, K.J and Santi Nindang; March 28, 2018, Southeast Asia's Fisheries Near Collapse from Overfishing.

De Young, C. (ed.)(2006). Review of the state of world marine capture fisheries management: Indian Ocean. FAO Fisheries Technical Paper. No. 488. Rome, FAO. 2006. 458p.

Dineshbabu, A.P., Thomas, S. and Vivekanandan, E. (2014). Assessment of low value bycatch and its application for management of trawl. fisheries. J. Mar. Biol. Ass. India, 56 (1), 103-108,

Fanning L.P., Khan, M.W., Kidwai, S. and Macauley. G.J. (2010) Surveys of the offshore fisheries resources of Pakistan – 2010. *FAO Fisheries and Aquaculture Circular.* No. 1065. Karachi, FAO. 2011. 87 pp.

Fanning, P., P. Medley, M. Wasim Khan, and T. Valinassa. 2016. "Comprehensive Assessment of Pakistan's Marine Fisheries Resources to 2015." Fisheries Resources Appraisal in Pakistan Project (FRAPP). Field Document No 9, UTF/PAK/108/PAK. Food and Agriculture Organization and the Marine Fisheries Department of the Government of Pakistan. 178 pp.

FAO (2014) APFIC/FAO Regional Expert Workshop on "Regional guidelines for the management of tropical trawl fisheries in Asia". Phuket, Thailand, 30 September–4 October 2013. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication 2014/01, 91 pp

FAO (2016). The Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, FAO 2016, http://www.fao.org/port-state-measures/en/

FAO. 2020. *The State of World Fisheries and Aquaculture 2020. In brief. Sustainability in action.* Rome. https://doi.org/10.4060/ca9231en

Feng, B., Xu, Y. and Lu H. (2009) A Modeling Evaluation of Effects of Closed Season on *Paragyrops edita* in Beibu Gulf. Resources Science, 31, (12) :2201-2207.

Fischer, W. and Bianchi, G. (1984), FAO Species identification sheets for fishery purposes - WESTERN INDIAN OCEAN, Fishing Area 51, Marine Resources Service, Fishery Resources and Environment Division FAO Fisheries Department. Rome, Italy

Fischer, W. and Whitehead, PJ.P (1974). AO Species Identification Guide for Fishery Purposes. Eastern Indian Ocean - Fishing Area 57 and Western Central Pacific - Fishing Area 71. Bony Fishes. FAO Department of Fisheries, Rome, Italy

Fulton, E.A., Smith, A.D.M. and Smith D.C (2007). Alternative Management Strategies for Southeast Australian Commonwealth Fisheries: Stage 2: Quantitative Management Strategy Evaluation Australian Fisheries Management Authority Fisheries Research and Development Corporation

Funge-Smith Simon, 2012, "Regional Overview of Fisheries and Aquaculture in the Asia-Pacific 2012", Asia Pacific Fishery Commission

Funge-Smith, S., Lee, R. and Matthew Leete, M. (2015) Regional review of illegal, unregulated and unreported (IUU) fishing by foreign vessels . RAP Publication 2015/x., Asia-Pacific Fishery Commission, Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, 2015

Garcia, S.M, Kolding, J., Rice, J., Rochet, M-J., Zhou, S., Arimoto, T., Beyer, J.E., Borges, L., Bundy, A., Dunn, D., Fulton, E.A., Hall, M., Heino, M., Law, R., Makino, M., Rijnsdorp, A.D., Simard, F. and Smith, A.D.M.

(2012). Reconsidering the Consequences of Selective Fisheries Science March 2012, Vol. 335 (6072), pp. 1045-1047

Goldstein, L.J (2013). Chinese fisheries enforcement: Environmental and strategic implications. Marine Policy 40, 187–193

Guenneugues, P. (2018). Surimi market update - The 12th SURIMI SCHOOL ASIA, October 31 – November 2, 2018.

Guenneugues P. (2019). Surimi market – supply and demand. Presented at the first Surimi School Korea, Busan, S Korea. Nov 5-6.

Guenneugues, P. (2019b) Surimi market update - The 11th SURIMI SCHOOL EUROPE, Madrid 24-26 September, 2019.

HADIL, R., JAMIL, M. and ANNIE LIM, P.K. (2011) Demersal Fish Resources Stock Assessment of East Coast Sabah-The Sulu Sulawesi Seas Economic Exclusive Zone of Malaysia, Malaysian Fisheries Journal 10: 12-69 (2011)

Hikmayani, Y., Aprilliani, T. and Adi, T.R. (2017). Alternative solutions for sustainability of the surimi industry in Indonesia. *Buletin Ilmiah "MARINA" Sosial Ekonomi Kelautan dan Perikanan Vol. 3 No. 1 Tahun 2017: 39-50.*

Hilborn, R., Punt, A. E. and Orensanz, J. (2004). Beyond band-aids in fisheries management: fixing world fisheries. Bulletin of Marine Science, 74(3): 493–507. – choke species/yields etc

Hilborn, R., Amoroso, R.O., Anderson, C.M., Baum, J.K., Branch, T.A., Costello, C., de Moor, C.L., Faraj, A., Hively, D., Jensen, O.P., Kurota, H., Little, L.R., Mace, P., McClanahan, T., Melnychuk, M.C., Minto, C., Osio, G.C., Parma, A.M., Pons, M., Segurado, S., Szuwalski, C.S., Wilson, J.R. & Ye, Y. 2020. Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences*, 117(4): 2218–2224 online.

Hilborn, R., Stewart, I.J., Branch, T.A., and Jensen, O.P. 2012. Defining trade-offs among conservation of species diversity abundances, profitability, and food security in the California Current bottom-trawl fishery. Conserv. Biol. **26**: 257–266. doi:10.1111/j.1523-1739.2011.01800.x. PMID:22443131.

Hosch, G., Ferraro, G. and Failler, P. (2011) The 1995 FAO Code of Conduct for Responsible Fisheries: Adopting, implementing or scoring results? Marine Policy 35: 189–200

Huang, Z. (2005). Study of stock and management of *Nemipterus virgatus* in southwestern continental shelf of Nansha Islands[J]. South China Fisheries Science. 1(4): 18-23

Irianto, H.E., Ariyanti Suhita Dewi , and Giyatmi (2014) Prospective Utilization of Fishery By-products in Indonesia. Chapter 3 in Kim, S.K. Seafood processing by-products: Trends and applications (pp.21-34).

Irin I. Kusmini, Deni Radona, M. H. Fariduddin Ath-Thar, Fera P. Putri, Anang H. Kristanto, Rudhy Gustiano (2019) Phenotypic diversity in three generations of domesticated Asian redtail catfish, Hemibagrus nemurus (Valenciennes, 1840) in Indonesia AACL Bioflux, 2019, Volume 12, Issue 1, 42-50

Iwatsuki, Y. & Carpenter, K.E. 2014. *Evynnis cardinalis*. *The IUCN Red List of Threatened Species* 2014: e.T59034974A59034995.

Jacobsen. N.S., Burgess, M.G. & Andersen, K.H. 2017. Efficiency of fisheries is increasing at the ecosystem level. *Fish and Fisheries*, 18(2): 199–211.

Ji C-L (2012) SURIMI SEAFOOD in THAILAND & SURIMI from other SE ASIA. 9th Surimi School Asia (Bangkok)

Jiang, Y-X., Cheng, J-H. and Li, S-F (2009). Temporal changes in the fish community resulting from a summer fishing moratorium in the northern East China Sea. Marine Ecology Progress Series. Vol. 387: 265–273,

Jin, Y. and Cheng, J. (2017) Assessment on the Effects of Summer Fishing Moratorium in East China Sea. Oceanography and Fisheries, Short Communication, Volume 3 Issue 4

Johnson Terry, Alaska Sea Grant, University of Alaska Fairbanks, 2016 Climate Change and Alaska Fisheries, http://doi.org/10.4027/ccaf.2016

Joshi K.K. (2010). Population dynamics of *Nemipterus japonicus* (Bloch) in the trawling grounds off Cochin. Indian J. Fish., 57(1) : 7-12, 2010

Kennelly, S.J., 2018. *Developing a National Bycatch Reporting System.* Final FRDC Report, ISBN 978-0-9924930-5-9, March, 2018. 99 pp.

Khileri, R.A., Mathew, K.L., Desai, A.Y., Lende, S.R., Baraiya, K.G. and Joshi, A.M. studies on some population attributes of *Nemipterus japonicas* (Bloch 1791) landed at Veraval, Gujarat. J. Exp. Zool. India Vol. 20, No. 1, pp. 599-604, 2017

Komatsu, M. 2013. Special Study on Sustainable Fisheries Management and International Trade in the Southeast Asia and Pacific Region. ADBI Working Paper 438. Tokyo. Asian Development Bank Institute. http://www.adbi.org/working- paper/2013/10/16/5913.sustainable.fisheries.mngt.international.trade/

Krakstad JO, Michalsen K, Krafft B, Bagøien E, Alvheim O, Strømme T, Mya Than Tun, Htun Thein, SanThar Tun. 2014 Cruise Report "Dr. Fridtjof Nansen" Myanmar Ecosystem Survey 13 November – 17 December 2013. IMR: Bergen. 100 pages

Krakstad JO, Krafft B, Alvheim O, Htun Thein, Peter Psomadakis 2015. Cruise Report "Dr. Fridtjof Nansen" Myanmar Ecosystem Survey 28 April – 02 June 2015 FAO-NORAD PROJECTNO: GCP/INT/003/NOR.

Kulanujaree, N., Salin, K.R. Noranarttragoon, P. and Yakupitiyage, A. (2020). The Transition from Unregulated to Regulated Fishing in Thailand. Sustainability 2020, 12, 5841; doi:10.3390/su12145841

Kusol, L. (2010). Surimi Industry in China. Surimi Forum Thailand, 24 November 2010

Kyaw (2009) Status and trend of total landing of important surimi species of Myanmar. Annex 8 in SEAFDEC (2009). Report of End-of-Project Meeting of the Working Party on Information Collection for Economically Important Species as Surimi Raw Materials in the Southeast Asian Region, Southeast Asian Fisheries Development Center, Training Department, Thailand, TD/RP/130

Leadbitter, D. and Benguerel, R. (2013). Sustainable tuna – can the marketplace improve fisheries management? Business Strategy and the Environment, Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/bse.1794

Lee J, Peng Y, Heidolph B, and Park JW. 2017. Physicochemical Properties of Frozen Alaska Pollock Fillets and Surimi as Affected by Various Sodium Phosphates. J of Food Processing and Preservation 42:e13530. Published Nov 2, 2017. https://doi.org/10.1111/jfpp.13530

Link, J.S. (2018) System-level optimal yield: increased value, less risk, improved stability, and better fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 75: 1-16

Liu ZY. Personal communication. Ocean University of China, Qingdao, China, 2012.

Liu, Y., Hu, W., Guo, X-X., Wang, X-C., Sun, S-Q. and Xu, C-H (2015). Rapid discrimination of three marine fish surimi by Tri-step infrared spectroscopy combined with Principle Component Regression. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 149: 516–522

Lu, Z. (2006). The production of fishery resources and the maximum sustained yield in the Min-zhong fishery in the Taiwan Strait. South China Fisheries Science, Vol 2, No. 2

Mohsin, M., Mu, Y.T., Mehak, A., Memon, A.M., Noman, M. and Pavase, T.R. (2019). An economic analysis of fisheries and molluscan fisheries nexus in Pakistan 1950-2014. The J. Anim. Plant Sci. 29(5):

Manojkumar, P.P. (2007). Fishery of threadfin breams with some aspects on the biology and stock assessment of *Nemipterus mesoprion* (Bleeker, 1853) off Malabar coast Indian J. Fish., 54(2) : 149-154

Mayua, D.H., Kurniawana and Febrianto, A. (2018). Analisis potensi dan tingkat pemanfaatan sumberdaya ikan di perairan Kabupaten Bangka Selatan. Jurnal Perikanan Tangkap 2: (1) Maret, 2018, 30-41

McQuaw, K and Ray Hilborn, 2020. *University of Washington, School of Aquatic and Fishery Sciences.* Why are catches in mixed fisheries well below TAC? Marine Policy. Marine Policy 117, Elsevier. http://www.elsevier.com/locate/marpol

Mohamed, K.S. and Zacharia, P.U. (1997) Catch-effort relationship and projection scenarios for the dual-fleet trawl fishery of Mangalore and Malpe, southwest coast of India Indian Journal of Marine Sciences Vol. 26, December 1997, pp. 366-371

Mohamed, K.S., Muthiah, C., Zacharia, P.U., Sukumaran, K.K., Rohit, P. and Krishnakumar, P.K. (1998). Marine Fisheries of Karnataka State, India. NAGA The ICLARM Quarterly, April/June 1998, 10-15

Morgan, G.R and Staples, D. (2006). The history of industrial marine fisheries in Southeast Asia by Gary R. Morgan and Derek J. Staples RAP PUBLICATION 2006/12

Mueter, FJ, NA Bond, JN Ianelli, and AB Hollowed. 2011. Expected declines in recruitment of walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea under future climate change. ICES Journal of Marine Science 68:1284-1296. http://dx.doi. org/10.1093/icesjms/fsr022

Muhammad Sharif, M., Niazi, M.A. and Abdul Jabbar, A. (2014). Seafood exports: challenges and way forward Pakistan J. Agric. Res. Vol. 27 No.4,

Murty, V.S., T Apparao, T., Srinath, M., Vivekanandan, E., Nair K.V.S., Chakraborty, S.K, Raje, S.G and Zachariah, P.U. (1992).Stock assessment of threadfin breams *(Nemipterus* spp.) of India. Indian Journal of Fisheries 39(1-2), 9-41

Murty, V.S., Joshi, K.K. and Nair, R.J. (2003). Threadfin Breams. Chapter 15 in Joseph, M.M. and Jayaprakash, A.A. eds Status of exploited marine fishery resources of India, CMFRI

Myo, A., Darbanandana, T., Boutson, A. and Kaewnern, M. (2018). Status of trash fish from bottom trawl fishery and utilisation in Myeik Township, Tanintharyi Region, Myanmar. Journal of Fisheries and Environment, 42(3) pp x-x.

Najmudeen, T.M., Sathianandan, T.V. and Zacharia, P.U. (2014). Fleet optimization of trawl fishery along southwest coast of India using surplus production model. J. Mar. Biol. Ass. India, 56 (2), July-December 2014, pp74-80.

Nair, K.V.S., Reghu, R., Balachandran, K., Menon, N.G., Chakraborty, S.K., Zacharia, P.U., Vivekanandan, E., Mohanraj, G., Rengaswamy, V.S. and Raje, S.G (1996). Threadfin breams and lizard fish resources in the shelf waters of the Indian EEZ In: Proceedings of the Second Workshop on Scientific Results of FORV Sagar Sampada, edited by V.K. Pillai, S.A.H. Abidi, V. Ravindran, K. K. Balachandran & V.V. Agadi, (Department of Ocean Development, New Delhi), pp. 127-137.

Newman, S.J., Brown, J.I., Fairclough, D.V., Wise, B.S., Bellchambers, L.M., Molony, B.W., Lenanton, R.C.J., Jackson, G., Smith, K.A., Gaughan, D.J., Fletcher, W.J., McAuley, R.B. and Wakefield, C.B. (2018) A risk assessment and prioritisation approach to the selection of indicator species for the assessment of multi-species, multi-gear, multi-sector fishery resources. Marine Policy 88: 11–22.

Nuruddin, A. A. (2013). Addressing Growth Overfishing and Trash Fish Catch in Trawlers in Malaysia. Presentation to the Asia Pacific Fisheries Commission Workshop on Guidelines for Tropical Trawl Fisheries, Phuket, Thailand.

Oktaviyani, S., Boer, M. and Yonvitner (2015) Degradation and Depreciation Analysis of Demersal Fish Resources on Dogol Fisheries in Sunda Strait Marine Fisheries Vol. 6, No. 2, November, : 119-128

Pan , J., Jia, H., Shang, M., Xu, C., Lian, H., Li, H. and Dong, X (2018). Physiochemical properties and tastes of gels from Japanese Spanish mackerel (*Scomberomorus niphonius*) surimi by different washing processes. J Texture Stud, Dec;49(6):578-585.

Pangsorn, S., Laongmanee, P. and Siriraksophon, S. (2007) Status of Surimi Industry in the Southeast Asia. South East Asia Fisheries Development Center, TD RES118.

Pangsorn, S. (2009). Status of surimi industry in the Southeast Asia during 2001-2006. Annex 6 in SEAFDEC 2009. Report of End-of-Project Me eting of the Working Party on Information Collection for Economically Important Species as Surimi Raw Materials in the Southeast Asian Region, Southeast Asian Fisheries Development Center, Training Department, Thailand, TD/RP/130

Park JW, Nozaki H, Suzuki T, Beliveau JL. 2014. Historical review and surimi technology and market developments. In *Surimi and Surimi Seafood, Third edition.* (Ed.) Park JW. Chapter 1. CRC Press: Boca Raton, FL.

Patil, D. Kaczan, J. Roberts, R. Jabeen, B. Roberts, J. Barbosa, S. Zuberi, T. Huntington, G. Haylor, S. Hussain, C. Brugere, I. Goulding, and M. Dillon, 2018. “Revitalizing Pakistan’s Fisheries: Options for Sustainable Development.” Washington, DC, The World Bank Group and L’Agence Française de Développement.

Pauly Daniel, 1979, Theory and Management of Tropical Multispecies Stocks, A review with Emphasis on the Southeast Asian Demersal Fisheries, ICLARM, https://hdl.handle.net/20.500.12348/3693

Pe, M. (2004) National report of Myanmar. On the Sustainable Management of The Bay of Bengal Large Marine Ecosystem (BOBLME) - Fishing Grounds of Myanmar and Landing Sites GCP/RAS/179/WBG.

Pitcher, T., Kalikoski, D., Short, K., Varkey, D. and Pramoda, G. (2009). An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. Marine Policy 33: 223– 232

Pomeroy, R., Parks, J., Pollnac, R., Campson, T., Genio, E., Marlessy, C., Holle, E., Pido, M., Nissapa, A., Boromthanarat, S. and Hue, N.T. (2007). Fish wars: Conflict and collaboration in fisheries management in Southeast Asia. Marine Policy 31 (2007) 645–656

Pramod, G. (2010) Illegal, Unreported and Unregulated Marine Fish Catches in the Indian Exclusive Economic Zone, Field Report, Policy and Ecosystem Restoration in Fisheries, Fisheries Centre, University of British Columbia, BC, Vancouver, Canada, 30 pages.

Qiu, Y., (2009). Stock status of the northern South China Sea fisheries resources. Presented at the Workshop on Assessment of the Fishery Stock Status in South and South East Asia, Bangkok, Thailand, October 5–9, 2009.

Rahman, N.Z. bin N.A. (2009) The surimi industry in Malaysia. Annex 7 in SEAFDEC. 2009. Report of End-of-Project Meeting of the Working Party on Information Collection for Economically Important Species as Surimi Raw Materials in the Southeast Asian Region, Southeast Asian Fisheries Development Center, Training Department, Thailand, TD/RP/130

Rindorf, A., C. M. Dichmont, P. S. Levin, P. Mace, S. Pascoe, R. Prellezo, A. E. Punt, D. G. Reid, R. Stephenson, C. Ulrich, Morten Vinther, and L. W. Clausen (2017) Food for thought: pretty good multi-species yield. ICES Journal of Marine Science 74: 475–486.

Riyanto, B. (2013), MINCED FISH- SURIMI and SURIMI SEAFOOD, FOOD, surimi historical review, resource and market

Rose, G.L and Tsamenyi, M 2013 Universalising jurisdiction over marine living resources crime. University of Wollongong Australian National Centre for Ocean Resources and Security (ANCORS). Report for WWF.

Rose 2014 - Rose G. (Ed.) *Following the Proceeds of Environmental Crime, as 2014: Forests Fish and Filthy Lucre*, Routledge ISBN 0415532396.

Russell, B.C. (1990). FAO Species Catalogue. Vol. 12. Nemipterid fishes of the world. (Threadfin breams, whiptail breams, monocle breams, dwarf monocle breams, and coral breams). Family Nemipteridae. An annotated and illustrated catalogue of nemipterid species known to date. FAO Fish. Synop. 125(12):149p. Rome: FAO

Saikliang, P. Development of closed seasons and areas in the Gulf of Thailand. J. Mar. Biol. Ass. India, 56 (1), 70-76.

Sainsbury, K.J. (1982). The biological management of Australia's multi-species tropical demersal fisheries: a review of problems and some approaches. Report No. 147, CSIRO Australia.

Salayo, N.D., Ahmed, M., L. Garces, L. Viswanathan, K (2006) An Overview of Fisheries Conflicts in South and Southeast Asia: Recommendations, Challenges and Directions. NAGA WorldFish Center Quarterly Vol. 29 No. 1 & 2 Jan-Jun 2006.

San, M.S. (2015). Burma eases 3 month fishing ban. https://www.irrawaddy.com/business/burma-eases-3-month-fishing-ban.html

Sathianandan, T.V Kuriakose, S., Mini K.G. and Safeena, P.K (2020). Maximum sustainable yield of trawl fishery along the south-west coast of India: Bayesian estimation approach. Indian J. Fish., 67(1): 23-29.

SEAFDEC. 2009. Report of End-of-Project Meeting of the Working Party on Information Collection for Economically Important Species as Surimi Raw Materials in the Southeast Asian Region, Southeast Asian Fisheries Development Center, Training Department, Thailand, TD/RP/130

SEAFDEC (2017) Regional Technical Consultation on Fishery Statistics and Information in Southeast Asia, Bangkok, Thailand, 15-18 August 2017, Pelagic Species in the SouthEast Asian Region, SEAFDEC -MFRDMD

SEAFDEC. 2017. Southeast Asian State of Fisheries and Aquaculture 2017. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 167 pp. http://www.seafdec.org/download/southeast-asian-state-fisheries-aquaculture-2017/

SEAFDEC (2020). Fishery Statistical Bulletin of South East Asia 2017. South East Asia Fisheries Development Centre, SEC/ST/52, January 2020, Bangkok, Thailand.

Shen, Z., Fan, Q and Sun, X (2009). Threatened fishes of the world: *Cyprinus pellegrini pellegrini* Tchang, 1933 (Cyprinidae). Environ Biol Fish, 86:485–486.

Shen, G. and Heino, M. (2015) An overview of marine fisheries management in China. Interim Report IR-13-067. International Institute for Applied Systems Analysis, Austria

Sivakami, S. (undated) DEMERSAL FISHERY RESOURCES OF INDIA – AN UPDATE. In K.S. Mohamed Winter School on Towards Ecosystem Based Management of Marine Fisheries – Building Mass Balance Trophic and Simulation Models – information notes. CMFRI

Siriraksophon, S, Pangsorn, S. and Laongmanee, P. (2009) The Surimi Industry in Southeast Asia: Trend and Demand for Raw Materials. Fish for the People, Volume 7 Number 2: 2009, 2-8.

Sobhana, K.S., Seetha, P.K., Mani, P.T., Kumar, S.D., Najmudeen, T.M., Nair, R.J., Abdussamad, E.M. and Zacharia, P.U. (2011). Heavy exploitation of juvenile threadfin bream, *Nemipterus randalli* along Kerala coast. Marine Fisheries Information Service *T&E Ser*., No. 210, 2011, 14-16

Son, D.M. and P. Thuoc 2003. Management of Coastal Fisheries in Vietnam, p. 957 - 986. In G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R.A. Valmonte-Santos, C. Luna, L. Lachica-Aliño, P. Munro, V. Christensen and D. Pauly (eds.) Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries. WorldFish Center Conference Proceedings 67, 1 120 p.

Sparre. P.J. (2000) Manual on sample-based data collection for fisheries assessment. Examples from Viet Nam. FAO Fisheries Technical Paper. No. 398. Rome, FAO. 2000. 171p.

Sreekanth, G.B., Zacharia, P.U., Sathianandan, T.V., Thomas, S., Lekshmi, N.M. and Singh, N.P (2015). Combining surplus production and spectral models to define fishery management advisory - a case study using the threadfin bream fishery along Kerala coast Indian J. Fish., 62 (1): 41-45

Sreekanth, G.B., Zacharia, P.U., Praveen, K. V., Lekshmi, N.M. and Singh, N.P. (2015). An inquiry into the trends in landings and marketing efficiency of threadfin breams, a trawl by catch resource along Kerala coast. South -Asian Journal of Multidisciplinary Studies: Volume 2 Issue 4, 24-36

Stremme, T., Nakken, O., Aung, S. and Saetersdal, G.S. (1981) REPORTS OF SURVEYS WITH THE R/V DR. FRIDTJOF NANSEN Surveys of the Marine Fish Resources of Burma September-November 1979 and March-April 1980. FAO, Rome and Institute of Marine Research, Bergen, Norway.

Strong, J, and KR Criddle. 2013. Fishing for pollock in a sea of change: A historical analysis of the Bering Sea pollock fishery. Alaska Sea Grant, University of Alaska Fairbanks. 188 pp. http://dx.doi.org/10.4027/fpschabspf.2013

Sudirman, M. and dan Rudi Sihbudi, I.N. (2008) DESKRIPSI ALAT TANGKAP CANTRANG, ANALISIS *BYCATCH*, *DISCARD* DAN KOMPOSISI UKURAN IKAN YANG TERTANGKAP DI PERAIRAN TAKALAR. Tulisan ini Telah dimuat dalam Jurnal Torani Tahun 2008, Nomor 2. Volume 18., Halaman 160-170

Suman, A., Satria, F., Nugraha, B., Priatna, A. and dan Mahiswara, K.A. (2018). The stock status of fish resources in 2016 at fisheries management area of Indonesian republic (FMAs) and its management alternative. Jurnal Kebijakan Perikanan Indonesia, Volume 10 Nomor 2 November 2018, 107-128.

Supawang S, Park JW, Thawornchinsombut S. 2018. Fat blocking roles of fish proteins in fried fish cake. LWT-Food Science and Technology *97 (2018) 462-468*.

Suuronen, P., Pitcher, C.R., McConnaughey, R.A., Kaiser, M.J., Hiddink, J.G. and Hilborn, R. (2020): A Path to a Sustainable Trawl Fishery in Southeast Asia, Reviews in Fisheries Science & Aquaculture, DOI: 10.1080/23308249.2020.1767036

Suwanrangsi, S (1988) *Development of minced fish industry in Thailand.* In: Proceedings of the Twentieth Anniversary Seminar on Development of Fish Products in Southeast Asia, Singapore, 27-31 October 1987. Singapore, Marine Fisheries Research Department, Southeast Asian Fisheries Development Center, pp. 81-86.

Suzuki T. 2010. History of surimi technology and its future. Presented at the first Surimi Forum Japan. Tokyo, Japan. July 20-21.

Szuwalski, C.S., Burgess, M.G., Costello, C. and Gaines, S.D. (2017). High fishery catches through trophic cascades in China PNAS, Vol. 114(4): 717–721

Thapanand-Chaidee, T., Myint Pe, U., & Chanrachkij, I. (2010). Status of Marine Fisheries Resources in Myanmar Waters: Estimates from Bottom Trawl Survey. *Journal of Fisheries and Environment*, *34*(1), 35-48.

Thorpe, R.B (2019). What is multispecies MSY? A worked example from the North Sea. J Fish Biol. 2019;94:1011–1018.

Tong Y., Mai R., Chen J. and Li X. (2012). Survey and analysis of landings on Hainan Island. South China Fisheries Science. Vol 8, No. 6.

Topsfield, J. 2017 Modern-day slavery: Indonesia cracks down on brutal conditions on foreign fishing boats. The Sydney Morning Herald. http://www.smh.com.au/world/modernday-slavery-indonesia-cracks-down-on-brutal-conditions-on-foreign-fishing-boats-20170124-gtxseo.html,

UNODC 2016 Regional partners urge focus on corruption, organized crime and illegal fishing to combat environmental crimes. https://www.unodc.org/southeastasiaandpacific/en/2016/01/wildlife-arpec/story.html

van Tung, B. (2014). Maximum sustainable production and strength in the South East South Sea. Journal of Science Can Tho University Part B: Agriculture, Fisheries and Biotechnology: 34 (2014): 55-63

Vidal-Giraud B. and Chateau D. (2007). World Surimi Market. GLOBEFISH Research Programme, Vol.89 Rome, FAO. 2007. p. 125.

Vu Viet Ha, A REVIEW ON THE MARINE FISHERIES RESOURCES AS USED FOR SURIMI RAW MATERIALS IN VIETNAM (2009) SEAFDEC, Research Institute for Marine Fisheries (RIMF), Haiphong, Vietnam, e-mail: vvha@rimf.org.vn

Walters, C. J., Christensen, V., Martell, S. J., and Kitchell, J. F. 2005. Possible ecosystem impacts of applying MSY policies from single-species assessment. e ICES Journal of Marine Science, 62: 558e568.

Wang X., Qiu Y., Du F., Lin Z., Sun D. and Huang, S (2017). Population parameters and dynamic pool models of commercial fishes in the Beibu Gulf, northern South China Sea. Chinese Journal of Oceanology and Limnology, Vol. 30 No. 1, P. 105-117, DOI: http://dx.doi.org/10.1007/s00343-012-1017-y

Wang, X., Qiu, Y., Du, F., Liu, W., Sun, D., Chen, X., Yuan, W. and Chen, Y. (2019. Roles of fishing and climate change in long-term fish species succession and population dynamics in the outer Beibu Gulf, South China Sea. *Acta Oceanol. Sin.*, 2019, Vol. 38, No. 10, P. 1–8, https://doi.org/10.1007/s13131-019-1484-5

Wang Y. and Yuan W. (2008). Changes of demersal trawl fishery resources in northern South China Sea as revealed by demersal trawling. South China Fisheries Science, Vol 4, No. 2, April 2008

White, W.T. 2006. *Rhinobatos jimbaranensis*. *The IUCN Red List of Threatened Species* 2006: e.T63167A12625681.

White W.T., Last P.R., Dharmadi, Faizah R., Chodrijah U., Prisantoso B.I., Pogonoski J.J., Puckridge M. and Blaber S.J.M. 2013 Market fishes of Indonesia (= Jenis-jenis ikan di Indonesia). ACIAR Monograph No. 155. Australian Centre for International Agricultural Research: Canberra. 438 pp.

Widodo. A.A. and Mahiswara (2011) CATCH RATE AND CATCH COMPOSITION OF FISH TRAWL BASED IN SIBOLGA, NORTH SUMATERA. Ind.Fish Res.J. Vol.17 No. 2 December 201

Wijayanto, D., Setiyanto, I and Setyawan, H. A. (2019) Financial analysis of the Danish seine fisheries in Rembang Regency, Indonesia. AACL Bioflux, Vol 12 (5): 1823-1831

Wong, M (2018). Surimi and surimi products in Malaysia and Indonesia. The 12th Surimi School Asia (31 OCT – 2 Nov 2018), Bangkok.

Xavier, S. (2014) Decline in Marine Fishery Resources of the Trawler Sector in Kerala –An Economic analysis. IOSR Journal of Economics and Finance (IOSR-JEF) Volume 5, Issue 3. (Sep.-Oct. 2014), pp 40-44.

Xu Y., Chen Z., Fan J. and Zhang J. (2015). Composition and biodiversity of catches by bottom trawl fishery in southwestern continent shelf of Nansha area. South China Fisheries Science, Vol 11, 5

Yan, Y (2005). Study on the biology and resource variation of hairtail (Trichiurus haumela) (Forskal) in Fujian sea area. South China Fisheries Science, Vol 1, No. 3

Ye, Y. & Gutierrez, N.L. 2017. Ending fishery overexploitation by expanding from local successes to globalized solutions. *Nature Ecology and Evolution*, 1: 0179 online.

Yin, T., Park,J.W. and Xiong, S. (2017). Effects ofmicron fish bone with different particle size on the properties of Silver Carp (*Hypophthalmichthys molitrix*) surimi gels. Journal of Food Quality Volume 2017, Article ID 8078062, 8 pages

Yin T, Park JW. 2015. Textural and rheological properties of Pacific whiting surimi as affected by nano-scaled fish bone and heating rates. Food Chemistry 180 (2015) 42–47.

Ye, Y., et al., (2011) Using ecological indicators in the context of an ecosystem approach to fisheries for d

Yusrizal, Krisnafi, Y., Nainggolan, C., Husen, E.S., Suharto, Kusdinar, A., Kusumo, T.E., Choerudin, H. and Danapraja, S. (2018) Cantrang Fisheries Performance in Tegal, Central Java, Indonesia The International Journal of Engineering and Science (IJES) Volume 7, Issue 12 Ver.I, pp 45-51.
ata-limited fisheries. Fish. Res. Volume 112, Issue 3, 108-116, doi:10.1016/j.fishres.2011.06.004

Zacharia, P U and Najmudeen, T M (2017) *Diversity and exploitation status of demersal fishery resources in India.* In: Course Manual Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management. Lecture Note Series No. 2/2017 . CMFRI; Kochi, Kochi, pp. 32-46.

Zhang J., Chen G., Chen Z., Yu J., Fan J. and Qiu Y. (2015). Acoustic estimation of fishery resources in southern continental shelf of Nansha area. South China Fisheries Science, Vol 11, 5

Zhang K., Zhang J., Xu Y., Sun M., Chen Z., and Yuan M. (2018). Application of a catch-based method for stock assessment of three important fisheries in the East China Sea. *Acta Oceanol. Sin.*, 2018, Vol. 37, No. 2, P. 102–109

Zhang P., Yang, L., Zhang, X-F. and Tang, Y-G.(2005). Study on selectivity of different mesh size gillnet for *Nemipterus virgatus* in South China Sea, South China Fisheries Science, Vol 1, No. 2

Zhang X., Zhang P., Tan Y. and Yang, L (2006) Analysis on catch selectivity of 30.3mm of square mesh codend of trawl in northern South China Sea. South China Fisheries Science, Vol 2, No. 2

Zhang, C., Chen, Y. and Rena, Y. (2016). An evaluation of implementing long-term MSY in ecosystem-based fisheries management: Incorporating trophic interaction, bycatch and uncertainty. Fisheries Research 174 (2016) 179–189 - China, bigger yields if managing across fisheries.

Zhang L, Ren Q, Liu M, Xu Q, Kang B and Jiang X (2020) Fishery Stock Assessments in the Min River Estuary and Its Adjacent Waters in Southern China Using the Length-Based Bayesian Estimation (LBB) method. Front. Mar. Sci. 7:507. doi: 10.3389/fmars.2020.00507

Zheng, T. and You, X-Y. (2014). Key food web technique and evaluation of nearshore marine ecological restoration of Bohai Bay. Ocean & Coastal Management 95, 1-10

Zhou J. 2020. Surimi and surimi seafood production in China. Personal communication

Butcher, J. G. (2002) Getting into trouble: The diaspora of Thai trawlers, 1965–2002. *International Journal of Maritime History* 14(2), 85-121.

# Appendix 1 Cold water surimi production

## A2.1 - Alaska pollock surimi production

Following the discovery of sugar to protect the fish protein from denaturation during freezing and keep its ability to make a firm, elastic gel in frozen storage, the Japanese surimi and surimi seafood industries enjoyed 10 years of fantastic growth between 1960 and 1970.

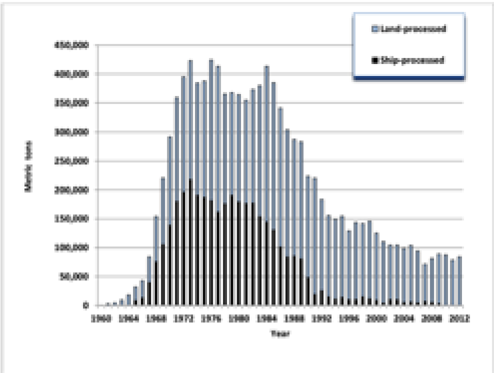



Figure 1. Japanese surimi production, 1960-2012 (metric tons).

Sources: Ministry of Agriculture, Forestry, & Fisheries 1964-2015

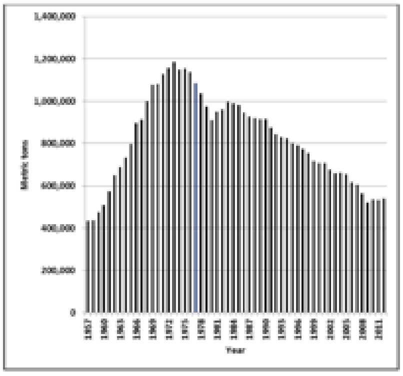



Figure 4. Japanese Production of Surimi-based Products, 1957-2012.

Source: Ministry of Agriculture, Forestry and Fisheries, 1959-2015

The surimi products market, previously restrained by the difficulty to preserve raw material, tripled in volume in just 10 years to a peak of 1.2 million tonnes, fueled by a surimi industry which processed 420,000 tonnes in 1972. During these years Japanese companies built shore plants in Hokkaido and factory trawlers which operated primarily in Alaska. The pollock fishery increased from less than half million tonnes in 1960 to 3 million tonnes in 1970 to respond to the demand of the Japanese market.

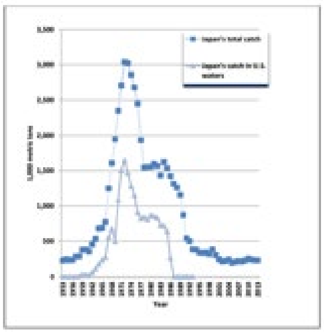


Figure 3. Japan's total catch of Alaska pollock and catch of Alaska pollock in U.S. waters, 1953-2013, (1,000 metric tons).

Sources: International North Pacific Fisheries Commission 1969 Japan Food Economy Company 1978

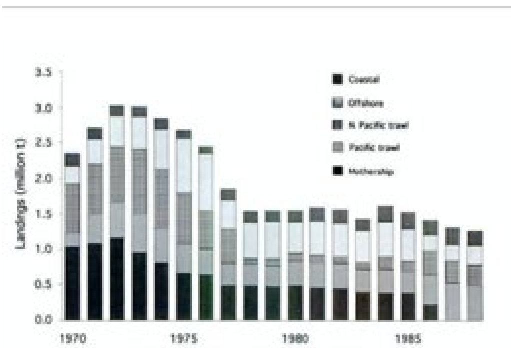



Figure 4. — Japanese landings of walleye pollock.

The Soviet Union and Korea also entered the fishery with factory trawlers in the 70's. The Russian catch reached 1.5 million tonnes by 1975 and doubled in the next decade.

Korea also built factory trawlers in the 80's to feed a fast growing surimi seafood industry and by 1989, the output of the Korean vessels reached 60,000MT. The Korean surimi seafood market quickly reached 300,000 tonnes in the form of fish cakes and other products.

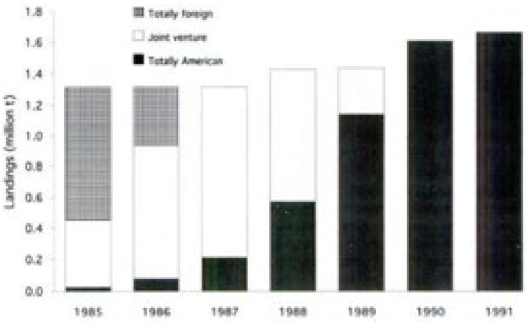


Figure 3. — Total landings of walleye pollock in the U.S. 200-mile EEZ, 1985-91.

The Japanese vessels were replaced by Japanese-American joint venture factory trawlers in the 80's while Japanese and US companies also invested into shore plants on the Aleutian Island.

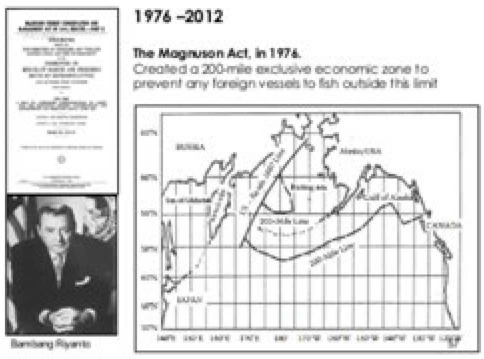



**Table 6.—Japanese surimi joint ventures[1] by quantity produced and year, 1978-89.**

| Year | U.S.[2] | U.S.S.R.[2] | DPRK | U.S./Can[3] | Total prod. (t) |
|---|---|---|---|---|---|
| | Partner and quantity (t) | | | | |
| 1978 | | 6,000 | 0 | 0 | 6,000 |
| 1979 | | 6,000 | 0 | 0 | 6,000 |
| 1980 | | 7,225 | 0 | 0 | 7,225 |
| 1981 | | 10,750 | 0 | 0 | 10,750 |
| 1982 | | 23,444 | 0 | 0 | 23,444 |
| 1983 | | 55,859 | 0 | 0 | 55,859 |
| 1984 | | 80,282 | 0 | 0 | 80,282 |
| 1985 | | 105,156 | 0 | 0 | 105,156 |
| 1986 | | 122,668 | 0 | 0 | 122,668 |
| 1987 | | 143,210 | 0 | 0 | 143,210 |
| 1988[4] | 113,500 | 23,400 | 2,300 | 2,000 | 141,200 |
| 1989[4] | 31,000 | 13,800 | 1,500 | 6,000 | 52,300 |

[1]Although the Japanese Government records joint venture surimi production as an import, the surimi is produced by Japanese factoryships from fish purchased over-the-side from joint venture partners.
[2]Country not specified until 1988.
[3]Pacific hake-based surimi production.
[4]Estimated or projected.

**Table 4.—Japanese surimi production by type and quantity, 1978-87.**

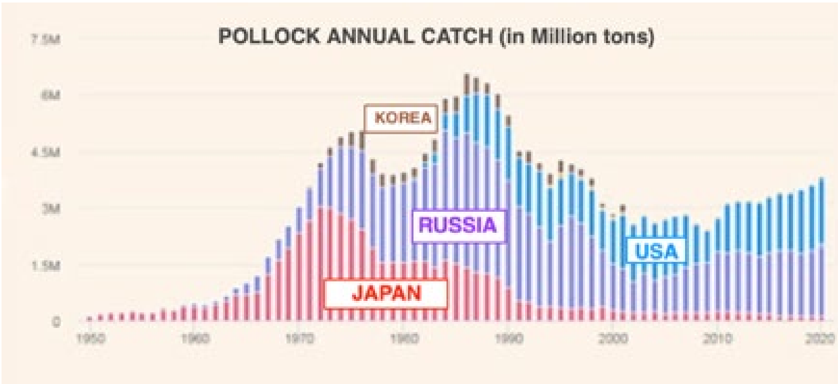
| Year | At-sea[1] prod. (t) | Shore-based (t) | | | Total domestic production (t) |
|---|---|---|---|---|---|
| | | Pollock | Other | Total | |
| 1978 | 175,853 | 177,655 | 12,075 | 189,730 | 365,583 |
| 1979 | 190,621 | 162,422 | 14,543 | 176,965 | 367,586 |
| 1980 | 179,331 | 165,818 | 19,097 | 184,915 | 364,246 |
| 1981 | 176,442 | 160,200 | 18,280 | 178,480 | 354,922 |
| 1982 | 177,095 | 178,941 | 17,013 | 195,154 | 373,049 |
| 1983 | 153,593 | 210,855 | 15,425 | 226,280 | 379,873 |
| 1984 | 146,000 | 248,186 | 24,258 | 272,444 | 418,444 |
| 1985 | 126,067 | 226,420 | 32,106 | 258,526 | 384,593 |
| 1986 | 101,054 | 205,074 | 43,419 | 248,466 | 341,833 |
| 1987 | 64,402 | 195,921 | 24,406 | 220,327 | 284,729 |
| 1988 | 90,000 | 180,000 | 20,000 | 200,000 | 290,000 |
| 1989[2] | 120,000 | 170,000 | 20,000 | 190,000 | 310,000 |

[1]Produced by Japanese factoryships at sea.
[2]Estimated.

**A2.1.1 The Alaska pollock fishery**

The Alaska pollock stock was first exploited by Japan to process surimi but with the development of the fishery by the Russian and Americanized fleets, the catch reached 6.7 million metric tonnes by 1986-1987.

Such level of harvest was unsustainable and rapidly the problem of overfishing became obvious. The catch decreased while the tools of stock assessment and resource management were developed for that fishery. This episode in the largest fish resource used for human consumption had the positive result to create awareness of the necessity to manage the world fish resources for sustainability and implement conservative measures in the fisheries.




With a total catch of 3 to 4 million tonnes caught in Alaska, Russia and Japan, pollock is the largest fishery used for human consumption. The production in Alaska is split equally between fish blocks sold to the US and EU and surimi sold to Japan. The Russian catch is primarily processed as frozen H&G and sold to China for reprocessing. The Japanese catch is processed into surimi or sold to the fresh fish market.

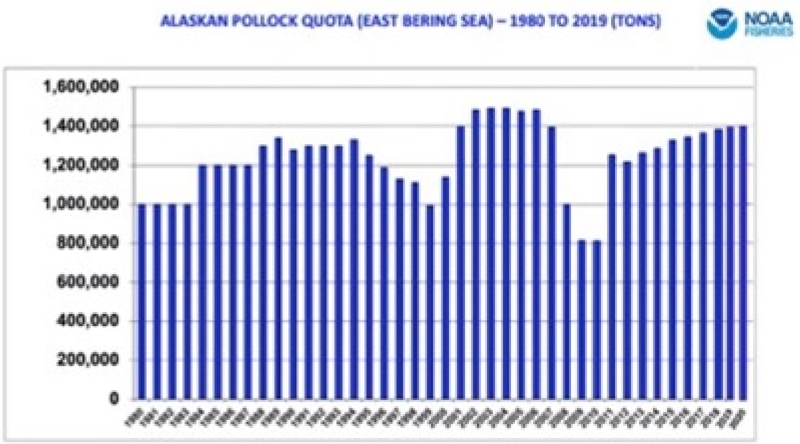
The annual quota in Alaska is based on resource assessment and allocated between catcher vessels delivering fish to shore plants, catcher vessels delivering to motherships and offshore catcher/processors with 10% allocated to the Community Development Quota.

SHORE PLANT DUTCH HARBOR – ALASKA

FACTORY TRAWLER

The main resource of Alaska pollock is the Bering Sea for 90% of the quota while the Gulf of Alaska represents less than 10% . The Total Allowable Catch is divided into two seasons – the A season (January 20 to June 10) and the B season (June 10 to November 1). In the A season, the fleets focus until early April on pre-spawning pollock for production of roe of high economic value which tends to result in a larger production of surimi to maximize the volume of fish processed in that period while the B season fishery from June to October targets more fillet or surimi production on the basis of market demand

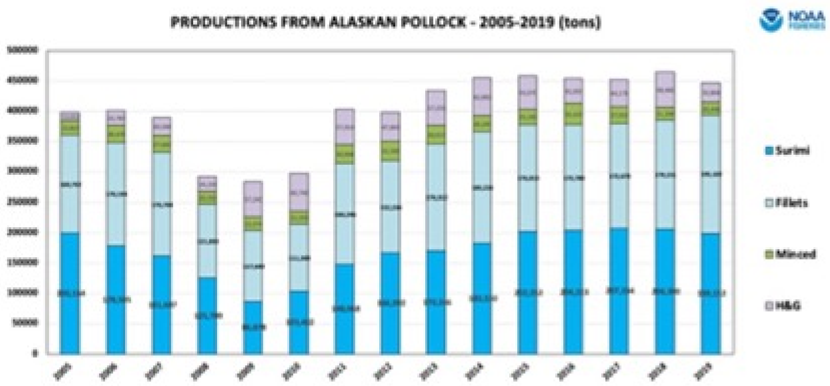
A sustainable fishery does not necessarily mean stable quota and the resource may vary over the years as a result of natural variations related to changes in water temperatures or other factors: in the years 2008 to 2010, the Alaska pollock quota was reduced from its high of 1.4 million in 2001-2007 down to 800,000 tonnes due to a stock reduction resulting from poor recruitment of juveniles and high mortality. In the next period 2012-2020, the quota was slowly increased from 1,2 million tonnes to 1.5 million tonnes as the stocks recovered.




Since pollock is the largest source of fish fillet blocks used for breaded fish and ready meals, the variations in the production volume of pollock surimi has been driven by the competition between these products in addition to variations of the fishing quota and natural constraints like the fish size and the distance of fishing grounds from the shore plants.

While the expansion of surimi production led to the development of the Alaska pollock fishery, the industry has been gradually shifting to the production of fish blocks following the development of this market. The driving force behind this change is the limited resource of white fish that can be processed into fish blocks while the surimi production has many more options. This also applies to other fisheries that have shared utilization between surimi and fish blocks like hake or hoki.

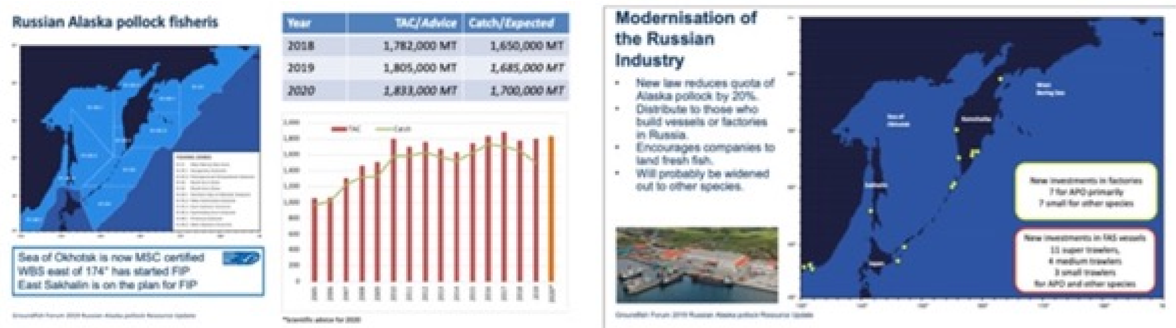
The proportion of fish used for primary surimi production (from fillets) continuously decreased over the last two decades but the improvement in technology compensated for this shift through substitution by lower grade surimi processed from filleting by-products (off-cuts, fish scalps, frame meat) and from recovery of small meat particles lost in the process water through decanter technology. These lower grades of 'recovery' surimi represent today over 30% of the production of pollock surimi and are also processed from the by-products of the filleting industry.




While the Alaska pollock resource is well managed, climate change and global warming is expected to have a significant effect on the pollock fishery in the next decade and the first signs of these changes appeared in 2020. Fishery scientists expect the biomass of harvestable pollock in the Bering Sea to diminish significantly over the next 10 years. Franz Mueter and his co-authors (2011) predict that by the middle of this century pollock recruitment will decline by 32% to 58%.

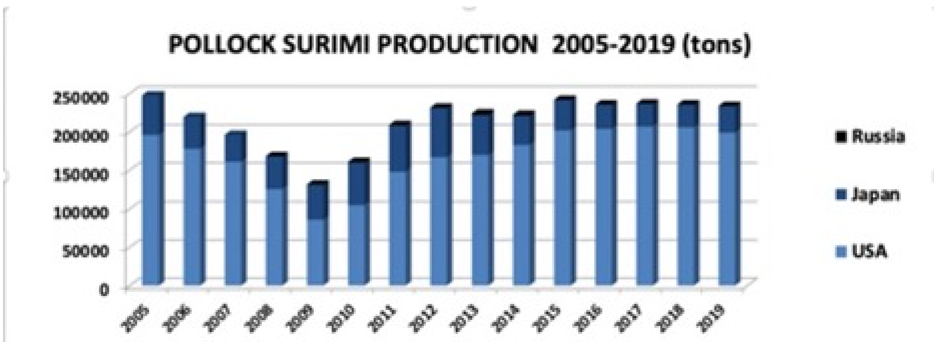
An additional concern for the Alaska pollock processors is that the shift of the pollock population northward over the shelf and slope of the northern Bering Sea will result in a significant increase in the distance between the fishing grounds and the shore plants. This impacts on the quality of the fish delivered to the factories and the ability to process fish fillets and high quality surimi.

Furthermore the pollock biomass is spreading across the maritime boundary into Russian waters, resulting in a transfer of American stocks to the Russian fishery (Strong and Criddle 2013). The Russian fisheries management agency has estimated that 35% of the pollock biomass on the US side eventually will be available to the Russian fleet. The Russian pollock catch already surpassed Alaska in the past few years and kept growing to reach 1.7 million tonnes in 2019.




Russian surimi production has been very limited in the last decade due to the absence of processing capacity after the exclusion of foreign investment from the Russian Fishery. That situation is changing since the Russia decided, with incentives for investment in the form of subsidies and quota allocation, to promote the modernization of its aging fishing fleet and processing facilities with a focus on processing value-added products to increase the revenues derived from its large resource and create employment for the fishing and shipyard industries. As a result, the large Russian fishing conglomerates are actively investing with the plan to build 18 modern factory trawlers - some of them with surimi processing capacity - and 14 shoreplants in processing hubs set-up in the Russian far east.

With an annual quota of 150,000 tonnes, Japan is processing Alaska pollock surimi at shore-plants located in Hokkaido. Japan surimi production decreased from 60,000 tonnes to 40,000 tonnes as a result of a decreasing biomass.




Despite the efforts of the US pollock industry to control the supply and maintain healthy and profitable markets, the change in the scope of production of pollock products in Russia combined with the uncertainty of the Alaska pollock fishery resulting from climate changes may impact significantly on the global production of pollock surimi in the next decade and disrupt the last period characterised by its stability.

Even though the Southeast Asia surimi production surpassed the production of Alaska pollock in the early 2000's, pollock surimi remains the surimi of reference as it dominates the market in Japan, USA and the European markets while threadfin bream surimi (itoyori) is the reference for high quality surimi in Southeast Asia and China.

## A2.2 - Pacific whiting surimi production

Pacific Whiting (which is actually a species of hake) is a migratory fish that typically spends the winter months (November-April) offshore California during its spawning season and moves to the north along the coastline to Canada after spawning, seeking colder waters and feed supply. U.S. harvest season opens on May 15th for the factory vessels and in June for the shore plants and the fishery lasts until Mid October, while the Canadian harvest season is open year around, although the fish typically are not in the Canadian Zone until June or July.

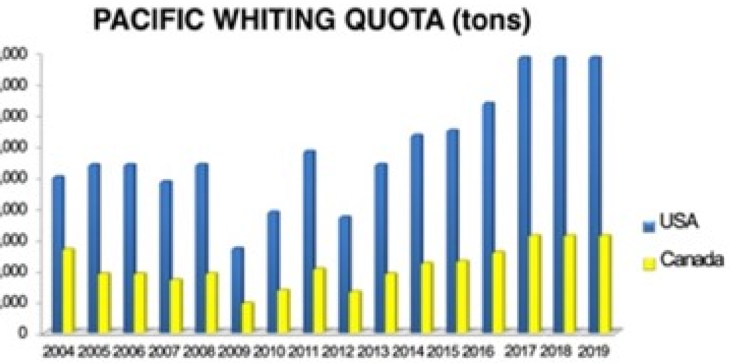
Pacific Whiting has been fished since the 1960s, primarily through foreign vessels that could operate to within 12 miles off the coastline. With the implementation of the EEZ in 1977, a combination of foreign fisheries and JV-mothership operations occurred.

The fish is processed as H&G that was traditionally sold to Eastern Europe as either fillets and surimi according to the market demand. The production of pacific whiting surimi showed rapid growth in the 1990s with the use of protease inhibitors and following the increased global demand for surimi in the 1990's which resulted in the construction of 3 shore plants in Canada and 4 in Oregon, USA. Today only one or two shore plants remain in operation in Oregon as the fluctuations in catches and market demand resulted in the bankruptcy of most of the factories. The factory vessels from Alaska remain involved in this fishery and process pacific whiting for surimi and fillet blocks.

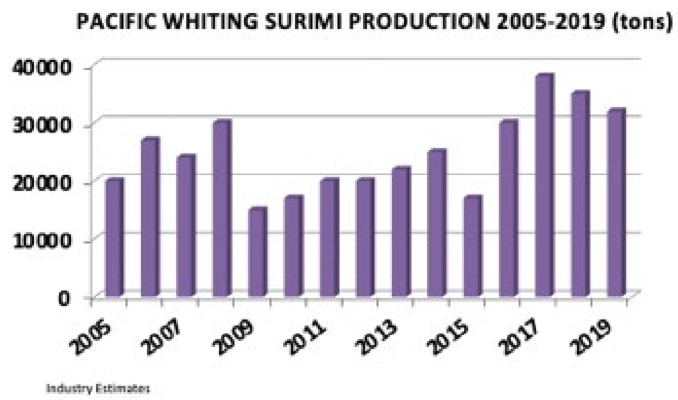
Pacific whiting has challenging quality characteristics, namely, a soft flesh that quickly deteriorates after catch due to high levels of protease enzymes in the muscle tissue associated with a myxosporidean parasite that is endemic throughout Pacific whiting stocks. The parasite induces an immune response in the fish and increased amounts of lysosomal proteases called cathepsins. Protease inhibitors such as egg white or whey protein have been identified and can be used in the production of whiting surimi. Because of the enzymatic activity in Pacific whiting, it is critical that fish are landed and processed within 24 hr of capture.

As a result of the protease issue, pacific whiting surimi requires special precautions to be used and is accepted by a limited number of end-users. It is considered in the marketplace as a lower quality substitute of Alaska pollock and as such has received a lower price than pollock. The majority of the product is used in the US and exported to Europe.

The quota has increased over the recent years from 400,000 to 600,000 MT but catches are only 60 to 70% of the quota due to the challenges related to harvest, processing and marketing its different product forms. The result is a limited harvesting and processing capacity since most of the shore plants closed down as a result of poor profitability. In recent years, only 20–30% of the TAC is caught in the US West Coast non-whiting fishery, whereas 60–80% of the TAC is caught in the Gulf of Alaska groundfish trawl fishery.




The explanations behind the under-utilization of the quota include the lack of infrastructure, resulting from the lack of stable market demand, and difficulties in harvesting due to low quota limits on some species also caught in the fishery thereby restricting the ability to harvest Pacific whiting without exceeding bycatch quotas. McQuaw and Hilborn (2020) suggest that rebuilding plans, under a strict timeline, ultimately created many of the choke species on the West Coast and reduced processing infrastructure, such that the fishery still struggles with low quota utilization even after stocks have been rebuilt. The results suggest that rebuilding plans intended to increase sustainable harvest have been successful at increasing abundance but have been unsuccessful at rebuilding the fishery.




Members of the At-Sea Processors (trade association) which now process the largest portion of the quota operate only in the gaps between pollock seasons and a large portion of the quota is left in the water. As a result, even though the quota has been high and stable or increasing, pacific whiting surimi production has varied erratically from 20,000 MT to 40,000 tonnes in the past decade.

## A2.3 - Alaska pollock and Pacific whiting surimi markets

Alaska Pollock and Pacific Whiting share the same markets, Pacific Whiting being often considered as cheaper substitute of inferior quality to the Alaska pollock surimi.

## 2.3.1 - US domestic market

After a short period of introduction of surimi crabsticks imported from Japanthis product form experienced rapid success and the market grew from 7,000 tonnes in 1982 to 35,000 tonnes in 1984.

Table 11.—U.S. surimi supply by domestic production, imports, exports, and quantity, 1980-89.

| Year | Domestic production | Imports (t) from: Japan | Other[1] | Total | Exports |
|---|---|---|---|---|---|
| 1980 | | 703 | | | |
| 1981 | | 829 | | | |
| 1982 | | 1,114 | | | |
| 1983 | | 1,708 | | | |
| 1984 | | 2,306 | | | |
| 1985 | | 4,801 | 122 | 4,923 | |
| 1986 | 4,000 | 6,056 | 1,528 | 7,584 | |
| 1987 | 18,000 | 1,000 | 2,165 | 3,165 | 5,500 |
| 1988 | 57,200 | 800 | 2,000 | 3,500 | 30,500 |
| 1989[2] | 141,000 | 400 | 500 | 900 | 106,000 |

[1]Primarily from South Korea, with small amounts from New Zealand.
[2]Projected.

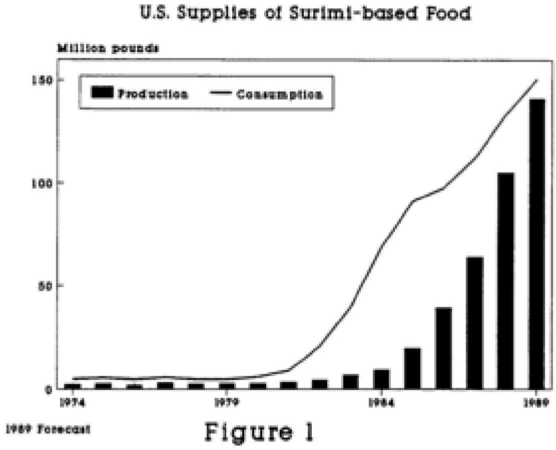
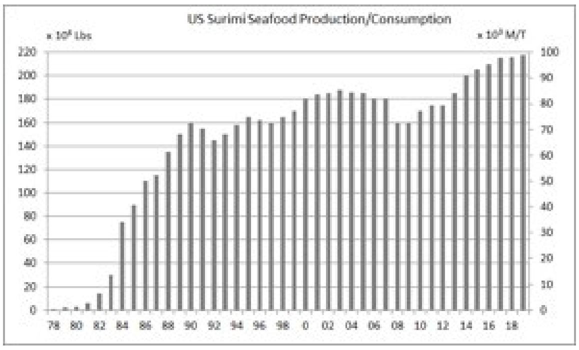


Figure 1

Eighteen surimi seafood factories were established by 1990 while the market reached 70,000 tonnes. The surimi supply crisis in 1991 which saw the cost of raw material double from January to July put an end to this rapid growth and the market declined for the next two years as a result of increased prices and decreased quality of the products.The formulations changed from 60% high grade pollock surimi to 35-40% of medium surimi and Alaska pollock was substituted by pacific whiting for half of the volume of the products.

In the next decade, the market matured with a slow growth to reach 80,000 tonnes while the industry consolidated. In 2008, with another surimi crisis and prices that increased by 50% within one year, the market followed the same scenario and declined back to 70,000 tonnes.

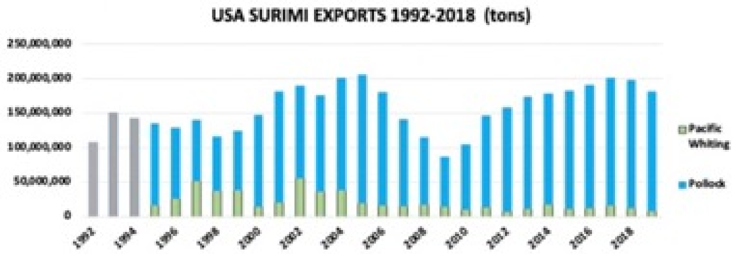



Every raw material price crisis resulted in the closure of factories that did not have their own resource of raw material and the surimi processors finally absorbed most of the surimi seafood industry. From 18 surimi seafood factories in the 1990's, only eight 8 remained by 2010.

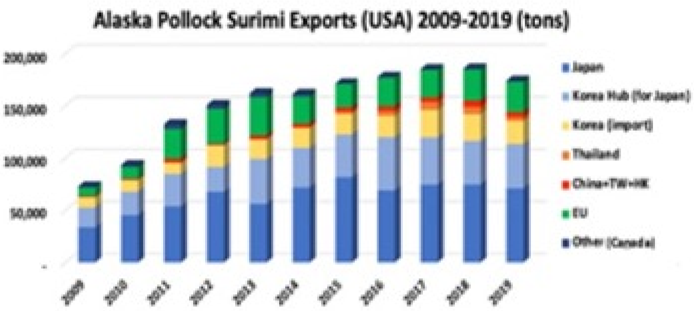


The US market has grown slowly in the past decade to reach 100,000 tonnes by 2019. The formulation of crabsticks and crabmeat have a surimi content of 35 to 45% so the US surimi seafood industry uses around 40,000 tonnes of surimi.

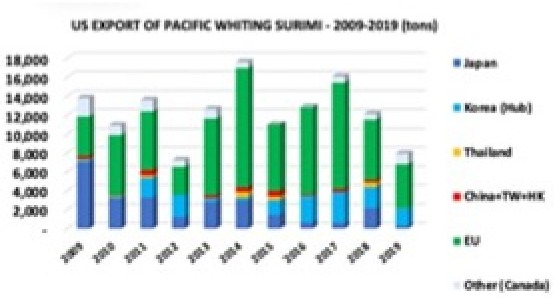
**A2.3.2 - Export markets for Alaska pollock and pacific whiting**




The export volume of Alaska pollock surimi followed the the increase of quota from 2009 to 2017 to reach a peak at 185,000 tonnes in 2017. In recent years, however, the volume decreased, down by 10,000 tonnes in 2019 while the quota was still slightly increasing as the processors favored the production of fillet block versus surimi as well as a slight increase of consumption by the US domestic market.




Besides Japan, the main importers of pollock surimi are the European Union and Korea.




We find the same destinations for Pacific Whiting but for this surimi Europe is by far the largest importer. The North American market (including Canada) and the European Union share 90% of the production of the 30,000 to 40,000 of pacific whiting surimi produced annually while while Japan consumes around 5,000 tonnes and Korea 1,000 ton.   Europe increased the import of Pacific Whiting as a cheaper surimi to substitute Alaska Pollock surimi since the early 2010's when it decreased the usage of tropical surimi for the issue of fishery certification and sustainability.

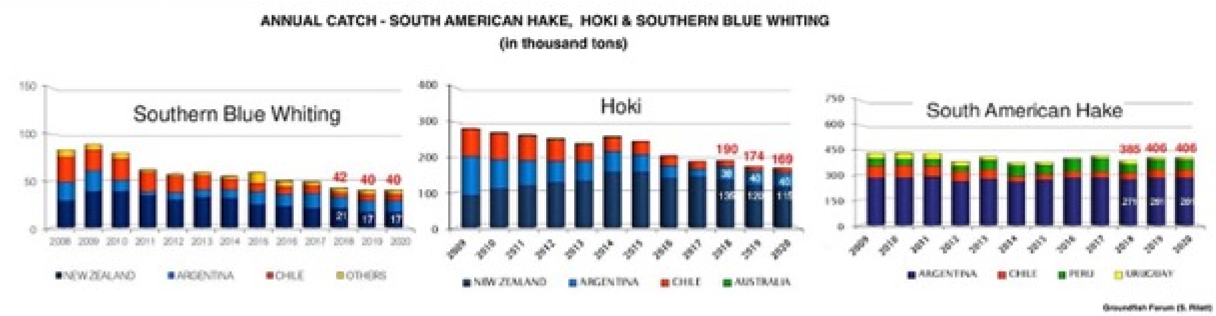
A recent study performed by GAPP (The Association of US Pollock Processors) has shown that for European consumers transparency is key. Two-thirds of consumers questioned said the origin of the fish is important in their purchasing decision, while over half believed the name "Alaska Pollock" on the pack relates not only to the species but also to the origin of the fish.

## A2.4 - Other cold water white fish surimi

## 2.4.1 Southern blue whiting, hoki and south Pacific hake surimi

Southern blue whiting (*Micromesistius australis*)(SBW) and hoki (*Macruronus novaezelandiae, Macruronus magellanicus* ) occur in the cooler waters of the southern hemisphere. Hoki supports major fisheries in New Zealand, Argentina and Chile. Hake (*Merluccius gayi*) is one of the species of Southern Pacific Hake caught along the coasts of Chile north of the Chiloe Islands.

These fisheries have large annual catches (Hake 450,000 tonnes, Hoki 170,000 tonnes, Southern Blue Whiting 40,000 tonnes) and these resources made a significant contribution to the global supply of surimi in the 1980's and 1990's.

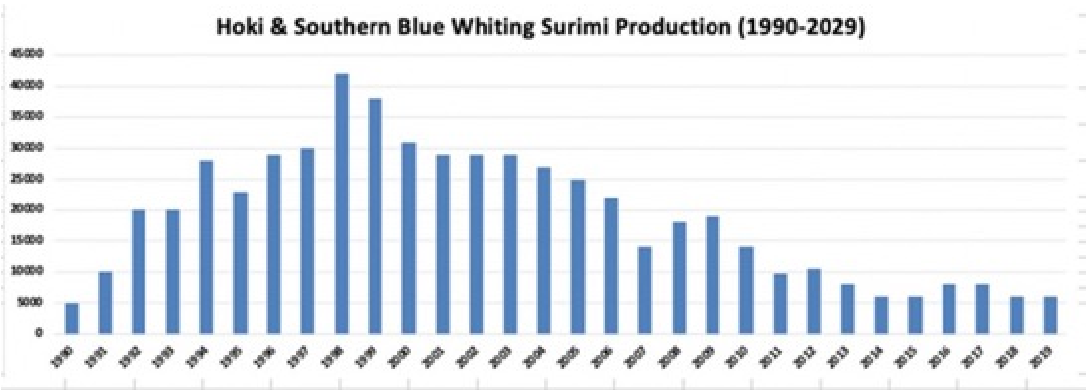



The Total Allowable Catches for hoki in Chile and Argentina are managed under a system Individual Quotas allocated per company.  The hoki fishery in Argentina was certified as sustainable by MSC in 2012 and the NZ fishery in 2001

During the second half of the 1980s, hoki (both species) and SBW surimi production was developed on factory trawlers operating in Argentina, New Zealand and Chile.  The production reached a peak with a half a dozen vessels producing up to 40,000 MT of surimi in the late 1990's. Both species proved to provide excellent quality surimi with good whiteness and high gel strength, similar to Alaska pollock.

Southern blue whiting is often contaminated with parasites that make this fish unsuitable for fillet production and therefore most of the catch is directed to surimi production. In contrast the surimi is of a premium quality and is particularly appreciated for the very high elasticity and the ability to set (suwari), a property interesting for the processing of specialties such as kamaboko and molded surimi products. Most of the supply goes to Japan.

After peaking up to 42,000 tonnes in 1998 with 6 factory trawlers operating, surimi production has much decreased in the 2000's as hake and hoki found more profitable markets in the form of fillets and fish blocks while the catch of southern blue whiting decreased down to 40,000 tonnes. By 2020 only two factory trawlers remained (one in Chile, one in Argentina) to process hoki and southern blue whiting surimi. Both have had financial difficulties: the F/T Tai An in Argentina changed ownership 3 times in the past decade. The two factory trawlers still operating represent a fraction of the catch of hoki that they process mostly into fillets or H&G while southern blue whiting is processed into surimi.




Chilean whiting (*Merluccius gayii)* also called "hake" (as it is a true hake from the family Merlucciidae) has been used to process surimi by shore plants in Talcahuano, Chile from 1994 to 2001, yielding about 1,000 MT/year. During this period when the management of the fishery was by "Olympic Fishery", surimi production was a means to rapidly process large amounts of fish and maximize the catch during the quota openings. In 2001, Chile adopted an ITQ management system by allocating individual quotas to the fishing companies involved in the fishery. With individual quotas, fishing could take place on longer period and the focus was changed to maximize the revenues from the fishery. Since the value of fillet production surpassed the revenues from surimi, the factories stopped processing surimi.

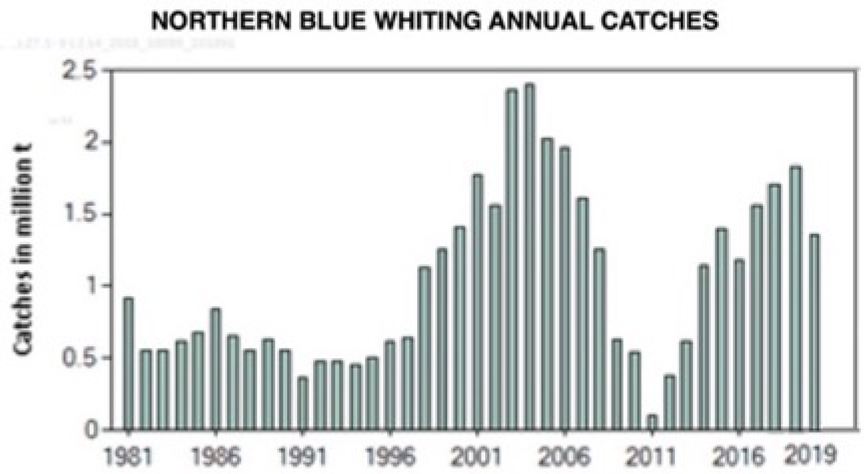
Southern Blue Whiting Surimi is a high grade surimi. It is particularly appreciated by its customers for its very high elasticity for the specialty products in which this product is used (like imitation baby eels and high grade crabsticks in Spain). When the US placed a ban on the export of Alaska pollock to Russia, following the conflict with Ukraine, the Russian processors used SBW and Hoki to replace pollock surimi in the formulations of high quality crabsticks. But in the past few years all production moved to Japan after the Japanese refinanced the vessel in Argentina.

## 2.4.2 - Northern blue whiting

Blue whiting (*Micromesistiu*s poutassou) in the Northeast Atlantic is a migrating straddling stock in the Exclusive Economic Zones of the Faroe Islands, the European Union, Iceland and Norway and Russia. This means effective regulation calls for international co-operation. After years of overfishing with a total catch of more than 2 million MT leading to a depletion of the resource, the countries involved in the North

Atlantic fishery reached an agreement over quota distribution by the mid 2000's and agreed to reduce the fishing pressure in order to stabilize and rebuild the resource. Since then, quota advice for blue whiting in the northeast Atlantic is provided by ICES.

The Northern Blue Whiting fishery has traditionally been oriented to fish meal production while the processing of products for human consumption is limited to surimi and a small volume of H&G fish. The quota for Northern Blue Whiting was gradually reduced down to about 500,000 MT by 2010 and then cut to 40,000 MT in 2011 due to concerns about resource depletion. The fishery scientists later agreed this cut was too extreme and unjustified and the quota was brought back to 390,000 MT in 2012 and increased to reach 1.3 to 1.7 million tonnes in past years.

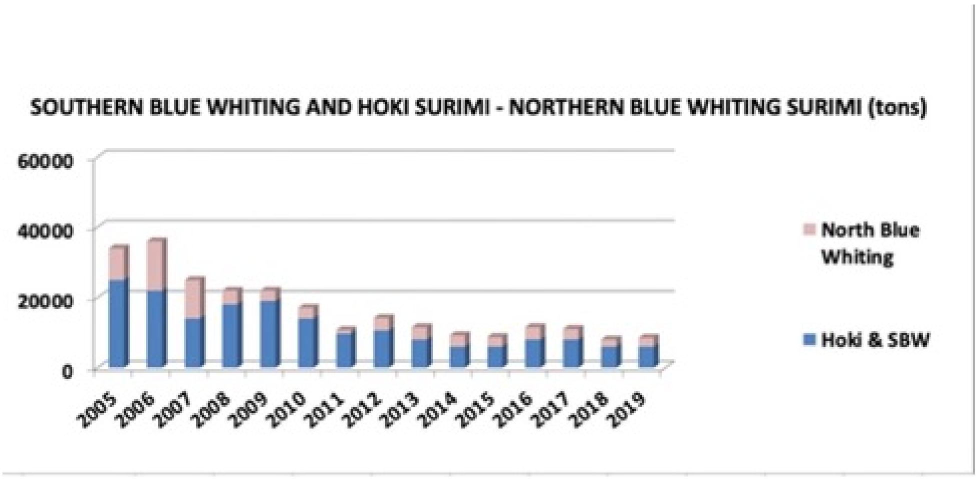



Since the early 1990's, a French factory trawler has produced Northern blue whiting surimi. Production volume increased and reached over 10,000 MT and now w produces around 3,000MT per year.

Northern blue whiting gives a high quality surimi similar to other cold water white fish, slightly darker than Alaska pollock but with high elasticity (high deformation value) as long as the fish is processed fresh. Similarly to Southern Blue Whiting the fish quality decreases rapidly after harvest which makes it difficult to process on shore-plants. This is further exacerbated by the migratory characteristics of this fish which results in short processing seasons. Since the fishing fleets normally catch very large volumes that they deliver to fish meal plants, organizing a regular daily supply for surimi processing on-shore is another difficulty.

With a stabilized quota, Northern Blue Whiting has the potential for further growth both for factory trawlers and shore-plants. Shore-plant production may be possible as long as the processor can secure fish supply from dedicated fishing vessels of size adapted to the plant processing capacity to deliver fresh fish on a daily basis.

In the last 2 decades, the fleet of Japanese and foreign vessels which once contributed significantly to the global supply of surimi gradually disappeared as the aging vessels had to be replaced and the revenues generated by surimi production could not cover the financial cost of the investment in new factory trawlers.


SOUTHERN BLUE WHITING AND HOKI SURIMI - NORTHERN BLUE WHITING SURIMI (tons)
60000
40000
20000
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
North Blue Whiting
Hoki & SBW

# Appendix 2 – questionnaires sent to surimi and surimi seafood producers

## A2.1 Surimi seafood producers

CERTIFICATION AND RATINGS
COLLABORATION

**Surimi Project Overview**

The Seafood Certification & Ratings Collaboration (CRC) unites five global programs working together to help encourage seafood producers to move along a clear path toward environmental sustainability and social responsibility. Membership includes the Aquaculture Stewardship Council, Fair Trade USA, Marine Stewardship Council, Monterey Bay Aquarium Seafood Watch and Sustainable Seafood Partnership. More detail can be found at - https://certificationandratings.org/

Through its work the CRC aims to encourage:

- Fisheries and aquaculture to move along a clear and measurable path delivering continuous improvement toward environmental sustainability and social responsibility.
- Businesses that buy and sell seafood and consumers to make decisions based on clear information and support fisheries and aquaculture operations to improve.
- Policymakers to make better-informed decisions to manage fisheries and aquaculture production.

In 2016, the world produced 850,000 metric tons of surimi which required about 3 million tonnes of whole fish. The industry is therefore a major user of the world's fish catch. Tropical fish species are used to make about 510 000 tonnes of this and little is known about their sustainability status.

Poorly managed fisheries are a business investment risk and all parts of the supply chain from fishermen to the end consumer benefit from good fisheries management. CRC members have worked with many seafood businesses for over twenty years to help them create a path to sustainability that results in confidence that there will be fish for the future.

The CRC has commissioned a 'landscape review' of surimi, that will collect industry, scientific, institutional and anecdotal knowledge on the production and environmental and social performance of fisheries that take fish used in the surimi industry. The aim is to develop a solid, factual basis for CRC members to have productive discussions with the industry about the need to move to a more sustainable footing, and how to do this.

The CRC has appointed international sustainable fisheries advisory company, Fish Matter Pty Ltd to run this project. It is headed by Mr Duncan Leadbitter who has over twenty five years experience in sustainable seafood and fisheries management, including working with industry groups and companies. Mr Leadbitter's team includes two of the most knowledgeable contributors to the industry; Professor Jae Park, who runs the Surimi School and who has decades of experience in surimi research and Dr Pascal Guenneugues who has established and run surimi businesses for decades.

If you would like to know more about this project please contact:

Duncan Leadbitter – dleadbitter@fishmatter.com.au

Prof. Jae Park is in charge of this survey and all of your answers will be treated **anonymously**. He will be only one in communication with you. Other team members will not know who and what you are. Your name and company name will not be disclosed, but will be randomly assigned like A of Company A. Please note your answers will make our industry sustainable and profitable for our current and next generations. Thank you so much. We truly appreciate your participation.

Can you please answer the questions in the following pages?

**Questionnaire for surimi seafood (finished products) factory owners or managers.**

The first set of questions is related to the knowledge regarding raw materials used in the products, their origins, etc.

The next set of questions are made to evaluate the importance given to sustainability and understand the views related to sustainability of the fisheries and the surimi industry.

## QUESTIONNAIRE

**1. What are the raw materials used by your company (by order of importance in terms of volume). Can you indicate the local name of the fish? Scientific Name of the fish?** Rank 1 for the most important while 12 for the least important.

| Rank | Surimi You used in the production of surimi seafood | Local name | Scientific (Latin) Name |
|---|---|---|---|
| | Alaska Pollock Surimi | | |
| | Pacific Whiting Surimi | | |
| | Southern Blue Whiting or | | |
| | Northern Blue Whiting Surimi | | |
| | Threadfin Bream (Itoyori) Surimi | | |
| | Itoyori Mix Surimi | | |
| | Lizard fish (Eso) Surimi | | |
| | Ribbon Fish Surimi | | |
| | Flying Fish, Mackerel, Sardine, Anchovy, Other Pelagic Fish Surimi | | |
| | Pangas, Silver Carp, Other aquaculture Fish Surimi | | |
| | Mixed Fish Surimi | | |
| | Other (please detail) | | |

2. **What is the region/country of origin of your raw material (indicate FAO Zone if known)?**

   Please mark (X) and write appropriately.

   - North Pacific
   - South Pacific
   - North Atlantic
   - South Atlantic
   - South China Sea
   - East China Sea
   - Eastern Indian Ocean
   - Western Indian Ocean
   - Aquaculture Fish: What Country/Region?
   - Other:

3. **In your opinion can these raw materials be considered as sustainable?**

   Yes ( ) – which one? ____________________ (Write the name of species)

   No ( ), which one?___________________ (Write the name of species)

   Not sure ( )

4. **How would you describe the matter of sustainability of the fisheries related to the business of your company?**

   Please mark (X) when it is true to your raw materials.

   - Something that is systematically taken into consideration when making purchase decisions
   - Important for the long term but not a major concern for the time being
   - A secondary issue compared to price and quality of the raw material
   - Something that needs to be considered in response to the demand of the market
   - A growing concern for the image of our brand
   - Not a concern for the time being, we focus of quality and price first
   - A primary concern for the long-term survival or prosperity of our company
   - A matter that is a growing concern due to awareness of the consumers/customers

- An issue that has to be considered to avoid negative communication from NGO's that may damage the image of our company and/or our brand

- A constraint that cannot be ignored or under-estimated due to the pressure of the retail distribution.

**5. When making a purchase decision for surimi raw material for the next few months, what are the criteria that you will consider by the order of importance? Please mark 1 – 4 appropriately.**

- ( ) The **quality** the product and its **price**
- ( ) The **origin** of the product and the **reputation** of the producer
- ( ) The **name of the fish** and its **impact** towards the consumers
- ( ) Independent proof (e.g. via **certification)** of the fishery in relation to sustainability

**6. In order to participate to the general trend towards sustainability of the fisheries, would you be ready to consider.** Mark (X) all that apply.

- ( ) to use alternative fish resources even though these may not be popular among the public consuming your products and as such would need a significant effort in your communication to get consumer acceptance and may present a risk for your sales on the short term?

- ( ) to abandon a resource that has been a backbone of your raw material supply if it becomes obvious that in the near future this resource may pose problems in terms of sustainability

- ( ) to push your management to look for alternative sources of raw material as scientist and specialists of the fisheries demonstrate that on the long term the raw material used to process your products is unsustainable.

- ( ) as a company, contribute to efforts to encourage the fishery to become sustainable

**7. Recent articles in the specialized press suggest changes that may affect the surimi production around the world. Would you agree with the statements below and do you think they can apply to your company?**

- The Alaska Pollock Fishery may be at least subject to drastic changes as a result of climate change particularly due to water temperature. Russian pollock processors are investing heavily in a modern fishing vessels and factories that include surimi processing. Northern Blue Whiting (NBW) in North Atlantic Ocean and Pacific Whiting (PW) in Oregon Coast are vast resources of white fish that give good quality surimi but have been either under-exploited (PW) or primarily used to process fishmeal (NBW):

**The continuous development of surimi production from these resources can be a good solution to substitute the possible decreased availability of Alaska Pollock in future.**

Mark (X) if you Agree (  ) or Disagree (  )

- Threadfin bream (Itoyori) and other Benthic Fish Species like big eye snapper (Kintokidai) have been a primary source of raw material in Asia for surimi but these resources are rapidly declining due to overfishing in most of the countries. Some countries like China turned to silver carp as being a more sustainable alternative for good quality white fish surimi and development of aquaculture of fresh water fish, vegetarian by nature, such as silver carp, pangas or tilapia, is another step to sustainability:

**This direction to replace benthic seawater fish by aquaculture fresh water fish can be a logical step for the surimi industry in the direction of better sustainability.**

Mark (X) if you Agree (  ) or Disagree (  )

- There is plenty of fish in the sea but species matter: small pelagic fish like sardine, mackerel, scad or anchovies are used for fish meal in countries like South America but could be used for surimi. Modern surimi technology allows to process good quality surimi from these species but gives a little darker color than white fish. Nevertheless, thissurimi can advantageously used to process certain finished products such as fried surimi seafood (fish cakes) or in combination with white fish surimi.

**This is something that I can consider to apply for the products processed by my company.**

Mark (X) if you Agree (  ) or Disagree (  )

- The fresh/frozen/canned seafood industry has, for the past 20 years, been supporting efforts to help fisheries make changes to make them more sustainable. They believe that supporting the transition to sustainability helps both their production and the fishermen as well as maintaining supply chains.

Is this an approach that your company would consider as worthwhile? Mark (X) if you Agree (  ) or Disagree (  )

**8. In your opinion, what are the main reasons that prevent surimi seafood companies to move towards more sustainability?** Please mark (X) and write appropriately.

- Lack of knowledge at the company level about sustainability issues
- Lack of concern of the consumers toward sustainability

- Consumers' ignorance regarding the problems of sustainability

- Conservatism of the older generations in terms of acceptance for food products

- Lack of availability of sustainable resources

- Price issues, sustainable surimi being more expensive than non-sustainable

- Insufficient and biased information regarding the problem of sustainability

- Differences in quality between sustainable and non-sustainable surimi

- Pressure of the modern retail distribution that prevents surimi seafood processors to shift more sustainable raw materials

- Regulatory issues such as the obligation to mention fish species in the products that complicates to change the origin of raw materials used in their products

- Other:

**9. In your opinion what are the reasons that may drive the surimi seafood industry to more sustainability?** Please mark (X) and write appropriately.

- Declining raw material availability that makes sourcing difficult

- Increasing consumers awareness regarding the issue of sustainability

- Increasing concern of the younger generations toward sustainability

- Better communication and better knowledge regarding sustainability

- Political changes resulting to new regulations imposed by governments

- Pressure of the retail distribution that forces processors to reject surimi raw material of non-certified origin

- Influence of the NGO's promoting sustainability

- Increased availability of sustainable surimi

- Modern technology that allows to use new resources

- Improved quality of the products issued from sustainable fisheries

- Other:

Thank you so much for your participation. Your answers will play a major role for us together to keep our global fisheries sustainable. Again, all of your answers will be recorded anonymously.

Jae Park, Ph.D.

Professor, Oregon State University

Director, OSU Surimi School & Jae Park Surimi School surimiman1@yahoo.com; 1-503-440-5636

## A2.2. Surimi producers

CERTIFICATION AND RATINGS
COLLABORATION

**Surimi Project Overview**

The Seafood Certification & Ratings Collaboration (CRC) unites five global programs working together to help encourage seafood producers to move along a clear path toward environmental sustainability and social responsibility. Membership includes the Aquaculture Stewardship Council, Fair Trade USA, Marine Stewardship Council, Monterey Bay Aquarium Seafood Watch and Sustainable Seafood Partnership. More detail can be found at - https://certificationandratings.org/

Through its work the CRC aims to encourage:

- Fisheries and aquaculture to move along a clear and measurable path delivering continuous improvement toward environmental sustainability and social responsibility.
- Businesses that buy and sell seafood and consumers to make decisions based on clear information and support fisheries and aquaculture operations to improve.
- Policymakers to make better-informed decisions to manage fisheries and aquaculture production.

In 2016, the world produced 850,000 metric tons of surimi which required about 3 million tonnes of whole fish. The industry is therefore a major user of the world's fish catch. Tropical fish species are used to make about 510 000 tonnes of this and little is known about their sustainability status.

Poorly managed fisheries are a business investment risk and all parts of the supply chain from fishermen to the end consumer benefit from good fisheries management. CRC members have worked with many seafood businesses for over twenty years to help them create a path to sustainability that results in confidence that there will be fish for the future.

The CRC has commissioned a 'landscape review' of surimi, that will collect industry, scientific, institutional and anecdotal knowledge on the production and environmental and social performance of fisheries that take fish used in the surimi industry. The aim is to develop a solid, factual basis for CRC members to have productive discussions with the industry about the need to move to a more sustainable footing, and how to do this.

The CRC has appointed international sustainable fisheries advisory company, Fish Matter Pty Ltd to run this project. It is headed by Mr Duncan Leadbitter who has over twenty five years experience in sustainable seafood and fisheries management, including working with industry groups and companies. Mr Leadbitter's team includes two of the most knowledgeable contributors to the industry; Professor Jae Park, who runs the Surimi School and who has decades of experience in surimi research and Dr Pascal Guenneugues who has established and run surimi businesses for decades.

If you would like to know more about this project please contact:

Duncan Leadbitter – dleadbitter@fishmatter.com.au

Prof. Jae Park is in charge of this survey and all of your answers will be treated anonymously. He will be only one in communication with you. Other team members will not know who and what you are. Your name and company name will not be disclosed, but will be randomly assigned like A of Company A. Please note your answers will make our industry sustainable and profitable for our current and next generations. Thank you so much. We truly appreciate your participation.

Could you please answer the questions in the following pages?

**Questionnaire to Surimi Processors**

**In broad terms we need your assistance to learn about:**

1. The species used – the most accurate way is to know the Latin name (e.g. *Nemipterus Japonicus*), and the common name (threadfin bream), followed by any local names. Local names can vary from place to place and the same name may apply to different species.

2. Where the fish come from – are they fished locally close to shore, in the waters of a particular state or province or a long way out to sea or even fished outside the country's national waters (if so, from what country, fishing area).

3. How the fish are caught – this helps me to understand what issues there may be in the fishery. Most seabed fish are caught on the seabed by trawls and surface fish by purse seines, but there may be other types of fishing gear used as well.

**Questions:**

1. What types of fish do you use to make the surimi? Common names and local names are acceptable but latin names are more accurate if possible. Do you have any photographs of the different types?

| **Latin Name** | **Common Name** | **Local Name** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

2. Do you make surimi from only one species of fish or do you mix different species of fish together? What types of fish would you mix? Please mark (X) or write appropriately.

   Only one species (   )

   Mix different species together (   ) – If so, what are they? ____________________________

3. If you make a mixed fish product are the fish mixed during surimi processing or different kinds of surimi mixed after processing? Please mark (X) or write appropriately.

   Fish is mixed before mincing/deboning (   )

   Screw press meat is mixed after surimi processing (   )

4. If your fish or surimi is imported from overseas, do you know where the fish is caught (area, country) and do you know if they result from legal or illegal fishing? Please mark (X) or write appropriately.

   We do not use imported fish (   )

   We use imported fish (   ), Name area and country where fish is caught:_________________

   Is imported fish from legal or illegal fishing?  Yes (   ), No (   ), Do not know (   )

5. If your fish is caught in your own country do you know where it is caught? Do you bring your fish by truck from more than 100 kilometres away? More than 500 km away? Please mark (X) or write appropriately.

   Is your fish caught in your own country water?  Yes (   ), No (   )

   Do you bring fish by truck from?  Less than 100 Km (   ), More than 100 Km (   ), More than 500 km (   ), or ________ Km

6. Do the fishermen in your country fish a long way out to sea more than 12 miles? more than 100 miles? or are they inshore fishermen (less than 12 miles)?

Please mark (X) or write appropriately.

They fish within 12 miles inshore (   ), More than 12 miles (   ), More than 100 miles (   )

7. Are there particular fishing seasons (what kind of fish, what months?) or are the fish caught all year round?

| **Fish Species** | **Fishing Season (allowed)** | **All year round (allowed)** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

8. Do you know what types of fishing nets the fishermen use for your fish supply?
   Can you write the types of fishing nets? ___________________________________

9. Are there limitations regarding the size of fish that you buy? What are these limitations?
   Can you write the size of fish you buy? ___________________________________

   What are the limits? ________________________

10. Is the average size of the fish you buy the same as it was five years ago? ten years ago?
    Yes (   ), No (  )

    Compared to 5-10 years ago, how has the size been changed? _________________

11. Is the volume of fish available the same as what it was five years ago? ten years ago?
    Yes (   ), No (  )

    Compared to 5-10 years ago, how has the volume of fish available been changed?
    _________________

12. Are the fish species and proportion of different species that you receive in your factory the same as what it was five years ago? ten years ago? How do you describe the changes if any?
    Yes ( ), No ( )

    Compared to 5-10 years ago, how has the proportion of fish species landed been changed?
    ________________

13. Is the origin of the fish (fishing ground) the same as it was five years ago? Ten years ago?
    Yes ( ), No ( )

    Compared to 5-10 years ago, how has the fishing ground been changed? ________________

14. How would you describe the general trend in the surimi industry in your country?
    ____________________________________________________________________________

15. What are the main factors that may influence your investment decisions for the coming years?

____________________________________________________________________________

Thank you so much for your participation. Your answers will play a major role for us together to keep our global fisheries sustainable. Again, all of your answers will be recorded anonymously with my professional responsibility.

Jae Park, Ph.D.

Professor, Oregon State University

Director, OSU Surimi School & Jae Park Surimi School

surimiman1@yahoo.com; 1-503-440-5636